



# WHEAT

Agri-Food Systems

## PROPOSAL

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RESEARCH  
PROGRAM ON  
Wheat

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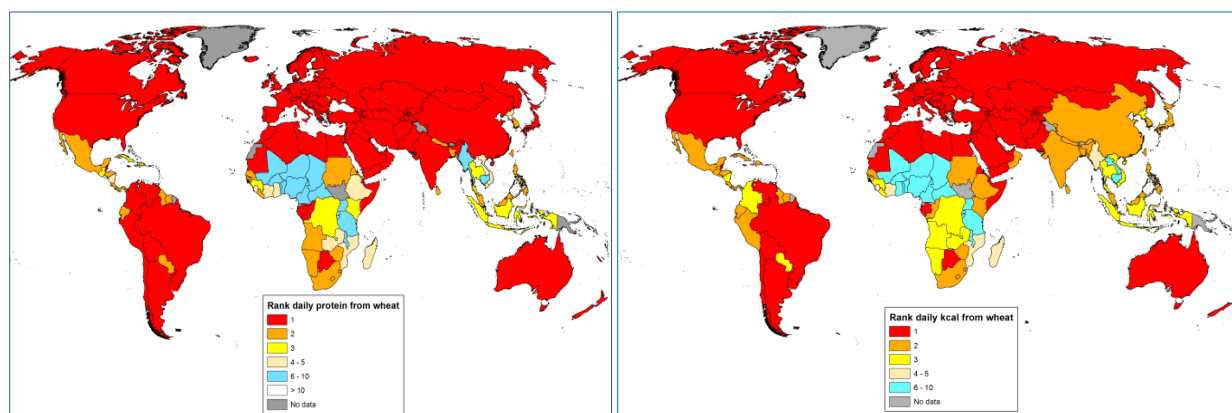
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## Section 1: CGIAR Research Program on Wheat (WHEAT)

### 1.1 WHEAT Rationale and scope

#### WHEAT strategic relevance and alignment with the CGIAR SRF

Wheat is a key food staple that provides around 20 percent of **protein and calories** consumed worldwide. Demand for wheat is projected to continue to grow over the coming decades, particularly in the developing world to feed an increasing population, and with wheat being a preferred food, continuing to account for a substantial share of human energy needs in 2050 (Wageningen FSC, 2016). Based on recent trends, an increasing number of poor consumers in low- and middle-income countries will want to eat wheat-based food at an affordable price as populations and economies grow, women and men seek employment in cities, and dietary habits change.



**Figure 1.** *Wheat provides 20% of the protein and 20% of calories in global diets. (FAOSTAT 2015)*

Projections regarding **wheat demand growth** to 2050 abound and vary widely around an average of approximately +50%, relative to 2010. The bulk of increased consumption is expected to occur in developing countries where studies predict demand growth of 34-60% by 2050 (Valin, 2014). Of particular **urgency is demand growth out to 2030**, when world population growth is predicted to peak (e.g. 1.15% p.a. in 2010; projected to decline to 0.75% p.a. by 2030 and 0.50% p.a. by 2050). GDP in developing countries is projected to grow at 4.3-5.3% p.a. (2015-18; low income countries at 6.2-6.6%, World Bank, Global Economic Prospects, 2016) across income levels, with a positive income elasticity of demand for wheat. China and India, which are home to half the world's poor (Sumner, 2012), already produce and consume 30% of global wheat. By 2023, demand for wheat is expected to grow by 22% in India, 20% in Pakistan and 19% in North Africa (OECD-FAO, 2014). Wheat agri-food systems prevail in North Africa and West Asia but both have proven volatile areas where wheat prices and food insecurity over the last decade triggered civil unrest and massive migration to Europe. Fueling the instability is the region's wheat import dependency: wheat imports totaled 41 million (M) tons in 2015. In rapidly urbanizing sub-Saharan Africa, wheat consumption is expected to grow 38% by 2023, with imports at 24 M tons in 2015 and at a cost of \$8 billion. (Source: USDA, Index Mundi, 2016).

Wheat productivity levels are at a critical juncture. The unfolding scenario implies a wheat demand growth of 1.4% p.a. to 2030 at constant prices. World wheat area has not increased over the last 20 years and there are limited prospects for it to increase over coming decades. The lack of area expansion has provided a huge environmental bonus, but implies the full burden continuing to fall on productivity growth: wheat yields must grow at least at 1.4 % p.a. through to 2030. Achieving the yield growth target would protect (net) wheat consumers (urban and rural) from increasing staple food prices and wheat

producers, including smallholders, would benefit from increased productivity and the associated producer surplus.

Just over half of global wheat production comes from 75 developing countries, characterized by smallholdings and more than 90% of globally irrigated wheat is grown in developing countries (Table 1). Over the period 1993 to 2013 **world wheat yield grew** at 1.0 % p.a. (relative to 2010 average yield), considerably below the 1.4 % p.a. target above. In addition, the future brings new yield constraints only now beginning to be seen in yield statistics, in particular limitations on irrigation water and climate change. The water constraint arises because of over-pumping of ground water in two of the developing world's bread baskets (the western Indo Gangetic Plains and the North China plain), whereas overuse of water and salinization are becoming major problems for irrigated areas in semi-arid regions. The climate change threat is most clear in terms of projected warming (rates vary between 0.1 and 0.4 °C per decade, with wheat yield reduced by around -5% to -8%/°C). Uncertainty surrounds projected rainfall change, but many models suggest Mediterranean climates may face increased drought. For wheat there will be some crop growth compensation through the CO<sub>2</sub> rise linked to the warming, but there is considerable variation in estimates of this benefit, so that the net effect of climate change on wheat yield is still likely to be very negative. The conclusion from these demand and supply considerations is **that developing countries and indeed the world must lift wheat yield growth rate by about 40% over the current rate**, whilst increasing stresses will exert increasing downward pressure. Furthermore, stakeholders expect this to be achieved sustainably, with greater input use efficiency and minimal off-site environmental impact, while preserving or improving the productive capacity of land under wheat.

The **challenges facing wheat Agri-Food Systems** (wheat AFS; for definition, see <http://www.fao.org/ag/ags/sustainable-food-consumption-and-production/en/>) are many and complex (see Table 3, section 1.2). The 2008 food-price crisis highlighted the extreme vulnerability of global wheat agri-food systems. Effects of local production problems, like droughts, flooding or disease outbreaks, are amplified by global markets, causing price spikes and food insecurity for disadvantaged consumers. Maynard (2015) estimated that in a multiple climate and crop production shock, prices for wheat would increase 4-fold (Maynard, 2015). Building on such broader analyses, research under WHEAT is looking at different 'what if' scenarios, such as worsening climate change, increased heat stress or repeated multi-year poor harvests in bread baskets. On top of this already challenging setting, biotic stresses continue to evolve in virulence – with the earlier outbreak of Ug99 stem rust causing major upheaval. Now, for the first time, Bangladesh and India reported wheat blast (*Magnaporthe oryzae*) in early 2016, a deadly disease heretofore confined to Latin America. Based on experience from Brazil, Bolivia and Paraguay, blast can develop into a major threat for wheat production in Asia's warm and humid areas. The bulk of global wheat consumption is met by national and regional production, with about 20% or 160 M tons traded on world markets; predicted to grow by 2050, as imbalances become more frequent and acute (Abis, 2015). Improving access to markets through more effective value chains will become even more important, as global and regional trade will grow to compensate for greater production and productivity variability (D'Odorico, 2014).

WHEAT faces specific gender and social inclusion challenges in several of its main target regions and at the global level (Wageningen FSC, 2016). Gender inequalities restrict the efficacy of wheat-based farming systems: women are frequently key actors in production and processing, yet may have restricted roles in decision-making on farm system management, access to resources and information, or capacity to assess and respond to emerging challenges (see Table 3, section 1.2).

Most poor producers and poor consumers live in WHEAT **target regions** (Table 2). Countries with high wheat production and consumption often also have low welfare indicators. Wheat productivity increases favorably affect human well-being primarily through the income effect for producers (higher

wheat production leads to higher income) and lower food prices for consumers. For low income countries this leads to higher wheat consumption. In middle income countries, improved wheat production leads to higher incomes and more diversified diets. Wheat consumption itself has a positive nutritional effect in those settings, where wheat contributes strongly to overall protein intake. Further research is needed, not least to better link political, socioeconomic and biophysical (e.g. wheat mega-environments, climate change) scenario analysis (Wageningen FSC, *ibid.*).

**Table 1.** *Wheat production in the developed and developing world*

	High income countries	Low and middle income countries
Wheat area (million ha)	95	130
Average yield (tons/ha)	3	3
Average farm size (ha)	40 - >5,000	1-3
Production (million tons)	330	390
Rainfed area (million ha)	90	65
Irrigated area (million ha)	5	60
Food use (%)	60	85
Feed/seed/other uses (%)	40	15

**Table 2.** *Priority farming environments and populations for WHEAT (see also Annex 3.7, 4.1)*

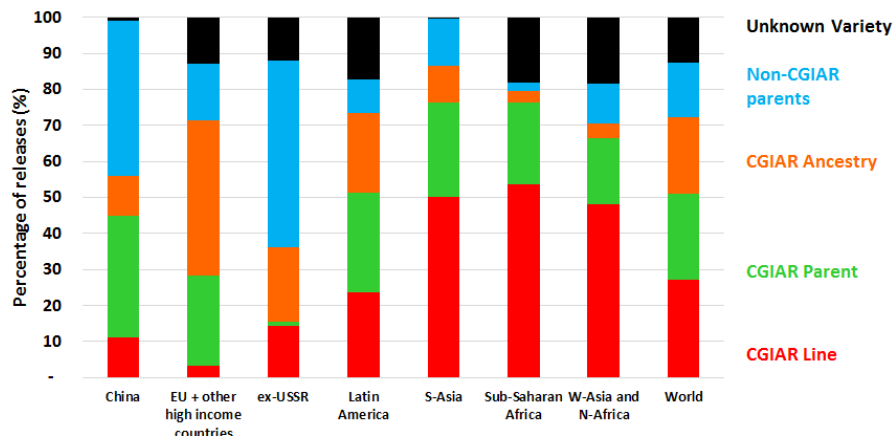
Description	Wheat area (M ha)	Inhabitants (M) earning less than USD 2/day	Representative country/region
Favorable, irrigated, low rainfall production	35	556	Afghanistan, China, Egypt, India, Iran, Mexico, Pakistan, Uzbekistan, Zambia
High rainfall, low edaphic constraints	6	107	Andes, Ethiopia, Kenya, Mediterranean & Caspian coasts, Mexico
Low rainfall	23	75	China, India, Iran, Morocco, Syria, Turkey
Hot, humid/dry	14	238	Bangladesh, Brazil, China, India, Nepal, Nigeria, Pakistan, Paraguay, Sudan
Irrigated facultative and winter wheat areas	12	159	Afghanistan, China, Central Asia, Iran, Turkey
Low rainfall winter wheat areas	17	14	Afghanistan, China, Central Asia, Iran, Turkey

Over the last decades, CIMMYT and ICARDA have been the most important providers of wheat germplasm used by national partners as parental lines for crossing or for direct release as varieties.

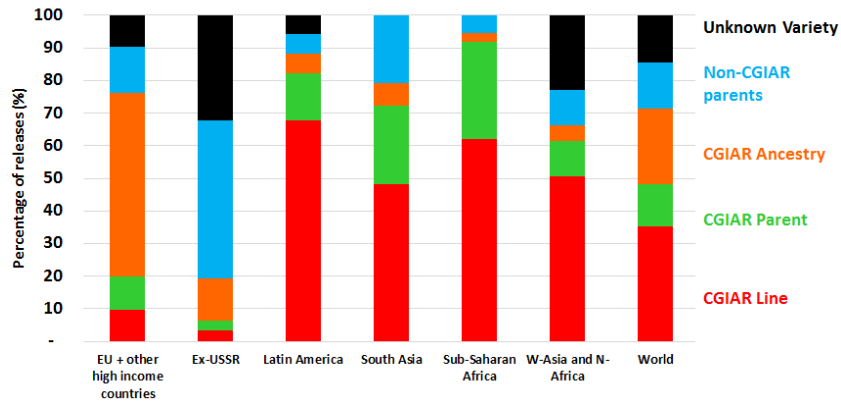
Figure 2 shows the percentage of varieties released in different world regions and their relation to CGIAR germplasm. In priority WHEAT target regions, between 50 to 70% of all varieties currently grown are either a direct introduction or derived from crosses using CGIAR lines. Given that the role of the private sector in developing countries as provider of varieties is minor (Figure 3), WHEAT expects that CGIAR-derived wheat lines will continue to be a major source for new varieties in coming decades. Indeed, climate change and evolving biotic stresses imply the need for continued public investments in wheat improvement and yield maintenance. Therefore, WHEAT and its partners are central to global food security and the future livelihood and health prospects of the world’s wheat producers and consumers, the environmental services used and impacted by world wheat agri-food systems, and the prevention of civil unrest. WHEAT generates enormous benefits and huge public returns to investment – provided it maintains secure and adequate funding for investments in wheat improvement and yield maintenance (Pardey et al, 2013; Lantican et al. 2016). Global benefits from improved CGIAR wheat varieties are valued at US\$2.2 to \$3.1 billion annually relative to baseline 1994 (Lantican et al. 2016).

In sum, over the coming decades, millions of smallholder farmers in wheat-producing countries will require support to sustainably raise crop productivity and meet the demand of millions of poor consumers. WHEAT helps smallholders improve farming practices, to make best use of their land in ever more challenging environmental conditions, including increasingly virulent biotic stresses, less water and agricultural inputs (World Bank, 2014), rising temperatures and more erratic rainfall (Vermeulen, 2014).

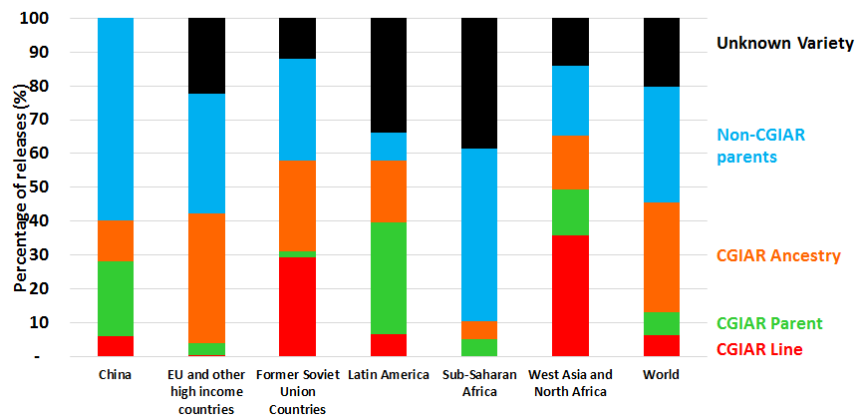
a. Spring bread wheat releases by region and origin 1994-2014



b. Spring durum wheat releases by region and origin 1994-2014



c. Winter bread wheat releases by region and origin 1994-2014



d. All wheat varieties releases by region and origin 1994-2014

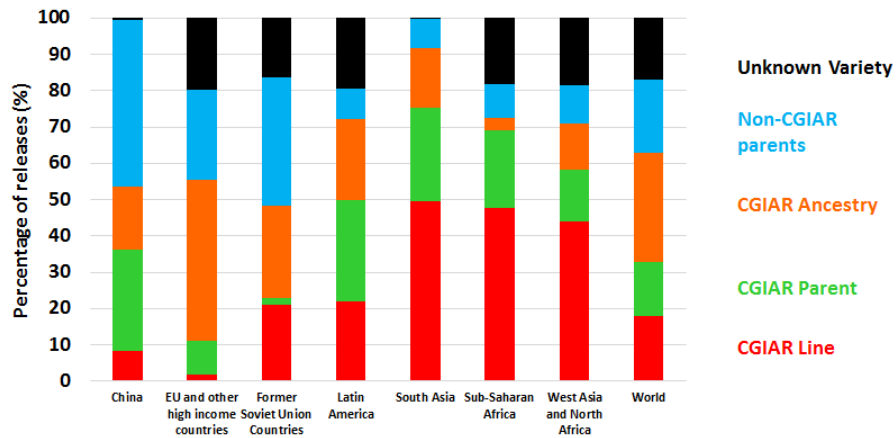
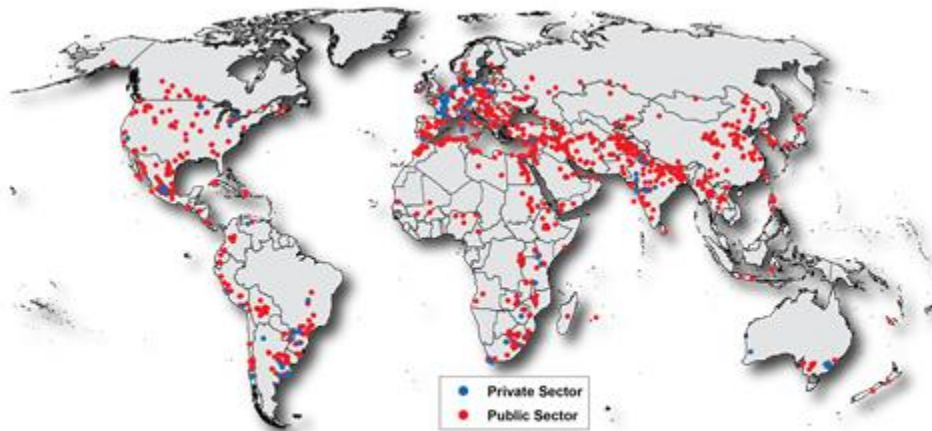


Figure 2 (a-d): Bread and durum wheat varieties released during 1994–2014 in various regions of the world. *Lantican et al. 2016.*



Note: Most of the private sector co-operators in developing countries release CGIAR derived varieties and produce seed; but they do not have a breeding operation at competitive scale

**Figure 3. Public and private co-operators in international wheat improvement network.**

How will **WHEAT go about addressing these challenges** in the next decade? By maintaining the two research strategies, or pillars of past success, namely germplasm improvement and sustainable intensification (see section 1.3), and knowledge pertaining to their development and adoption, since the CGIAR has amply demonstrated a strong comparative advantage in these areas (see section 1.8). The two pillars underpin four Flagship Projects (FP's, see section 1.6):

**FP1, “Enhancing WHEAT’s R4D strategy for impact”**, maximizes the value-for-money for WHEAT as a whole by providing horizontal guidance to WHEAT based on a solid understanding of its potential impact and comparative advantage in a dynamic and heterogeneous world. It strengthens foresight and targeting to enhance priority setting and planning (FP1.1), seeks opportunities along the whole wheat value chain (FP1.4), and revamps impact assessment (FP1.2). Also, it formalizes attention to gender and youth (FP1.3). These are areas that have been neglected in the last decade, in particular the gender dimension with its large effect on household decision making, technology adoption and social inclusiveness. Overall FP1 will amount to 9% of the total budget.

**FP2, “Novel tools for improving genetic gains and breeding efficiency”**, creates a formal home for all upstream, more strategic, genetic research activities which aim to deliver new tools and unique germplasm to mainstream breeding. WHEAT’s comparative advantage lies in its access to predictable field testing environments and the close proximity of FP2 to the mainstream breeding (FP3) and its network of collaborators in developing country wheat environments. Risk of failure (e.g. absence of useful outputs going ‘downstream’) is moderately high. Efficiencies may be gained by linking to the new Genetic Gains Platform.

WHEATs mainstream breeding, its first pillar for outputs with substantial outcomes and impact, is delivered by **FP3, “Better varieties reach farmers faster”**. This includes breeding spring bread, durum wheat and triticale (Mexico, Morocco, Kenya), and winter and facultative bread wheat (Turkey), along with the wide international distribution and testing of resultant germplasm. It is the largest FP, taking 31% of the total budget. Genetic improvement targets yield, yield stability against various abiotic stresses, host plant resistance, and end-use traits such as industrial, nutritional and dietary qualities. This strategy assumes genetic improvement in wheat, especially in yield potential, is not exhausted. There is solid evidence for this supposition, with current breeding progress in yield around 0.6% p.a. But

it is globally recognized that greater investments are needed to maintain and increase breeding progress for yield to needed levels.

**FP4, “Sustainable intensification (SI) of wheat based-farming systems”**, continues the second impact pillar, namely wheat systems agronomy, incorporating Dryland Systems components and taking 26% of the total budget. Notwithstanding the old age of varieties grown in some countries and, especially, in marginal areas, it is the lack of adoption of improved crop management which most explains wheat yield gaps and the manifest inefficiencies in use of inputs like water and nutrients. FP4 promotes the sustainable intensification of wheat systems, which may mean more physical inputs where they are lacking, but also implies a multitude of management and cropping system changes to maximize productivity and minimize off-site environmental damage, including mitigating greenhouse gases. This requires much more well-informed farmers, farm advisers and local agribusinesses.

The theory and practice of scaling out will receive more attention in FP4, in collaboration with other CRPs working in these systems. Significant impact is based on successfully dealing with a level of complexity that is greater than that associated with farmer adoption of improved cultivars. Even with new tools such as crop and system modelling, geographic information systems, remote sensing, and socioeconomic modelling, substantial resources will be needed.

WHEAT Phase II will incorporate one cross-cutting cluster of activities (CoA), namely “**Capacity building for the next generation of researchers and farmers**”. It includes the traditional hands-on breeding and agronomy training, so effective in the early years and still heavily demanded, as well as graduate studies combined with field work and new formats, such as the WHEAT Learning Platform. A special challenge will be farmer training, since this depends greatly on investment by national governments.

## 1.2 Goals, objectives, target

*“Where there’s no law, there’s no bread.” – Benjamin Franklin*

### The strategic role of WHEAT and its contributions to the Strategy and Results Framework (SRF)

WHEAT will contribute to the achievement of eight Sustainable Development Goals (SDGs) outlined by the United Nations, in particular to: end poverty in all its forms everywhere (SDG 1); end hunger, achieve food security and improved nutrition, and promote sustainable agriculture (SDG 2); ensure healthy lives and promote well-being for all at all ages (SDG 3); achieve gender equality and empower all women and girls (SDG 5); ensure sustainable consumption and production patterns (SDG12); take urgent action to combat climate change and its impacts (SDG 13); protect, restore and promote sustainable use of terrestrial ecosystems, halt and reverse land degradation and biodiversity loss to improve natural resources systems and ecosystems services (SDG 15); and strengthen the means of implementation and revitalize the global partnership for sustainable development (SDG 17). These SDGs closely align with the System Level Outcomes, (sub-) IDOs and Grand Challenges (see Table 3) described in the CGIAR Strategy and Results Framework. WHEAT aims to:

1. *Ensure wheat-based systems in less developed countries are more profitable and sustainable by developing, adapting and scaling out systems approaches; these incorporate germplasm and sustainable intensification and diversification solutions, which target six high priority mega-environments where 90% of poor people earning less than \$2 a day in wheat growing environments live and 85% of the wheat in developing countries is grown. (See Table 2 above)*
2. *Keep wheat-based products affordable and in collaboration with A4N&H, nutritious for approximately 1.2 billion poor wheat consumers by maintaining yield gains despite climate change, new pests and diseases, and by working with CRP PIM to better connect rural and urban markets.*

**Table 3. SRF grand challenges addressed by WHEAT outcomes.**

Grand Challenge	FP1	FP2	FP3	FP3-FP4 (scaling out)	
Competition for land	R4D on competition for land and spatial dimensions of soil, water degradation to better target and prioritize interventions		High-yielding, abiotic and biotic stress resistant varieties = increased productivity = less land use, more livestock, crop diversity; shorter duration wheat = increased cropping intensity, diversification	Diversified multi-crop/ livestock /agroforestry cropping systems with greater systems intensity reduce pressure on land	Scaling out sustainable intensification options = greater productivity, food security, without expansion into marginal areas
Soil degradation		Bringing together multiple types of data to better understand GxExM interactions and develop sustainable solutions	Crop mgmt practices adoption arrests soil degradation (part of technologies combinations)		
Overdrawn and polluted water supplies			Disease-, pest-resistant varieties = less chemical use, protect water resources. Nitrogen-efficient-wheat = less water pollution	Precision water mgmt practices, farmer decision-making support tools drive irrigation by crop demand	Improved seed production and maintenance

Employment, income opportunities for men, women, youth					Private sector more involved: Develop business, marketing skills, linkages to markets, finance
Climate change (CC)	Climate change, other dynamics, their impact on landscapes integral to the foresight analyses	Traits and genes (heat drought, ..) into new, high-yielding wheat	Broad genetic-based resistant germplasm mitigates threat of CC-driven new, more disease/pests; provided to wheat breeders globally	More resilient farms landscapes, optimized cropping systems use less fertilizer (mainly N) sequesters carbon and helps reduce GHG emissions	Optimized seed systems through climate-smart mgmt of land, water, biodiversity
Diminishing genetic resources		Ex/In-situ conservation of genetic resources with NARS in major diversity spots	Mine landraces, wild relatives for novel sources for key traits = contributes to on-farm genetic diversity		
Nutritious and diverse agri-food systems and diets			Bio-fortified, micronutrient -rich lines contribute to improved health, less malnourished poor; More nutritional (proteins), healthy wheat (fibre) reduces diabetes II, cardiovascular disease risk	Diversified (multi-crop / livestock / agroforestry) farming systems	
Post-harvest losses	Value chain R4D: Entrepreneurial, job opportunities other options to address post-harvest losses, enhance food safety		Diseases/pests resistance = protection from post-harvest losses (e.g. mycotoxins, etc.)		

*Better dry bread in peacetime than meat in wartime. – Hungarian Proverb*

### **Value for money**

WHEAT provides substantive value for money, as the independent reviewers of the CGIAR-IEA-led External Evaluation attested: “Overall, the Evaluation Team concludes WHEAT to be relevant in terms of coherence, comparative advantage, and program design (and) WHEAT is contributing sufficient value from CGIAR’s research investments to generate results to warrant continuation during the extension phase and beyond. WHEAT has used W1&2 funding for leveraging bilateral funding and aligning bilateral projects better within the program strategies. WHEAT exploits its comparative advantage, which is unique in terms of access to and knowledge of wheat germplasm, experienced researchers, and long standing relationships with the relevant and highly committed NARS and ARIs, to deliver public goods to appropriate NARS partners who use these in local efforts to enhance production of wheat for producer and consumer benefits.”

Based on the importance of crops for poor producers and consumers in the developing world, it is possible to estimate targets to be achieved by WHEAT to meet the 2030 targets of the SRF (Table 4). With adequate, secure and strategic funding, WHEAT is set to provide a major contribution to the SRF targets – but for the respective contribution per CRP methodologies for calculating such impacts must be aligned between CRPs.

**Table 4. WHEAT contributions in view of SRF commitments, estimated relative to the importance of wheat for poor producers and consumers and to proposed core budget (see also PIM Table A).**

SRF targets (2022/2030)	WHEAT (2022)	WHEAT (2030)	Assumptions
1.1 100/350 M more farm households have adopted improved varieties, breeds or trees, and/or improved management practices.	17.5M	36 M	Improved varieties released by NARS 2015-2030; 169 M farm households producing wheat (of 570 M farms in developing world; FAO 2014) in low-middle income countries; 15-30% adopting new WHEAT innovations (dependent on country income level); based on global impact study (Lantican et al. 2016). Estimates will be refined through further ex post impact studies for specific geographies (FP1.2) and updated global variety release and adoption data (uploaded in wheatatlas.org).
1.2 30/100 M people, of which 50% are women, assisted to exit poverty.	5.7M	12 M	Based on \$1.25/day purchasing power parity (World Bank); number of poor (producers & consumers) in wheat growing areas categorized by the relative importance of wheat (share in food crop area); assumed poverty effect (0-15%) of stratified adoption (15-30%), both dependent on country income level (low-middle income countries).
2.1 Improve the rate of yield increase for major food staples from current 1% to 1.2-1.5% / <2% to 2.5% per annum (pa)	1.4% pa	2.5% pa	Global average yield growth rate, broken down to WHEAT target geographies, based on reported farmers' yields in official statistics; 2022 target already implies 40% increased annual gains; 50% gains each (0.7%) from germplasm (genetic gains) & from crop management; assumes maintenance breeding translates into avoided losses (Lantican et al. 2016).
2.2 30/150 M more people, of which 50% are women, meeting minimum dietary energy requirements	10M	55 M	Based on FAO World Hunger Map (SOFI 2014), WHEAT target regions and on average 20% of daily calories for 1.2 bn wheat-dependent poor (\$2/day) producers and consumers. Wheat kCal contribution per capita has been constant over past decades; and will continue to account for a substantial share of human energy needs (kcal) for a growing world population in 2050 (Wageningen FSC, 2016); assuming affordability, access.
2.4 10%/33% reduction in women of reproductive age consuming less than the adequate number of food groups.	3M	10 M	Indirect impact of maintaining low staple food (wheat) prices for poor consumers, thereby able to spend more of their income on other diverse non-staple foods; consumption of Zn/Fe enriched wheat varieties (see also A4NH/Harvest+); assuming affordability, access.
3.1 5%/20% increase in water and nutrient (inorganic, biological) use efficiency in agro-ecosystems ...	5M ha	20 M ha	20% wheat area in target geographies, equivalent to ca 100 M of global 240 M ha sown to wheat.
3.2 Reduce GHG emissions related to agriculture by 0.2/0.8 Gt CO <sub>2</sub> yr <sup>-1</sup> (15%) compared with a business-as-usual scenario in 2030.	5%	Between 5%-20%	Agri emission intensities reduction in select target regions, in terms of % change from 2015 baseline in fertilizer N consumption, NUE and soil carbon; Biological nitrification inhibition (BNI) varieties on farmers' fields.
3.4 2.5/7.5 M ha of forest saved from deforestation	0.18 M ha	0.5 M ha	Indirect effect of net land savings (Stevenson et al. 2013).

**Table 5. WHEAT development objectives and indicators matched to CGIAR SLOs and SDGs.**

Assumptions:

- Match one target to one sub-IDO, even if other sub-IDOs relevant, to keep progress-towards-outcome monitoring manageable.
- Several sub-IDOs may have to be achieved to reach the SLO-level target.
- Several to-outcomes progress indicators may need to be monitored for one sub-IDO and one target.

SRF Portfolio-level Targets 2030	Relates to CGIAR sub-IDO	Relates to SDG	WHEAT Strategic Goals & Targets by 2030	Via WHEAT FP	Proposed indicator to use
<b>SLO1: Reduced Poverty</b> 1.1 350 M more farm households have adopted improved varieties 1.2 100 M people, of which 50% are female, assisted to exit poverty	Enhanced genetic gain <i>on-farm</i> (1.4.3)	1, 2, 5, 15, 17	A. >US\$180 M per year value added, as 5M (of 50M) women and men farmers change to new, improved varieties every year. Weighted, average age of wheat varieties in use reduced from currently 12 to 9 years, during 2015-2030.  B. >US\$100 M per year value added to households having adopted a specific combination of improved management/agronomy technologies due to increased productivity and / or cost reduction (assuming 5M hh and US\$20/hh).	FP2-3, 4	% change in income attributable to yield, quality traits, yield stability; for new users/adopters. Farm-level production and profitability increases resulting from integration of sustainable intensification options; Impact studies: Increased value capture at global/regional/country levels documented through macro level WHEAT impact updates SDSN 13: Crop yield gap; actual yield as % of attainable yield (FAO to be lead monitoring agency).
	Reduced prod. risk (1.1.2 & 1.4.1)	1, 2	C. By 2030, total harvest losses p.a. avoided (yield, quality) in target regions, by farmer adoption of resistant varieties (3 rusts, FHB, septoria, tan spot, spot blotch, wheat blast, insects) equals ca. \$ 500 M: based on 2 M tons saved via resistance; conservative estimate.	FP3, 4	Model to estimate harvest loss reducing impact of improved varieties; relate to empirical data ( <a href="http://rusttracker.cimmyt.org/other">rusttracker.cimmyt.org/other</a> ), summarize in impact study.

<p><b>SLO 2: Improved food and nutrition security for health</b></p> <p>2.1 Yield increase</p> <p>2.2 150 M more people meet min dietary requirement</p> <p>2.4 33% reduction in women of reprod. age eating less than ...</p>	<p>Increased availability of diverse nutrient-rich foods (2.1.1)</p>	<p>2, 3</p>	<p>D. Annual genetic yield gains of 0.7&gt;&gt; 1%* achieved via international partnerships and steady flow of improved lines to NARS for testing and adaptation, resulting in farmer adoption of genetically diverse varieties in Asia, Africa and Latin America (4 priority mega-environments); yield increase of 1.4% p.a. by 2022 (through germplasm and agronomy).</p> <p>Via A4NH</p>	<p>FP3, FP4</p>	<p>*Global average annual yield increase, based on aggregation of national production &amp; productivity statistics, reflecting on-farm gains.</p> <p>Location-specific crop yield gap (actual yield as % of attainable yield) see SNSN 13 above.</p> <p>% change cultivar replacement rates.</p> <p>See A4NH; Zn and Fe enriched varieties adoption (ha).</p> <p>SDSN 12: Percentage of women, 15-49 years, who consume at least 5 of 10 defined food groups (FAO, WHO as potential lead monitoring agency).</p>
<p><b>SLO 3: Improved natural resources systems and ecosystems services</b></p> <p>3.1 20% increase in H<sub>2</sub>O and Nutrient use efficiency</p> <p>3.2 Reduce agriculturally related GHG emissions</p> <p>3.4 7.5 M ha forest saved</p>	<p>Agri systems diversified, intensified in ways ... (3.2.2 &amp; 1.3.4)</p> <p>Enhanced capacity to deal with risks (A.1.4)</p>	<p>1,2, 5, 13, 17</p>	<p>E. 20% increase in water and nutrient use efficiency (from 30–50%) in targeted wheat-based farming systems in 2030.</p> <p>F. Reduced agriculturally-related GHG emission intensities in wheat-based farming systems by 20%, relative to 2015 levels, in 2030.</p> <p>G. Improved N-retention and reduced N-leakage through low-nitrifying and low N<sub>2</sub>O-emitting agri production systems based on genetic mitigation technology (BNI).</p> <p>H. Via WLE (inter-CRP effort).</p>	<p>FP2-3 &amp; FP4</p>	<p>% change in nitrate losses, P losses.</p> <p>% change in herbicide/pesticide use per unit of production.</p> <p>% change from baseline for fertilizer N consumption, soil C indices, erosion indices, soil biological properties.</p> <p>SDSN 15: NUE in food systems (FAO, IFA as lead monitoring).</p> <p>SDSN 16: Crop water productivity (tons of harvested product per unit irrigation water); FAO lead monitor.</p> <p>CCAFS: Gt CO<sub>2</sub> e yr<sup>-1</sup>.</p> <p>SDSN 79: Net GHG emissions in the Agriculture, Forest and other Land Use (AFOLU) sector (t CO<sub>2</sub> e) (UNFCC as potential lead monitoring agency).</p>

**Table 5a. Performance Indicator Table A: WHEAT SLO-level targets broken down per priority countries.**

WHEAT PIM Table A			WHEAT by CGIAR priority countries														WHEAT Other countries				Synergies with other CRPs
SIO Targets 2022 (based on SRF)	CRP 2022 target	estimated 6 YR investment \$ (core budget)	Bangladesh	India	Nepal	Ethiopia	Kenya	Rwanda	Nigeria	Tanzania	Zambia	Morocco	Pakistan	Iran	Uzbekistan	Kazakhstan	Mexico	Other countries (China, Egypt only)	Notes		
100 million more farm households have adopted improved varieties, breeds or trees, and/or improved management practices	17,500,000	36,560,281	340,000	8,000,000	330,000	2,000,000	15,000	20,000	tbd	10,000	5,000	400,000	500,000	300,000	20,000	30,000	30,000	5,500,000	CCAFS, other AFS-CRPs (companion crops; country coordination), A4NH (for Ze/Fn-rich wheat)		
1.1 30 million people, of which 50% are female, assisted to exit poverty	5,700,000	45,700,352	100,000	2,000,000	99,000	1,000,000	-	tbd	tbd	tbd	tbd	100,000	250,000	tbd			1,000	2,150,000	PIM		
1.2 Improve the rate of yield increase for major food staples from current <1% to 1.2-1.5%/year	1.40	41,130,317	1.40	1.40	1.40	1.40	1.40	1.40	tbd			1.40				1.40	1.40	1.40	Genetic Gains platform, Genebank platform, Big Data platform, WLE		
2.1 30 million more people, of which 50% are female, meeting minimum dietary energy	10,000,000	41,130,317	1,500,000	3,600,000	800,000	2,000,000						60,000	1,000,000	340,000				700,000	PIM, A4NH		
2.2 150 million more people, of which 50% are female, without deficiencies of one or more of the following essential micronutrients: iron, zinc, iodine, vitamin A, folate, and vitamin B12	via A4NH																		A4NH		
2.3 10% reduction in women of reproductive age who are consuming less than the adequate number of food groups	3,000,000	27,420,211	85,000	1,200,000	80,000	430,000	tbd	tbd	tbd	tbd	tbd	100,000	100,000				5,000	1,000,000	Other AFS-CRPs		
2.4 5% increase in water and nutrient (inorganic, biological) use efficiency in agro-ecosystems, including through recycling and reuse	5,000,000	54,840,422	100,000	1,500,000	100,000	200,000	tbd	tbd				500,000	250,000	500,000	tbd	tbd	50,000	1,800,000	WLE, CCAFS		
3.1 Reduce agriculturally-related greenhouse gas emissions by 0.2 Gt CO <sub>2</sub> -e yr <sup>-1</sup> (5%)	0.00120	31,990,246	0.00005	0.00017	0.00007	0.00087	0.00311	0.00055				0.00218					0.00088	0.00034	0.00378	CCAFS, PIM, Livestock	
3.2 55 million ha degraded land area restored	via WLE																		-	WLE	
3.3 2.5 million ha of forest saved from deforestation	175,000	13,710,106	tbd			tbd				tbd				tbd				tbd		FTA, CCAFS	
<b>Baseline or reference information</b>			World Bank \$1.25 pop	82,194,289	322,382,949	16,407,866	18,762,032	641,710	2,953,005	9,620,735	2,463,536	1,279,884	608,069	34,759,080	1,306,121	12,118,449	349,612	824,975	181,477,541		
	wheat area Mha	0.44	29.9	0.77	1.7	0.16	0.044		0.065	0.043	3.2	2.6	6.5	1.4	15	0.7					
	wheat farmers per country total	3,200,000	60,000,000	1,500,000	4,600,000	15,000	45,000				33,000	100	3,000,000	430,000	1,640,000	100,000	100,000				
	ave smallholder farmsize ha	0.5		0.9	0.5	2.5	0.7				2	1.5	1	6	4	12.7	500				
	References	RWC-CSISA/Laser Land Levelling (2014 study): 1.5M ha, 1.2M farmers (1988-2013)														2011 paper, smallholder farmers					
		Ethiopia 90% national wheat area covered w/ CGIAR-derived varieties (2014 study, 2015 global impact study)																			
		2015: project proposal to IFAD																			
																China: 24M ha wheat area, 80M farm HH, 0.3 ha ave farm size					
																China impact study (2015): CGIAR-derived varieties sown 1.815M ha, 6.05M farmers (1982-2012)					
																Egypt: 2M wheat farming HH, 0.5ha ave farmsize					

### 1.3 Impact pathway and theory of change

The WHEAT impact pathway and its associated theory of change (ToC) were developed during workshops with Flagship project teams. A participatory approach was used to capture diverse views, experiences and known evidence. The impact pathway will serve as the CRP's hypotheses of how change is expected to occur from output to outcome and impact. ToC for individual FPs are given in the respective Flagship sections.

On the basis of the Flagship projects' theories of change, the CRP will be focusing on seven sub-IDOs and six cross-cutting sub-IDOs:

- 1.1.2. Reduced production risk.
- 1.3.4. More efficient use of inputs.
- 1.4.1. Reduced pre- and post-harvest losses, including those caused by climate change.
- 1.4.2. Closed yield gaps.
- 1.4.3. Enhanced genetic gain.
- 1.4.4. Increase conservation and use of genetic resources.
- 3.2.2. Agricultural systems diversified and intensified in ways that protect soils and water.
- A.1.4. Enhanced capacity to deal with climatic risks and extremes.
- B.1.2. Technologies that reduce women's labor and energy expenditure developed and disseminated.
- B.1.3. Improved capacity of women and young people in decision-making.
- C.1.1. Increased capacity of beneficiaries to adopt research outputs.
- D.1.1. Enhanced institutional capacity of partner research organizations.
- D.1.3. Increased capacity for innovation in partner research organizations.

From these areas of focus and in line with the CGIAR Strategy and Results Framework (SRF), the CRP will contribute to reducing poverty (SLO 1), improving food and nutrition security for health (SLO2), and improving natural resource systems and ecosystem services (SLO3) by the mean of increasing resilience of the poor to climate change and other shocks (IDO 1.1), increasing income and employment (IDO 1.3), increasing productivity (IDO 1.4), enhancing benefits from ecosystem goods and services (IDO 3.2), and enhancing the cross-cutting issues of climate change (A), gender and youth (B), policies and institutions (C) and capacity development (D).

The CRP impact pathway and associated Flagship project theories of change respond and will contribute to the achievement of 8 Sustainable Development Goals outlined by the United Nations (SDGs 1, 2, 3, 5, 12, 13, 15 and 17 – as detailed in section 1.2).

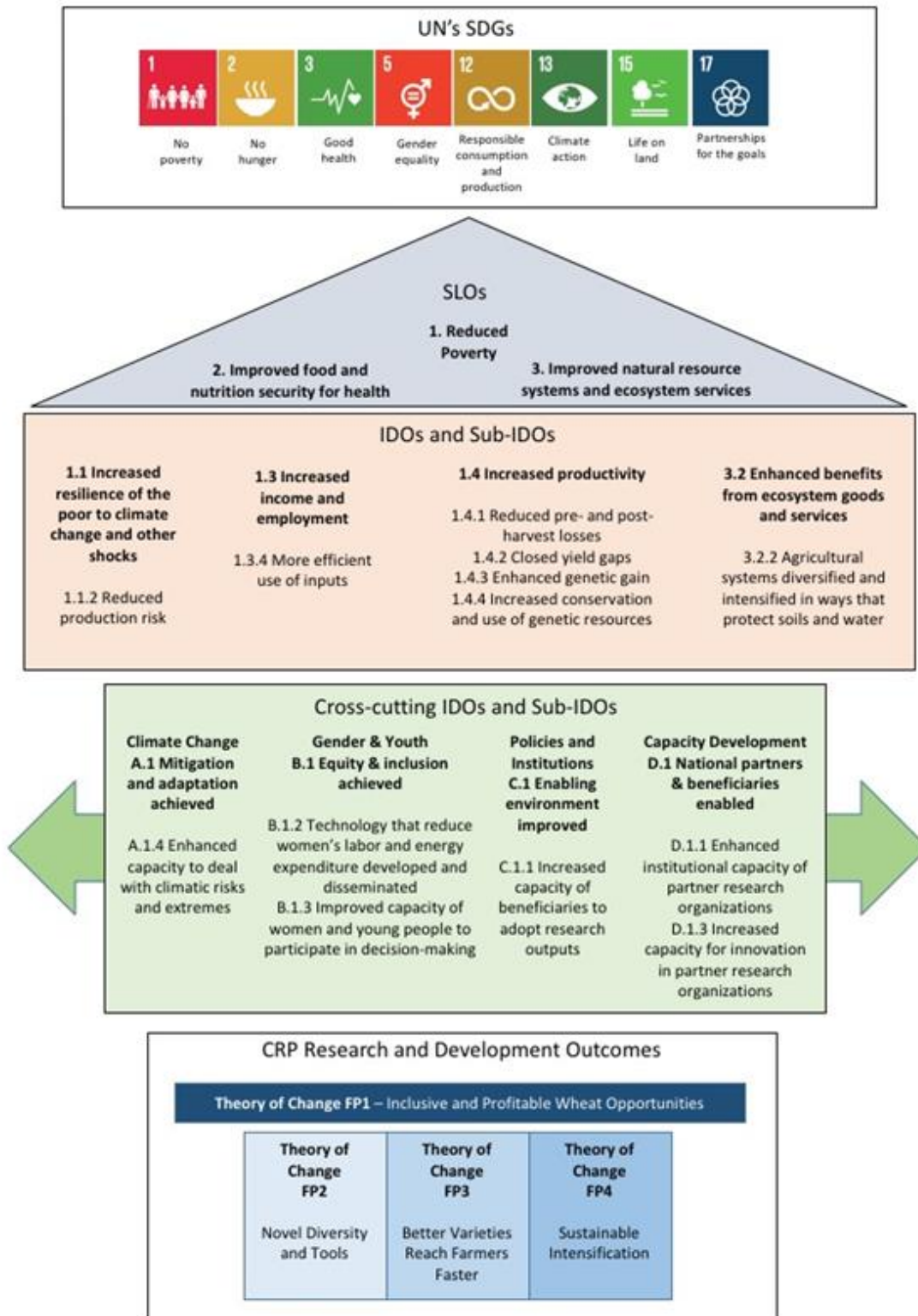


Figure 4. WHEAT Theory of Change.

## Results-based management and monitoring, evaluation, learning and impact assessment

WHEAT will develop and implement a comprehensive results-based management (RBM) framework which builds on six globally recognized RBM principles:

- A culture focused on outcomes.
- Strong leadership in RBM to model results orientation across the system.
- Participatory approaches at all levels including partners and stakeholders.
- Learning and adaptation through the use of performance information.
- Accountability and transparency where program staff are held accountable for appropriate levels of results that are acquired and reported in a transparent manner.
- Utilization-focused and flexible operational system where RBM tools, procedures and practices can be adapted based on contexts and needs.

To effectively implement the RBM framework, it will be necessary to strengthen monitoring, evaluation, learning and impact assessment (MELIA) at both project and program levels. A robust and strategic plan is proposed and will support CRP cycle of planning, budget allocation and reporting steps.

The principles listed above support the WHEAT-MC, FP and project leaders in managing risks inherent in the theory of change. The key risk categories are: a) dealing with external factors, which affect moving from outputs to outcomes, such as making the wrong assumptions or uncertainties in the assumption; b) challenges related to establishing and maintaining different kinds of partnerships essential to moving along the impact pathway. CRP Program risk management (e.g. within the CRPs' circle of direct control or influence) is described under 1.15.

Major risks driven by external factors	Likelihood	Impact
Genetic yield gains for potential yield and water-limited potential yield cannot be achieved	Medium	High
International germplasm exchange, including data, is constrained	Medium	High
Unanticipated or anticipated disease epidemic (e.g. rust, wheat blast) with global reach	Medium	High

WHEAT continues to pro-actively monitor wheat agri-food systems globally through its partner network and on-going research. Emerging threats, including severe biotic and/or abiotic stresses, are picked up in the early stages and acted upon as appropriate. For instance, the virulent Ug99 stem rust continues to receive the needed attention from WHEAT's network of global partners (Patpour et al. in press). The emergence of wheat blast outside Latin America had been predicted. Now that it has emerged early 2016 in Bangladesh and India, measures are planned and taken. For further details on the RBM framework and MELIA strategic plan, please refer to Annex 3.6.

### Impact-driven research strategies at CRP level

WHEAT pursues to complementary research strategies, or pillars, to move along the impact pathway shown above and turn the ToC into a reality for approximately 1.2 billion poor wheat consumers and producers. The pillars underlie the research program structure (see section 1.6):

## Interlinked WHEAT Flagship Projects in Phase II

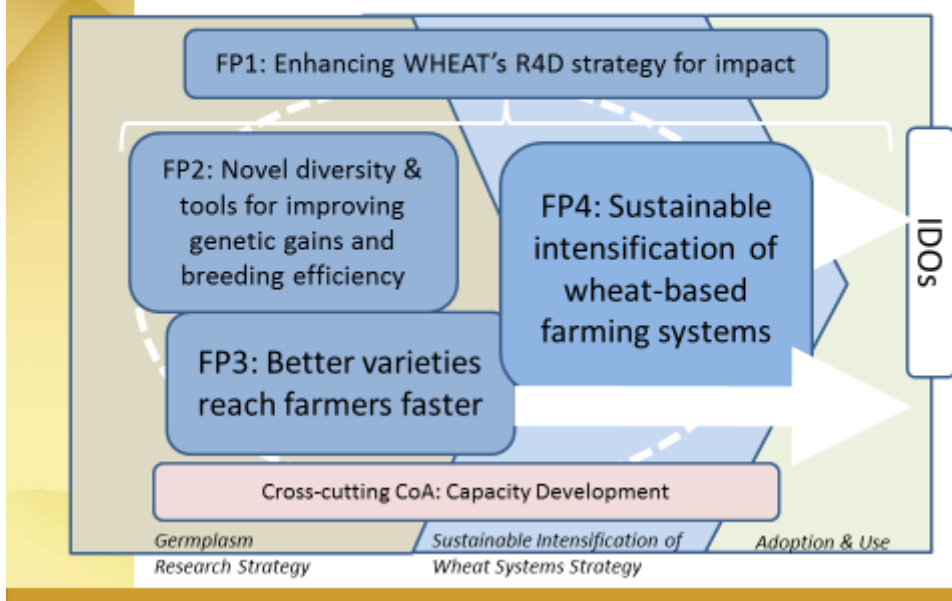


Figure 5. WHEAT research strategies matched to FPs.

### a) Germplasm pillar

Based on the comparative advantage of a global breeding platform with a global partner network that reaches basically every wheat program worldwide, WHEAT is making use of advances in science and technology through more precise phenotyping and genotyping that results in more efficient selections and shorter breeding cycles. Coupled with increased adoption rates, this will assure that farmers benefit from sustained yield increases and greater yield stability. The genetic diversity of commercially grown varieties is expanded through use of materials from other breeding programs, landraces, wheat wild relatives, and synthetic wheat (Warburton, 2006). Molecular markers are used to identify and assure genetic diversity. That is why WHEAT (FP2-3) is prioritizing:

1. Multi-ARI/NARS partner research on genomic selection for breeding, to improve precision and reduce cycle time (Review of CIMMYT Breeding Program, 2015).
2. Multi-NARS partner network of field precision phenotyping platforms for priority traits, to generate higher precision multi-location data on prioritized traits of both CGIAR and NARS germplasm. The platforms provide breeders and the seed sector earlier access to improved germplasm, allowing them to make faster gains *and* to increase the genetic diversity among varieties they select.
3. With regard to pests and diseases and prevention of losses, maintain R&D on rusts, fusarium head blight, septoria, spot blotch, tan spot, nematodes and crown rot, insects (aphids, sunn pest, Hessian Fly); develop crowd-sourcing prevention tools for other diseases and pests modeled on [rusttracker.cimmyt.org/](http://rusttracker.cimmyt.org/) and mobilize resources to fight wheat blast.
4. Greater investment in food safety and nutritional food security. FP 3 is prioritizing additional investments in R&D on wheat nutritional value and safety (see FP3.5), complementary to R&D performed by CRP AR4NH.

## **b) Sustainable intensification pillar**

The WHEAT impact target of global annual average yield gains of 1.4% (0.7% each from agronomy and genetics) can be reached only if improved wheat lines and better agronomy and precision agriculture come together on farmers' fields. "This potential cannot be realized without mechanisms to ground technology development within the specific opportunities and constraints of key agro-ecosystems (ISPC)." WHEAT prioritizes:

1. Multi-scale innovation systems research, underpinned by a robust geospatial framework that includes biophysical and socioeconomic extrapolation domains (Van Wart, 2013), for trade-off analysis at different scales to better target and prioritize interventions.
2. Innovation platforms, which bring together different actors in testing, adapting and adopting combinations of technologies, whilst mainstreaming gender into specific contexts.
3. Increased "farm power," with an emphasis on appropriate scale-mechanization.
4. Responding to repeated R&D partner feedback, WHEAT aims to invest more in capacity development, with a new CoA on capacity development around innovation and a Learning Platform.
5. Scaling out technologies.

The above priorities are aligned with the G-20 Wheat Initiative's "Strategic Research Agenda" and thus with global efforts to better coordinate national wheat research. CIMMYT and ICARDA are members in all nine expert working groups (<http://www.wheatinitiative.org/>). Table 7 in section 1.7 shows how WHEAT will manage linkages with other CRPs. For details on inter-CRP collaboration and W1&2 investments see sections 1.7, 1.8 and Annexes 3.7 and 4.3 (Tables 11 and 12).

Four interconnected Flagship Projects (Fig.4) deliver international public goods (IPG), technologies and methods adapted to local needs. The delivery mechanism for these IPGs will be driven by ToC related to FPs and partnerships (see sections 1.7, 1.8 and Annex 3.7), including by adapting research and developing concrete products. Theories will be tested, improved, used and disseminated. Partners have a key role in the research-to-development continuum and ensure feedback loops among research, development partners and users. Note that all FPs have referenced climate change-relevant sub-IDOs in their Impact Pathways and Theories of Change.

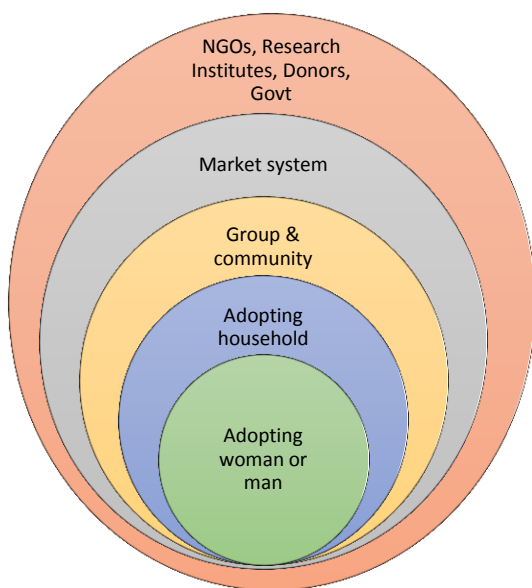
Whilst overall FP2 is the most upstream Flagship Project (e.g. new germplasm characterization and screening methods), all FPs incorporate upstream research, including translating R&D partners' and other CRPs' upstream research into developing country contexts. FP3 includes research on faster and more precise screening (e.g. remote sensing) and selection methods for breeding and adapting new methodologies to germplasm improvement. FP4 incorporates new approaches to multi-scale framework analysis, innovations at farm level (e.g. remote-sensing based farmer-decision support, precision agriculture solutions) and innovative approaches to value chain development (e.g., business models). FP1 includes strategic gender research (e.g. multi-disciplinary approaches) and impact assessment innovations (e.g. finger-printing to assess variety adoption).

WHEAT FP downstream research-for-development relies on cross-CRP collaboration and partnerships (see 1.7, 1.8). Within FP1, the focus is on site-specific understanding of farmer adoption and impacts, as well as gender mainstreaming. FP2 focuses on validation and scaling-out of new knowledge and methods to WHEAT and other researchers. FP3 focuses on partnerships to involve farmers in improved variety selection, to facilitate greater adoption over time. Applied wheat quality research targets value chain participants and consumers. FP4 focuses on systems research and innovation systems to validate a combination of solutions with first users and innovation networks to scale up / out and facilitate greater adoption.

## 1.4 Gender

### Rationale and relevance

The integration of gender and social inclusion in CRP WHEAT is guided by the WHEAT Gender Strategy (<http://wheat.org/wp-content/uploads/sites/4/2013/08/Updated-WHEAT-Gender-Strategy-2015.pdf>). Technologies are targeted to poor and mid-level farmers and consumers and increasingly to women specifically. Achieving effective targeting is complex because agricultural environments are structured a priori by gender and other relations (Fairhead & Leach 2005; Farnworth, 2010). Potential women and men adopters develop livelihoods in the midst of complex social relationships, including intra- and inter-household systems, group and community systems, market systems, and the overall policy and legislative environment - as well as within agro-ecological landscapes which are typically used in gender-



differentiated ways. Gender is a key structuring principle which intersects with other social identities such as age, caste, ethnicity etc. to create barriers and opportunities to participation in technology development, selection, adaptation and adoption processes.

Power relations at each of these levels, and between levels, affect the extent to which women and men are able to select, use and benefit from technologies. CRP WHEAT recognizes that in order to design and undertake agricultural R4D that is both technically and socially robust, it is necessary to understand and take into account how agri-food systems operate across different social enabling environments.

### Relevance of Gender for Wheat R4D

Gender in wheat-based systems has been weakly researched. Gender analysis and strategic gender research generated by CRP WHEAT is therefore capable of creating the basis for a large leap in understanding and for providing empirical, grounded information for gender-equitable project development. This is essential for moving towards achieving the IDOs and sub-IDOS on Gender and Inclusive Development in the large parts of the world which grow wheat yet are simultaneously characterized by strongly gender-unequal societies. Emerging findings from research conducted in Phase I will be built on and developed in Phase II to understand how gender affects vulnerability, risk management and coping strategies, technology adoption, and project outcomes in wheat-based systems. Selected recent findings emerging from WHEAT Phase I and other research (including, as relevant, on other crops in wheat areas) are summarized in Annex 3.4.

### Gender in WHEAT Phase II

Priority areas for gender research in Phase II encompass:

- Technology development and dissemination: trait preferences — e.g., related to labor and input savings, risk reduction, nutrition and processing qualities — based on downstream research.

- Technology diffusion and adoption: promoting access to information; strengthening bargaining and decision making capacity; creating favorable and inclusive enabling environments and value chains.
- Gender research and analysis will be included in technical research; e.g., socioeconomic surveys and wheat breeding, to capture differences in the perspectives and assets of male and female farmers with different socio-cultural and socio-economic characteristics and ages. Information will be fed into technology and policy development processes. Gender research on strategic issues will broaden and deepen the knowledge base on gender in wheat-based farming. This will inform other research themes, as well as overall priority setting and targeting.

Ongoing research continued under Phase II shall include:

*GENNOVATE*: Phase II will focus on analyzing the vast data base now generated. WHEAT will develop synthesis reports, journal papers and other user-orientated data. Findings are expected to strengthen the contextually grounded systems approaches needed for the design and roll-out of equitable and efficient wheat agri-food system innovations. The reports and publications based on this work, as well as the study methodology, will fill an important gap in the existing gender and wheat-based systems literature and contribute to CRP WHEAT's strategic planning of Phase II by: (1) enhancing the gender responsiveness of targeting, priority setting and theories of change; (2) advancing gender transformative outcomes of wheat research and development interventions at scale; (3) building the evidence base and actions to address the role of gender norms in relation to adoption of improved wheat technologies and related development processes.

*Understanding gender in wheat-based livelihoods for enhanced WHEAT R4D Impact in Afghanistan, Pakistan and Ethiopia*: The goal of this project is to contribute to reduction in rural poverty (SLO1) and increased food security (SLO2) by shaping and targeting research and development activities related to wheat in ways that increase the empowerment of disadvantaged groups, in particular poor women and youth in wheat-based systems. The project purpose is to assist WHEAT research and development partners to appreciate gender integration and social inclusion as an opportunity to enhance impact, and use the project's outputs to strengthen the integration of gender and social inclusion in wheat technology development, adaptation and diffusion. The project will deliver the following outputs: (1) Scoping studies: Situation analysis with regards to gender and social equity perspectives in wheat R4D; (2) Case studies: Gender norms and agency in wheat based systems and livelihoods; (3) 'Reverse-engineering' studies: Analysis of successful integration of gender in agricultural R&D interventions; (4) Analytical overview: Opportunities for strengthening gender integration in wheat R&D; (5) Validation workshops: Collaborative analysis with stakeholders at local and national levels; (6) Publications: Open access research papers, policy briefs and guidelines; (7) Capacity building workshops; (8) Training key partners on findings and guidelines.

*Sustainable Intensification (SI) in wheat-based systems*: The SI program will work with value chain actors (farmers, extension staff, private sector) to create equitable market access. SI knowledge/technology portfolios differentiated for gender, youth, and resource-poor communities will be developed. A second component will focus on integrating crop-livestock systems to promote multi-functional climate-smart farming systems. This will include nutrition. A third component will research and model the implications of gender-asset gaps for intra-household food security, technology adoption, and market participation.

*Enabling Environment in South Asia*: Develop strategies and cross-project approaches to improve interaction between gender and agricultural research actors. A Scoping Study commissioned by WHEAT on the Integration of Gender and Social Equity in R4D on Wheat-Based Systems in South Asia (Jafry

2013) noted that many entities with capacity to address gender and social equity in agriculture exist, but there is little interaction between these and national wheat research systems (ibid).

### **Two-pronged approach to implementing the WHEAT Gender Strategy**

The WHEAT Gender Strategy outlines the process and approaches that WHEAT continues to adopt and adapt in order to contribute to and promote gender equality in agricultural R4D related to wheat-based systems. The objective of the strategy is to strengthen the capacity to address issues of gender and social differentiation in wheat R4D and ensure that interventions do not exacerbate existing gender disparities, but instead contribute to improved gender equality and transformation of unequal gender norms and rights wherever possible. It therefore supports the SRF gender IDO by actively working towards equity and social inclusion with, in Phase II, a stronger focus on youth inclusion. The integration of gender in WHEAT is conceived as a process of continual improvement, in which research design and practice, and research management frameworks and procedures are designed to complement and reinforce each other. The Gender Strategy is implemented through

- a. Strategic gender research and analysis, which informs WHEAT research priorities.
- b. Mainstreaming gender research into ongoing and future projects under the different FPs, while incorporating gender research into institutional frameworks, in particular the project cycle (e.g. program and project planning) and monitoring, evaluation, and learning and impact assessment (MELIA; see annex 3.4. Tracking and evaluating progress).

### **Strategic gender research and analysis**

The concept of gender is used as an analytical tool to strengthen the relevance and targeting of R4D under WHEAT and enhance development impacts, through gender analysis as part of other technical research, complemented by gender research on strategic issues to further expand the knowledge base.

Emerging findings from Phase I and planned research in Phase II will allow WHEAT to define entry points for working towards achievement of the Gender and Youth IDO and associated sub-IDOs. For example, technologies expected to reduce women's labor will be disseminated in the understanding that achieving this sub-IDO can only work if complementary work is undertaken on other sub-IDOs, in particular improving the capacity of women and young people to participate in decision-making at intra-household and community levels.

WHEAT's gender and social inclusion will strengthen broader technology and policy development processes. Work undertaken under CIMMYT-CCAFS will contribute towards taking gender to scale in mitigation and adaptation work. At the macro-level WHEAT aims to help create gender-responsive agricultural policy environments. It will move towards this by stimulating the institutional capacity of partner research and development organizations to conduct gender and socially inclusive R4D and to develop national and local level implementation strategies. This should assist these partners to build the ability of end users to engage effectively in innovation processes and to adopt WHEAT research outputs. This multi-level, cross-cutting work is central to taking gender and social inclusion to scale in WHEAT's work. Special attention will be paid to improving WHEAT work on youth inclusion in Phase II within the Gender and Youth IDO, and through stimulating partner capacity in relation to other IDOs.

This work will be underpinned by gender research on strategic issues to further expand the knowledge base on gender in relation to wheat-based farming and livelihoods. Six guiding categories of research questions are provided here. Each FP and associated scientists and partners are expected to develop their specific questions for Phase II work:

1. How do women and men farmers' roles, resources, constraints and priorities differ in wheat-based production systems? What are the implications of this, e.g. for technology development and diffusion?
2. How do gender relations and access to resources influence men's and women's adoption of new wheat technologies? And how does the introduction of new technologies influence gender relations?
3. How can we ensure that the introduction of improved wheat technologies benefits both men and women?
4. What is the capacity for gender responsive technology generation and dissemination of R&D partners, including advisory services, input- and service providers, and seed enterprises?
5. What are the gendered impacts of wheat R4D; who benefits, and how?
6. Mainstreaming gender research into ongoing and future programs and projects.

The WHEAT Gender Strategy sets an ambitious agenda in terms of the integration of gender analysis and gender research perspectives in each WHEAT Flagship Project. Its vision is that gender, social inclusion and poverty lenses are systematically applied to all WHEAT's major innovation pipelines and assessments. The growing WHEAT gender, youth and poverty-differentiated knowledge base will thus support differentiated recommendations on choice of interventions and scaling out strategies that support social inclusion and greater empowerment of women and youth within wheat value chains.

As WHEAT continues to strengthen its institutional gender expertise within its network of implementing partners its work will expand to encompass the full R4D portfolio. The gender-responsive objectives for each of the five FPs are:

**Table 6. Gender-response objectives per Flagship Project.**

FP1	To strengthen the evidence base on gender in wheat-based systems and livelihoods; and ensure that foresight and targeting, adoption- and impact studies, as well as wheat related value chain development interventions, are informed by a gender and social inclusion perspective.
Fp2	To ensure that perspectives of male and female end users are taken into account in up-stream targeting and decision making.
FP3	Understanding gender differentiated preferences/constraints in relation to specific traits in wheat germplasm, and the implications hereof in relation to priority setting and targeting of wheat breeding strategies.
FP4	To ensure that sustainable intensification of wheat-based systems and livelihoods take gender- and social disparities into account and delivers positive benefits to both men and women of different social groups.

For further information on prioritization, planned methodologies and FP specific gender research questions, see the gender sections per FP and in annex 3.4.

**Incorporating the gender research dimension in institutional frameworks**

Gender will be mainstreamed into all relevant WHEAT research development, implementation and evaluation processes (e.g. the project lifecycle), from gender-responsive R4D project design to accountability for gender-responsive outcomes.

Strong attention will be paid to managing iterative research processes. As results and lessons learnt with respect to gender are generated, they will be fed back into FP and CRP learning processes, thus contributing to the further development and calibration of the programmatic and institutional frameworks. In turn this will inform the next generation of research projects and FP implementation. For more detail, see Annex 3.4

## Budget / Investment

Apart from maintaining the core team (FP1.3) with support from BMZ (CIM), linked to gender specialists in several bilaterally funded projects, the top investment priorities are: Attracting funding for strategic research projects building on GENNOVATE, whilst building a critical mass of gender scientists (e.g. cohort of PhD students with Wageningen University - uplift budget); increasing the budget for gender mainstreaming (e.g. building capacity among a greater number of researchers) and integrating gender into the new scaling-out partnerships under FP4.4 (uplift budget).

### 1.5 Youth

WHEAT approaches youth as an integral constituent of our understanding of gender. Gender as a relational concept intersects with other social identities, including youth. As such, gender and youth are not mutually exclusive, but often overlap, depending on the specific context, situation and parties involved. In WHEAT the approach to gender is informed by the concept of social heterogeneity, e.g., men and women, boys and girls, belonging to different social or ethnic groups, different ages, etc., experiencing different combinations of social identities and positionalities. As such, in WHEAT gender research in principle also includes consideration of young men and women. Youth-*focused* research, on the other hand, centers on young men and young women.

With increased focus on the role of youth in relation to agri-food systems development, in phase II WHEAT will seek to progressively address youth-focused research questions, e.g., on employment opportunities along the wheat value chain and how to better link R4D to new business models. In 2016 and the first stage of phase II, WHEAT will develop a strategic framework for its engagement with young people and youth-related issues, as well as implement key standards for age-disaggregation in data collection and analysis. Furthermore, in the course of time, WHEAT will combine bottom-up and top-down approaches. The rationale and overall approach for how WHEAT will address youth in its research is outlined in Annex 3.5. We thank YPARD-KIT for their review and suggestions for strategy development.

## 1.6 Program structure and flagship projects

Section 1.1 and 1.3 introduced the two research strategies underpinning the WHEAT program structure, as well as the research priorities under each pillar and the mix of upstream and downstream research. The Flagship Projects (Figures 5, 7) comprise the following Clusters of Activity (for more detail, see section 2 on FPs).

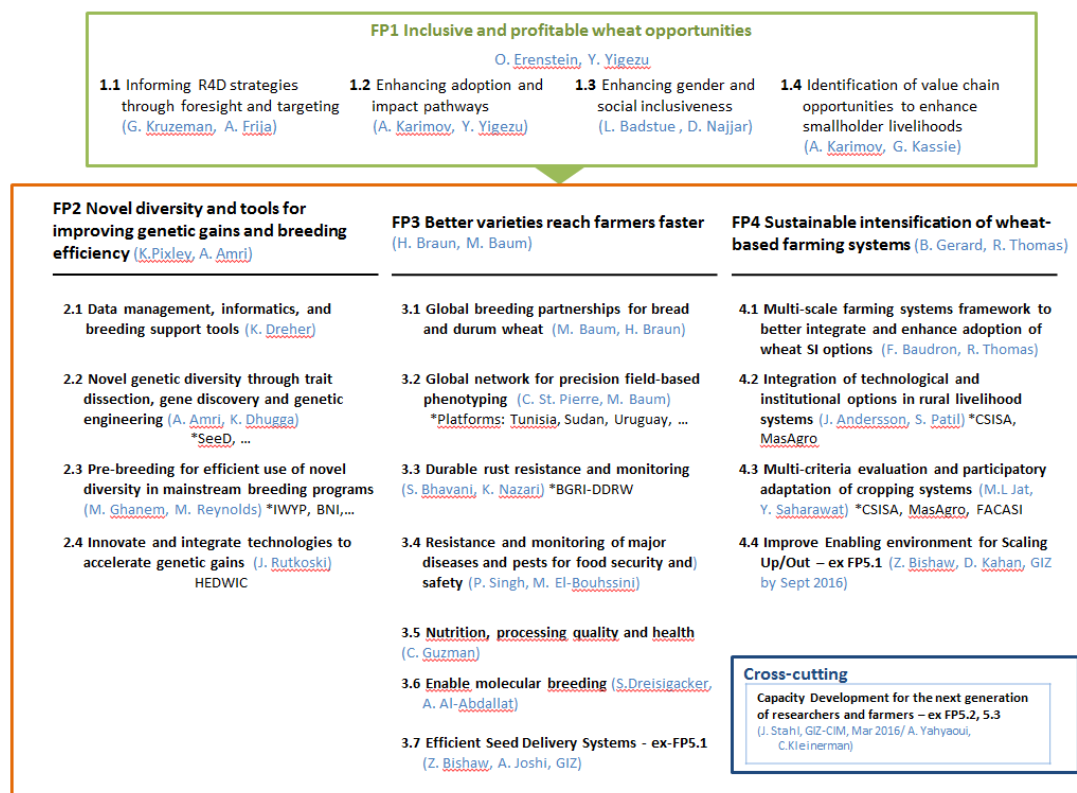


Figure 7. WHEAT FP, clusters of activity and docking stations (aligned with AFS-CRPs FP structure).

### Key outputs delivered by the FPs

**FP1. Enhancing WHEAT's R4D strategy for impact** guides all other FPs by focusing on the prioritization and targeting of AR4D interventions for the greatest impact among resource-poor farmers and consumers, including with regard to gender equity and social inclusion.

FP1's overall aim is to maximize value for money for WHEAT as a whole, by providing an evidence base to target and guide research investments. FP1 produces four types of outputs:

1. WHEAT's AR4D strategy underpinned with better foresight and targeting.
2. Key lessons about WHEAT's interventions that can be used in future work.
3. Enhanced gender and social inclusiveness in WHEAT's portfolio of research and in its impacts.
4. Wheat value chain opportunities identified to enhance smallholder livelihoods.

**FP2. Novel diversity and tools** focuses on bringing useful genetic diversity into wheat using new tools and approaches for understanding genes and traits. FP2 produces four types of outputs:

1. Tools for data management, data stewardship (including open access), and data mining or analysis; to enhance breeding efficiency that results in faster genetic gains.
2. Knowledge from key trait dissection and novel genetic diversity for key traits, by delving into the physiology of the wheat plant to identify key traits associated with increasing yield potential and adaptation to climate change. This research builds on the “mined” genomic diversity and is passed onto breeders.
3. Bridging germplasm that incorporates novel diversity for key traits in adapted backgrounds, providing the building blocks to breeding programs of key-trait-enriched germplasm. Novel genetic diversity can thus be transferred into elite lines and varieties.
4. Tools and support for the optimal application of breeding technologies to accelerate genetic gain. Key breeding technologies include genomic selection and high-throughput phenotyping.

**FP3. Better varieties reach farmers faster** aims to funnel the targeting evidence generated in FP1, the novel genetic diversity unlocked in FP2, and the agronomic improvements developed in FP4 into a wheat variety-generating engine that delivers higher yields and more biotic and abiotic stress resistant wheat to farmers and with appropriate processing and end-use characteristics. Key outputs will be:

1. Novel and scaled-out use of precise phenotyping approaches, protocols, and screening tools, leading to faster progress in yield and other desirable traits.
2. Wheat lines with better drought and heat tolerance and salinity tolerance in irrigated areas.
3. Better rust and other disease tracking, identification, characterization and use of new resistance genes that result in durable resistance of lines distributed in international wheat nurseries.
4. Biofortified wheat with enhanced iron (Fe) and zinc (Zn) grain concentration and bioavailability in wholegrain and white flour (**in collaboration with CRP A4NH**), and processing quality traits integrated in the breeding program.
5. Integration of a cost-effective molecular breeding platform at CGIAR centers and in national programs. A single low cost SNP platform will be adopted, and relevant markers converted.
6. Mechanisms and strategic partnerships that enable farmer-preferred varieties to reach smallholder farmers in the shortest possible time.
7. More efficient, gender-responsive seed targeting and delivery systems.

**FP4. Sustainable intensification of wheat-based farming systems** will result in a better understanding of those systems to develop comprehensive, climate-smart best- and component-management practices. FP4 incorporates GxExM interactions to supply viable solutions for impending productivity challenges, co-developed with farmers and other stakeholders. Key outputs include:

1. Improved conservation and precision agriculture methods at multiple scales to reduce farmers’ production costs and conserve resources, including labor, energy, fuel, soils, and time.
2. Crop management practices backed by appropriate genotypes to confer improved heat tolerance, nitrogen, and water use efficiency, as these issues are projected to have the greatest impact on global wheat yields by 2050.
3. Participatory approaches to adapt and integrate technological components of sustainable intensification and crop diversification.

4. Better understanding of adoption, adaptation, innovation and scaling processes and the interactions between technologies, organizational and institutional settings along with wheat agri-food systems.
5. Improved capacity and enabling environment for adoption of sustainable intensification options, and expanded and enhanced capacity development for the next generation of researchers and farmers (collaborations for enhanced scaling out; GIZ).

FP4 embraces systems approaches embedding the social, political and biophysical diversity at the farm and landscape scales to prioritize investments responding to key constraints. FP4 focuses on gender-responsive research outputs enabling farmers to close wheat crop and farm-level yield gaps, contributing to household food and income security, enhanced livelihoods and regional food availability and price stability. Primary beneficiaries and co-innovators include poorer households in systems where wheat is a major contributor to rural livelihoods, either for food or income security, in addition to other crops, livestock, and off-farm work.

**The cross-cutting Cluster on Capacity Development** will support NARS partners in selected countries in realizing a comprehensive capacity development assessment, maintain and expand international training programs that cut across all FP scientific domains and (co)lead on the design and implementation of a WHEAT Learning Platform. This CoA will work together with FP4 on developing approaches to simultaneously increase the ‘capacity to innovate’ in all components of an innovation system.

**Climate change.** All WHEAT FPs have referenced Climate Change-relevant sub-IDOs in their Theories of Change. In addition, FP3 is committed to achieving outcomes under *1.4.1 Reduced pre- and post-harvest losses, including those caused by climate change*; and both FP3&4 under *A.1.4 Enhanced capacity to deal with climatic risks and extremes*. WHEAT and CCAFS will collaborate on four key questions:

1. How can genotypic responses to climate be better understood through use of current and future crop and climate databases and modeling tools?
2. What are the predictable aspects of climate that need to be taken into account when breeding for future climates?
3. How can previous research and breeding efforts accelerate rapid adaptation of cropping systems in climate vulnerable hotspots?
4. What WHEAT SI practices and technologies work where, for whom and by which efficiency?

Promising climate-resilient material will be evaluated more intensely in climate vulnerable sites, such as CCAFS climate smart villages in Asia and Africa, among others, where outputs together with other FP4-driven management practices will be evaluated under a climate lens. WHEAT and CCAFS data and tools will support the evaluation of technologies, which enhance resilience to climate variability and extremes, mitigation of GHG emissions and associated costs. CCAFS, together with WHEAT and other AFS-CRPs, will also examine the role of fertilisers, particularly nitrogen, in achieving the CSA targets. For more detail, see Annex 3.7. **The key Big Data** opportunities and deliverables per FP are shown in Table 7 in the next section.

## 1.7 Cross CRP collaboration including country collaboration

The key give and takes of WHEAT collaboration with other CRPs, the baseline for collaboration with the Big Data Platform and the approach to country coordination are described below. In annex 3.7, CRP-with-CRP and multi-CRP collaborations are detailed in Table 37-1a and 37-1b.

**Table 7. Give and take of inter-CRP collaboration from WHEAT's perspective (Provides = P / Receives = R).**

WHEAT (Per FP)	FP1	FP2	FP3	FP4
Generic AFS-CRP FPs	Targeting and prioritizing, value chains, gender	Germplasm improvement from novel traits, methods to breeding to seed systems		Sustainable intensification, systems research, scaling out
Genebank Platform		R: Genetic diversity for traits research. P: New knowledge, data per accession. P&R: Enable greater global use of PGRFA by researchers, ensure international germplasm exchange.		
Genetic Gains Platform		R: Bio-informatics, big data, high-throughput genotyping services (faster, better, cheaper; used by several, all AFS-CRPs); get advice on broad range of approaches for increasing breeding efficiency.		
	WHEAT will become a member of the Genetic Gains and Genebanks Platforms and participate in managing Platform components and abide by the obligations of AFS-CRP members as described in their Full Proposals (e.g. Genetic Gains Platform proposal, p.18).			
IBP (ex-GCP)		P&R: Use, improve Breeding Mgmt System		
(Other) AFS-CRPs	P&R: Shared MEL methods, tools, data. See also PIM below	P&R: Approaches to accelerated breeding cycle, varieties release and seed scale-up; precision phenotyping methods and sites co-use.		P&R: Innovations tested, integrated at common innovation platforms, incl for companion and full purpose crops; learning on 'capacity to innovate', scaling out.
GI-CRPs				
Climate Change, WLE	P&R: Improved foresight modeling, targeting (with other AFS-CRPs, WLE, PIM). R: Global level policy influencing. R: Land mgmt analysis, targeting.	R: Heat, drought, other trait improved germplasm, data. P: Model impact on climate change.	P&R: CSA Villages to test climate smart varieties.	R: Models and tools; pro-CSA policy. P: CSA technologies & data, long-term experiments; pilots at innovation platforms incl CSA Villages. R: Water, irrigation & erosion mgmt adaptable solutions. P: Impact data.
Nutrition & Health	P&R: Drivers, trends of staples consumption & price, food systems; joint impact assessment (biofortified crops).		P: New knowledge on food safety, nutritional, health quality, biofortified breeding.	P&R: Collaborate on NARS technology adoption; add nutritional value to value chains, diet diversification.
Policies, Innovations, Markets	P&R: Value chain research methods, tools, cross-CRP learning.		R: Seed systems analysis approaches. P: Cross-CRP learning.	R: Adapt methods, capacity development for building multi-crop value chains.
	R: Gender foresight, strategic research tools. P: New knowledge, data for inter-CRP learning.			R: Knowledge, approaches for farmer organization dynamics, mechanization benefits, trade-offs (multi-country level).
Major non-CGIAR regional, international programs	Int'l agri/crop modeling initiatives; 3ie impact assessment program.	G 20 Wheat Initiative, wheat data interoperability (RDA), major national and international R&D programs and consortia (e.g. WISP, BreedWheat, etc.).		FeedAfrica (AfDB), 4p1000 (INRA, CGIAR MoU), IntensAfrica (EU), major agri/rural development projects (e.g. GIZ portfolio of 1,500 projects; IFAD country programs, etc.).

## Big open data across WHEAT Flagships and the Big Data Platform

Recent advances in technology provide agricultural research with new tools which, if used efficiently, will accelerate research, development, and release of new wheat varieties required to fill the food gap and counter the impacts of climate change. High-throughput genotyping and phenotyping platforms, remote sensing and geo-informatics serve as examples; they generate large numbers of high volume and highly heterogeneous datasets, which accumulate over years. These datasets are usually fragmented and need to be compiled and made available as a global public good. The challenge ahead is how to store, curate, search, transfer, visualize, and analyze such “big data.” Table 8 provides an overview of major projects and collaborations per FP, which represent the basis for WHEAT collaboration with the new Big Data Platform.

**Table 8. Overview of big data activities and partners outside the CGIAR, per FP.**

	FP1	FP2	FP3	FP4
<b>Data collection and generation</b>	Household surveys; geo-referenced data for crop prod., weather, poverty, nutrition, markets.	Genotype and phenotype accessions; high-volume weather data for GxE simulations; remote sensing for precision phenotyping.	Co-operator multi-location data; molecular analysis; remote sensing genomics data for genomic selection.	Remote sensing for field productivity; sustainability data; farm-level diagnosis and input recommendations.
<b>Data analysis</b>	Priority setting based on: Risk-benefit analyses; predicted climates; geographic definition of impact opportunities.	WHEAT focal point FP2.1 & 2.4; Gene discovery and allele mining; models for implementation of GS; integration of genomics and phenomics into selection models incl. remote sensing.  Link data to efficient mining of genetic resources for priority traits.	Implementation of genomic selection; conversion of image data into selection criteria for yield trials.	Rapid capture and conversion of remote image data, integration with economic models to develop recommendations.
<b>Data standards</b>	Apply CGIAR OA Guidelines, CIMMYT and ICARDA Data Management Policies and practices (e.g. OA storage of raw research data on Dataverse repositories, Genesys & GRIN-Global for gene bank material Germinate to integrate genotypic and phenotypic data); maintain global wheat genetic resources DB			
<b>WHEAT-led projects</b>	Rustracker.cimmyt.org,	Seeds of Discovery, HeDWIC, IWYP, FIGS-GRDC	IWIN, Precision Phenotyping Platforms; Wheat Atlas; Wheat pedigrees Common SNP Platform	MasAgro,
<b>Coordination &amp; collaboration with non-CGIAR-led initiatives</b>	InStEPP (University of Minnesota), CCAFS	RDA, Wheat Initiative (Wheatual), DivSeek, GOBII, DArT, Kansas SU., Cornell Univ.	RDA, Wheat Initiative (Wheatual); Cornell Uni, Kansas SU	Global, regional farming systems and climate change models

## Country Collaboration (site integration)

WHEAT commitment and priorities with regard to country coordination focus on Bangladesh, Ethiopia and Nigeria. WHEAT scientists have participated or co-led initial consultations with national partners in Bangladesh, Ethiopia, India, Kenya, Nepal, Nigeria and Tanzania.

WHEAT proposes a flexible and partner/demand-driven approach to country coordination. The coordination effort can focus on CRPs and their partners or on more complex issues (e.g. policy change) involving partners outside the Centers' circle of influence:

- Bottom-up, identify opportunities for and develop joint activities to
  - Exchange of research knowledge, know-how and data and on that basis define joint R4D activities or projects.
  - Align their partner engagements and exchange information about partner relationships.
  - Link or co-locate intervention sites, with their project staff activities.
  
- Top-down, with national partners, identify opportunities and joint efforts to
  - Exchange information about national approaches and plans to Sustainable Development Goals implementation related to the CGIAR SRF and targets, including Monitoring, Evaluation and Learning.
  - Establish or improve coordination mechanisms
  - Establish new linkages to relevant national programs, including those focused on gender, youth, capacity development, as well as the domains of the Global Integrating CRPs on nutrition and health, climate change and policies, innovation and markets.
  - Develop new initiatives with inter-CRP participation and dedicated partner funding (whatever source).

Most important of all is the national partners' commitment to co-invest in such coordination and follow-up. WHEAT anticipates that its Coordinators in high priority Country Coordination undertakings will invest about 20% of their time on coordination and communications activities, which will need to be funded by W1&2. Lead Coordinators among CRPs/Centers will have to invest more.

In Annex 3.7, Table 37-3 describes which Country Coordination countries are priority for WHEAT, intended scope of engagement and opportunities for inter-CRP collaboration, as well as additional countries for 'bottom-up' Country Coordination with interested CRPs. Table 37-4 provides more detail.

## 1.8 Partnerships and comparative advantage

WHEAT's ability to interact effectively among ARI, CRP and NARS partners has been demonstrated during the last five decades and ultimately defines its success as a provider of public goods for resource-poor wheat farmers and consumers. Its global partners' network is unparalleled and essential for addressing cross-border challenges, co-developing and disseminating International Public Goods and thus maintain the WHEAT comparative advantage (see Table 10). The ILAC-led 'Analysis of the portfolio of activities and networks of WHEAT' (draft report, March 2015) states that WHEAT has "enabled stronger connections with "downstream" partners, but these collaborations are still few in number", whilst at the same time WHEAT has "slightly strengthened (that) orientation" of strong links with the international research community.

During Phase II, WHEAT will

- Co-invest in stronger collaboration with a select group of NARS (e.g. precision phenotyping platforms network), whilst maintaining its global NARS partner networks.
- Experiment with new kinds of partnership for greater impact. Inter-CRP collaboration, including on country coordination, the new GIZ partnership on scaling out and better understanding of drivers of change (research on scaling out) come together here.

- Contribute to better aligning national and multi-national wheat research, where needed and feasible, chiefly through the G-20 Wheat Initiative.

Between 20 and 30% of the total WHEAT budget will continue to be allocated to non-CGIAR research and development partners. In addition, several major bilaterally funded projects under, or aligned with WHEAT, integrate expertise from many ARIs with NARS partners. WHEAT will attempt to better track non-CGIAR partners' in-kind and financial investments directly related to collaboration with WHEAT.

The most important partnerships by FP are shown in Table 8a below, whilst WHEAT strategic partners are listed in Table 8b. At annex 3.2, Table 32-1 describes the different types of partnerships along the continuum from discovery of new knowledge to achievement of systemic change. Table 32-2 describes the mix of (co)-funding approaches and modalities used, to accommodate different partnership purposes and partner co-funding ability. Partners' involvement in shaping WHEAT strategy and contributing to Phase II proposal development (e.g. GCARD3) is described in Annex 3.2.

**Engagement with the private sector:** Wheat-related research remains overwhelmingly in the public sector, though in recent years, private sector engagement has increased in developed countries. WHEAT engages with this sector by:

1. Performing joint and commissioned research, such as on wheat hybrids, marker development, conservation agriculture and fertilizer regimes.
2. Co-developing business models for appropriate-scale mechanization solutions.
3. Working with seed companies to disseminate improved varieties for adoption by farmers.
4. Through further capacity development and knowledge-sharing capacity; for example, the Borlaug Foundation for Training, with private sector contributions; sponsorship of conferences and awards, such as the Jeanie Borlaug Laube Women in Triticum (WIT) Early Career Award.
5. Engaging private sector wheat agri-food system actors through innovation hubs (e.g. CSISA, AIP, and MasAgro).

Table 9a. Key partners and CRP collaborations on each flagship project.

FP1	FP2	FP3
<b>Key partners</b>		
<p><b>NARS</b> (e.g. EIAR, ASARECA, U Pretoria, ICAR, WOCAN, <u>Grameen</u>): Research co-implementation, including context-specific knowledge, expertise and policy linkages</p> <p><b>ARIs</b> (e.g. U. of Minnesota, U of Florida, WUR, IDS): Foresight, modelling, youth</p> <p>International: CBD, ITPGRA, WIPO, TRIPS</p>	<p><b>NARS</b> (e.g. ICAR, CAAS, EMBRAPA, TAGEM): Data and germplasm exchange, joint and competitive grant research</p> <p><b>ARIs</b>, (e.g. CSIRO, ACPFG, Cornell, IPK, JHI, JIRCAS, Lancaster U., JIC, NIAB, <u>Nottingham Uni</u>): joint research, OS-software development, big data, genotyping services; biological nitrification inhibition</p> <p><b>Private sector</b> (<u>DARt</u>, <u>TraitGenetics</u>, <u>ARCADIA-US</u>): Genotyping services, marker development</p> <p>G20 Wheat Initiative (various expert working groups)</p>	<p><b>NARS</b> (e.g. INIA-UY, <u>ARC-Sud</u>, ARC-ET, CAAS-CHN, EIAR-ETH, ICAR-IND, KALRO-KEN, INRA-MOR, INIFAP-MEX, IRESA-TUN, MAIL-AFG, PARC-PAK, SPII-IRN, TAGEM-TUR): multi-location phenotyping, germplasm and data exchange, joint and competitive grant research</p> <p><b>ARIs</b> (e.g. <u>Aus</u>: PBI; CSIRO, CDN: CWA, <u>Uni Saskatchewan</u>); US: KSU, Cornell, Nebraska, UC-Davis, USDA-ARS, D: JKI IPK, F: INRA, GB: <u>Rothamsted</u>, JIC DK: Aarhus,, E: <u>Uni Barcelona</u></p> <p><b>Private sector</b> (<u>Syngenta</u>, <u>Limagrain</u>, <u>KWS</u>, <u>Mahyco</u>, <u>BAYER</u>): Inputs R&amp;D, hybrids</p> <p><b>Regional, int'l coordination</b>: ASARECA, CGARD, CCARDESA, APAARI, CACAARI, PROCISUR, G20 Wheat Initiative</p>
<b>Inter-CRP integration</b>		
<p><b>PIM</b> Foresight, impact assessment, value chain <u>analysis</u>, <u>Gender Platform</u>, Inter-CRP learning, M&amp;E, strategic research projects</p> <p><b>CCAFS</b> <u>Modeling</u>, impact assessment</p> <p><b>A4NH</b> Food systems</p>	<p><b>CCAFS</b> Identify climate vulnerable ecologies (physical and socio-economic); Climate-proof Wheat Consortium: Identify resistant genes needed on-farm in 25 years</p> <p><b>Genebanks</b> Mine accessions including wild relatives for priority traits (GCDT)</p> <p><b>MAIZE, other AFS-CRPs</b> Pre-breeding approaches</p> <p><b>Big Data and Genetic Gains Platforms</b> Data standards, interoperability, BMS, GOBII</p>	<p><b>AFS-CRPs</b> Precision phenotyping platforms, Companion crops in wheat-based systems, breeding approaches, dual-purpose crops/livestock</p> <p><b>A4NH, Gender Platform</b> Harvest+, Healthy Wheat, value chains, women farmers/consumer empowerment (PVS, gendered traits)</p> <p><b>Big Data and Genetic Gains Platforms</b> GOBII, molecular breeding data standards, access</p>
FP4		FP3.7 & FP4.4 (scaling out)
<b>Key partners</b>		
<p><b>NARES</b> (e.g. ICAR, IPNI, KALRO, SAGARPA, <u>Borlaug Institute for South Asia (BISA)</u>): Co-implement programs, projects</p> <p><b>ARIs</b> (e.g. ORNL, WUR, <u>Quantalab</u>, UC Davis): Remote sensing, <u>modeling</u>, decision support tool development, crop monitoring</p> <p><b>Private sector</b> (e.g. ACI Ltd, <u>National Agri Industries</u>): Mechanization, irrigation solutions, seed sector</p>	<p><b>NARES incl. NGOs, CSOs, business associations, platforms</b> (e.g. <u>IDE</u>, BRAC, RUFORUM): Seed SME systems and scaling-out project partners; capacity development (cap dev) needs assess; WHEAT Learning Platform</p> <p><b>Universities, ARIs, e-learning companies</b>: Learning (channel) providers, M&amp;E partners</p> <p><b>Regional coordination</b>: see FP3</p> <p><b>Private sector</b> (see FP4): scaling out partners</p>	
<b>Inter-CRP integration</b>		
<p><b>MAIZE, DCL, other AFS-Systems</b> Systems research integration into WHEAT, shared models, approaches, <u>iSAMG</u></p> <p><b>CCAFS</b> Climate-smart technologies validation and scaling-out</p> <p><b>PIM</b> Value chain development (precision <u>agri</u>, mechanization)</p> <p><b>WLE</b>: Soil, water conservation at landscape scale; site sharing Bangladesh</p>	<p><b>PIM, other AFS-CRPs</b> Seed systems development</p> <p><b>MAIZE, DCL, WLE</b> Joint cap dev for systems / sustainable intensification innovation</p> <p><b>Capacity Development Platform, DCL</b> Joint cap dev for new generation of wheat scientists, BECA as genetics-related learning hub</p>	

**Table 9b. WHEAT strategic partners.**

<b>CRP-level</b>	<b>FP-level</b>	<b>Cross-cutting</b>
BBSRC (UK), ICAR (India), ACIAR (AU) : CRP management, members WHEAT-MC	GIZ-BEAF: Develop scaling out networks  International Wheat Yield Partnership: Long-term global research program  KALRO (Kenya): rust research  Several NARS: Set up network of precision phenotyping platforms	G20 Wheat Initiative: Int'l research coordination  ASARECA, CCARDESA: Wheat-for- Africa strategy  GRDC, CSIRO (AU), INRA (F), other ARIs: Long-term, renewable MoUs for collaboration on researchable issues  ICAR: Research coordination and collaboration (5YR plan)

**Table 10. WHEAT comparative advantages.**

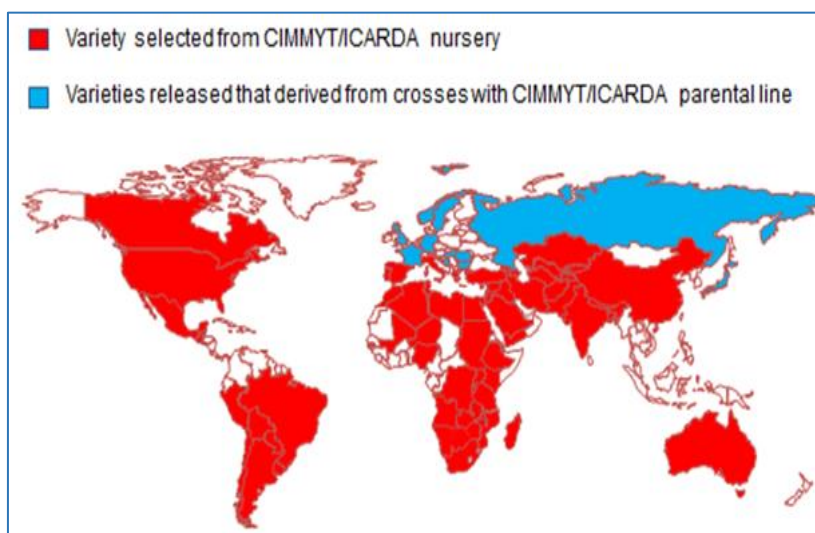
CGIAR niche SRF	Comparative advantage
<b>Partnering for impact</b>	<ul style="list-style-type: none"> <li>✓ Demand-driven global network of public and private sector breeding research: 1,000+ new wheat lines from CIMMYT and ICARDA tested every year at 200+ sites across the globe (nurseries, yield trials) and subsequent data sharing</li> <li>✓ Growing inter-disciplinary partner networks under FP1 (gender), FP2 (genomic selection, etc.) FP3 (phenotyping) and FP4 (remote sensing, mechanization, trade-off analysis)</li> <li>✓ Bridging between NARS and Advanced Research Institutions (e.g. WHEAT scientists connected to major national and international wheat R&amp;D projects). WHEAT is founding member of G-20 Wheat Initiative, member International Plant Phenotyping Network (IPPN)</li> </ul>
<b>Providing research leadership</b>	<ul style="list-style-type: none"> <li>✓ Leader in research-applied-to development (e.g. field precision phenotyping)</li> <li>✓ Recognition as global leader in state-of-the-art high-throughput ground-based and aerial phenotyping platforms, genomic selection for breeding, durable pest/disease resistance, pre-breeding; categorization of wheat growing environments)</li> </ul>
<b>Providing international public goods</b>	<ul style="list-style-type: none"> <li>✓ Germplasm: CIMMYT lines reach basically any wheat program world wide – possibly largest network for germplasm exchange. Free international exchange, open access to curated (e.g. Wheat Atlas, pedigree.net) and raw data (e.g. International Wheat Improvement Network, in its fifth decade, collected 11.2m raw phenotypic data points)</li> <li>✓ Highly efficient pre-breeding efforts able to incorporate new alleles into elite background; due to the wide adaptation of elite lines, co-operators can use them without further improvement in their crossing program; CGIAR germplasm has unique combination of APR that provide resistance against rusts and several other disease – making CGIAR germplasm well buffered against climate change impacts (e.g. unanticipated disease break-out)</li> <li>✓ Sustainable intensification: Productivity and resource-use efficiency-enhancing technologies and methods, long-term agronomy trials data, multi-scale systems innovation research</li> <li>✓ Academic publications, user-oriented publications (guides, protocols)</li> </ul>
<b>Safeguarding and utilizing genetic resources</b>	<ul style="list-style-type: none"> <li>✓ Wheat germplasm collections and Seeds of Discovery (Seed) project, to harness the genetic diversity. CIMMYT &amp; ICARDA maintain the world’s largest wheat germplasm collection</li> <li>✓ Open access to germplasm collection</li> </ul>
<b>Strengthening research capacity</b>	<ul style="list-style-type: none"> <li>✓ International basic and advanced wheat improvement and conservation agriculture training courses; see 2014 study of CIMMYT training impact in China</li> <li>✓ Project-funded capacity development activities</li> </ul>
<b>Manage open data sharing knowledge</b>	<ul style="list-style-type: none"> <li>✓ See above (IWIN, other curated or raw data); greater investment and open access improvements during 2015-16</li> </ul>

## 1.9 Evidence of demand and stakeholder commitment

### Evidence of demand for investments in WHEAT

Among maize, rice, wheat – the three global staple food crops – wheat is the most heavily dependent on public sector R&D for germplasm improvement, with less than 10% of the area in the developing world catered for by private sector breeding programs. Table 10a shows that 94% of all germplasm exchanged internationally in the frame of the Multilateral System of the International Treaty of Plant Genetic Resources for Food and Agriculture (ITPGRFA) is distributed by the CGIAR and wheat (CIMMYT and ICARDA combined) accounts for more than one-third of all germplasm requests ([FAO 2015](#)).

Private sector incentives to invest in wheat germplasm are dampened by the self-pollinating nature of wheat, which allows farmers to recycle seed for a number of years with limited yield loss. WHEAT routinely sends seed shipments to breeding programs in around 100 countries. The extensive use of CGIAR germplasm by public and private breeding programs and the widespread adoption of WHEAT-derived varieties are well documented. Elite spring bread and durum and winter bread wheat lines developed by CGIAR wheat breeding programs are widely used as varieties and parental lines across the globe, with significant spillovers to the developed world.



**Figure 8. Use of CGIAR germplasm in wheat variety releases since 1966.**

In recent years, the WHEAT breeding platform has focused heavily and successfully on introgressing useful genes from landraces or wheat alien species, given that breeders are generally reluctant to use unimproved parents. Therefore, WHEAT is a major source for increasing genetic diversity in NARS breeding programs and ultimately farmers' fields.

WHEAT Phase-II was developed in collaboration with partners through a global WHEAT Partner Priorities Survey, which included 92 responses from 37 countries and a global partner meeting in Turkey, in December 2014, with participants from 20 countries. In addition, 15 to 20 project-specific meetings are held annually for priority setting and planning of interventions (see Annex 3.7).

Most partners believe that the greatest progress towards WHEAT goals will be made via continued farm-level yield improvements and a strong focus on managing major diseases and pests. Capacity development is a significant priority for all partners with respect to training, education, information and

resource sharing. Partners also look toward WHEAT for other priority topics, as adaptation to climate change, raising the wheat yield barrier, making available new genetic variation for heat and drought. In case of the occurrence of Ug 99, a rust race virulent to more than 90% of the by then globally cultivated wheat varieties, the Global Wheat Community with CGIAR centers leading the breeding component, responded extremely fast and by now more than 30 resistant varieties are released. Similar responses would be required in case of newly emerging pests and diseases (e.g. wheat blast). Partners also look at CGIAR for access to proven and or new methods that accelerate breeding gains. Partners need management solutions for reducing water and fertilizer use in wheat based systems, while maintaining and increasing outputs. So far, the implementation of conservation agriculture, laser leveling and more appropriate fertilizer application has brought benefits to over 1.5 M hectares in rice-wheat systems in South Asia (Y. Singh, 2014).

**Table 10a. Germplasm distributed from CGIAR centers and other contracting parties during the 2007-2014 period, as part of the multilateral system (Source: FAO 2015; FAO 2016; CIAT 2016).**

Institution	Plant Genetic Resource for Food and Agriculture (PGRFA)									PGRFA under development Annual	Total germplasm Annual	Shipments Annual
	2007	2008	2009	2010	2011	2012	2013	2014	Annual			
AfricaRice	364	931	7,538	2,938	2,508	3,355	10,135	8,795	4,571	2,685	7,256	50
Bioversity	421	324	646	680	505	434	997	685	587	69	656	41
CIAT	4,243	7,451	4,809	10,194	8,082	5,471	4,568	5,446	6,283	24,101	30,384	353
CIMMYT	142,695	98,603	139,339	192,278	241,426	256,328	241,247	230,702	192,827	0	192,827	1,877
CIP	877	2,031	2,791	1,052	1,403	1,487	1,357	1,160	1,520	949	2,469	56
ICARDA	8,598	89,999	88,829	98,827	109,645	6,940	20,886	14,783	54,813	0	54,813	
ICRAF					10		25	79	38	0	38	14
ICRISAT			47	21,902	18,637	21,631	16,134	33,412	18,627	3,892	22,519	430
IITA	6,823	1,877	1,477	2,841	2,508	1,391	1,035	3,255	2,651	0	2,651	61
ILRI	1,373	560	516	453	1,195	811	1,680		941	0	941	82
IRRI		55,200	77,598	80,055	95,287	65,971	43,855	63,122	68,727	36,808	105,535	680
<b>Total CGIAR</b>	<b>165,394</b>	<b>256,976</b>	<b>323,590</b>	<b>411,220</b>	<b>481,206</b>	<b>363,819</b>	<b>341,919</b>	<b>361,439</b>	<b>351,584</b>	<b>68,504</b>	<b>420,088</b>	<b>3,643</b>
Other Contr. Parties	4,722	20,384	31,262	27,929	41,568	35,548	33,384	23,093	27,236			
<b>Grand Total</b>	<b>170,116</b>	<b>277,360</b>	<b>354,852</b>	<b>439,149</b>	<b>522,774</b>	<b>399,367</b>	<b>375,303</b>	<b>384,532</b>	<b>378,821</b>			

## 1.10 Capacity development

WHEAT-MC decided to merge FP5 scaling out components into FPs 3 and 4 and to transform the former FP5 capacity development CoAs 5.2 and 5.3 into a cross-cutting Cluster of Activity, led by a Capacity Development Strategy expert (co-funded by BMZ-CIM) and reporting directly to the CRP Director.

By investing in capacity development, WHEAT focuses on two long-term objectives:

1. Build a new generation of wheat scientists among our NARS partners and within CIMMYT and ICARDA, together with a committed group of national public and private partners;
2. Integrate capacity development strategy and activities into improved scaling out approaches and partnerships for greater impact, complementary to the FP4.4 objective of enabling improved farmer decision-making and farm management through tailored capacity development at community and landscape levels, which can be scaled out by development partners (see FP4 section).

WHEAT will combine a strategic, top-down and bottom-up approach to realize the goals at the three levels: Individual (competence development), organizational development and to the extent possible based on inter-CRP collaboration, at the societal level (e.g. development of cooperation systems and of enabling frameworks). Strategic actions are framed by a detailed understanding of the role of capacity development (see Annex 3.3) in each FP's impact pathway and theory of change. They include:

- Support NARS partner(s) in a particular country in realizing a comprehensive capacity development assessment, which may point to the need for change at the institutional level.
- Maintain and expand international training programs (e.g. new CIMMYT PostDocs initiative) that cut across all FP's scientific domains and foster a network of alumni, who promote international agricultural research for development ([borlaugtrainingfoundation.org](http://borlaugtrainingfoundation.org)); make use of inter-CRP collaboration (e.g. BecA-ILRI-Hub). Since 1968, the 1 to 3-month trainings attracted over 1,000 participants from 106 countries, see: <http://wheat.org/forty-years-of-wheat-training-at-cimmyt/>
- Building on this, with a group of partners, design and implement a WHEAT Learning Platform, as a model for effective and sustainable information management (e.g. [wheatatlas.cimmyt.org](http://wheatatlas.cimmyt.org)), knowledge sharing and learning tools. It will make use of new learning formats and channels and provides a major inroad for inter-CRP collaboration.
  - Given the lower overall W1&2 funding scenario, as a first step this Platform will focus on demand-driven knowledge-sharing and learning activities with the NARS partners of the Precision Phenotyping Platforms Network (15 partners/locations across the globe by 2020).
- A joint undertaking with FP4.4, develop approaches to simultaneously increase the 'capacity to innovate' in all components of an innovation system, at the individual, organization and enabling environment levels, so that local stakeholders' capacity to negotiate their agricultural futures is improved.

The project portfolio under WHEAT is expected to continue to be 66-75% funded bilaterally. This has practical implications for capacity development scope, objectives and implementation. Bottom-up approaches reflects this reality. They aim to build the competence of all project leaders and scientist-'trainers' planning and practicing capacity development under WHEAT:

- Build, maintain and share an overview of Capacity Development activities in all projects;
- Assist R4D implementation partners (non-CGIAR, CGIAR), with methods and tools to identify performance gaps, learning needs, provide options for how to train/learning formats, collective and self-assessments of learning impact, as well as planning for capacity development in departmental and project budgets.

## 1.11 Program management and governance

### CRP Leadership: Governance and management structure

Following the recommendations of the Governance and Management Review of the CGIAR, WHEAT has made changes (effective January 2015), which have been externally reviewed by the IEA and considered appropriate for Phase II. WHEAT is overseen by the [Independent Steering Committee \(W-ISC\)](#), which supervises strategy and priority setting and implementation through the WHEAT Director. The ISC is composed of eight voting members from all major wheat growing regions worldwide, who combine public and private sector expertise in agricultural economics, agronomy, breeding/genomics, gender research, seed systems and value chain/private sector. The link to CIMMYT and ICARDA boards and senior management is assured through five ex-officio, non-voting members. As lead center, through its Board of Trustees and director general, CIMMYT is responsible for the successful management and implementation of WHEAT. CIMMYT's Board of Trustees also has the fiduciary and legal responsibility and accountability for CRP implementation.

WHEAT is headed by a CRP Director who has been head of the combined wheat programs of CIMMYT and ICARDA since January 2015. The [2014 IEA-led External Evaluation of WHEAT](#) (p. xiv) assessed this approach and concluded, "... that the revised governance structure and processes of WHEAT are suitable for effectively implementing WHEAT and facilitating increased programmatic collaboration between CIMMYT, ICARDA and other partners of WHEAT. These changes will help promote greater authority and capacity of the CRP Director to manage results; and ensure that the CRP governance is free of conflicts of interest, thereby addressing issues of legitimacy and independence." The CRP-WHEAT Director attends both CIMMYT and ICARDA Board of Trustee meetings, to report on progress and raise governance issues. A team of five supports the CRP Director, including the WHEAT program manager and a senior monitoring, evaluation and learning specialist.

The [Management Committee \(W-MC\)](#) is the executive working committee of WHEAT. The W-MC comprises the CIMMYT and ICARDA program directors and three external members representing strategic R&D partners (ACIAR/AU, BBSRC/UK and ICAR/India). They review work plans and budgets, identify research gaps and coordinate the peer-review process for competitive grants. Flagship supervision is assigned to distinct members, yet decisions are taken as one body, which requires endorsement by external members. This results in shared leadership for several flagships and cluster of activities. IWYP and Cornell (DGGW) are *external* CoA co-leaders. GIZ will provide a senior advisor to the scaling-out flagship project.

Shared FP and CoA leadership also reflects progress towards CIMMYT and ICARDA, building one global CGIAR wheat program, which is driven by a five-year milestone plan endorsed by both centers' Boards of Trustees. The independent chair of the WHEAT-Independent Steering Committee considers this inter-center integration objective critical to long-term WHEAT success.

## 1.12 Intellectual asset management

WHEAT is committed to effective and efficient management of intellectual assets at every stage of the CRP life cycle, to effectively disseminate research outputs and maximize impact. WHEAT research outputs will be managed in line with the CGIAR Principles on the Management of Intellectual Assets and their Implementation Guidelines, as International Public Goods (IPG). Critical issues during CRP implementation and anticipated challenges include:

1. Incorporating of IA management into the project lifecycle;
2. Aligning CGIAR IA Principles' requirements with private sector partner interests, local legislation and local markets/practices;
3. Ensuring available funding and human resources for proper implementation ; and
4. Performing due diligence to allow for dissemination of CRP outputs.

Item 1 will be addressed through (i) participation in the project management lifecycle; (ii) implementation of IA principles for the Lead Center, Participating Center and other partners; and (iii) subject to available budget, capacity building.

Key dissemination pathways for maximizing global impact include open access repositories, adapted information channels to specific target groups, partnership approaches and capacity development, management as International Public Goods, partnerships (with NARs, PPPs, etc.), scaling up and out, networks, on-farm management & participatory research.

Operations include incorporation of IA management into Lead Center's and partners' project cycles; IA tracking; negotiation and drafting of agreements with partners; compliance with Convention on Biological Diversity, the International Treaty on Plant Genetic Resources for Food and Agriculture and country by country laws and regulations on genetic resources; ethics in research and privacy protection; and CGIAR and Center policy development updates. Coordination and decision making is led by WHEAT-MC, with the Lead Center's IP & Legal office. See Annex 3.10.

### 1.13 Open access management

WHEAT seeks to ensure that research data and information products produced or supported by the CRP are managed to enable further research, development and innovation, leading to impact on target beneficiaries in accordance with the CGIAR SRF. WHEAT supports the CGIAR Open Access and Data Management Policy, which is a critical component to providing IPG, safeguarding and utilizing genetic resources, and strengthening research capacity (see also section 1.8). CIMMYT and ICARDA both have Open Access and Data Management Policies that adhere to these principles ([www.cimmyt.org/en/who-we-are/policies](http://www.cimmyt.org/en/who-we-are/policies) ) and are in the process of finalizing data management plans guided by the CGIAR implementation plan guidelines. WHEAT will encourage all non-CG collaborators to abide by CGIAR OA/OD principles and to coordinate their open access efforts with the Lead or Participating Center.

Both Centers support the early inclusion of open access planning in the project management lifecycle for new projects. They will initiate activities that induce behavioral change in scientists to embrace Open Access practices, both within and outside the CGIAR. An overview of repositories can be found (<http://data.cimmyt.org/dvn/>).

WHEAT will continue to (co)-fund and participate in development of Open Access and Open Data-related standards, methods and tools (e.g. CGIAR Open Access & Open Data Support Pack), both within the CGIAR and, more importantly, outside: Namely international efforts focused on interoperability, dissemination pathways and other topics related to increased uptake of CRP data and information products. Within the Research Data Alliance, the wheat interoperability working group is the only crop-based group. It has advanced more than other interoperability working groups, producing a 'cook book' and use cases, thanks to support from the G-20 Wheat Initiative. Additional investment budget (uplift) and other additional information are found in Annex 3.9.

### 1.14 Communication strategy

The communications team at CIMMYT and ICARDA will provide expertise and strategic guidance to management, researchers and partners, enhancing the effectiveness and impact of WHEAT work, public image and donor support, through these priority activities, in collaboration with R4D partners' communicators and service providers:

- Communicating about the program, science, results, and progress towards achievement of the SRF 2022 targets throughout the CRP life cycle. This includes:
  - Documenting successes of key projects, partnerships (IWYP, MasAgro, CSISA, AIP-Pakistan, SARD-SC, etc.), and competitive grantees, and share the information with relevant audiences through diverse outputs and media.
  - Assisting partners and donor agencies to document successes.
- Promoting learning and sharing of information to improve communications and collaboration with CRP oversight, CGIAR, partners, and within and across CRPs:
  - Maintaining and promoting use of platforms (web sites, social media) with pertinent CRP documentation and tools.
  - Promoting the development and effective use of relevant apps (Slate, infographics, interactive maps, among others).
  - Sharing information about progress and impacts (reporting, studies, newsletters).
- Engaging with actors on the ground to scale out technologies and practices:
  - Media and marketing campaigns to generate technology awareness, local engagement.
  - Developing outreach material (print, video, other).
  - Catalyzing and other support for extension, including strategic guidance and building local capacity.
  - Working with local NGOs and other CRPs (CCAFs, Climate Smart Villages in India; A4NH) to document farm-level success and learning.
- Engaging in and providing support for policy dialogue and events (Wheat for Africa, linking with CAADP, FARA-2014, CGIAR Development Dialogues, Borlaug100, Mexico Forum with State Ministers of Agriculture) attended by policy makers, opinion leaders, and other key stakeholders.

### 1.15 Risk management

Since 2014, the WHEAT-MC works with a risk management matrix that was created to regularly assess and manage CRP-specific risks, which are mainly driven by the rights and obligations of the Performance Implementation Agreement signed between the Consortium and the Lead Center CIMMYT, as well as CGIAR regulations referenced therein. The matrix identifies a number of risks related to asset management, compliance, general management, change management, finance, technology and achievement of outcomes identified in the theory of change. Based on the risk assessment, WHEAT-MC agrees on specific mitigation measures. This complements (and does not duplicate) the risk management performed by CIMMYT and ICARDA Center Management.

The top risk in the past and going forward is the in-financial year W1&2 budget changes and delayed transfer of W1&2 funds, which directly affects CRP research and development operations. Up to now, WHEAT-MC has agreed to prioritize CGIAR-led research over partner and management budgets, to maintain the WHEAT partner budget as the most flexible component of the budget and commit a reserve. WHEAT continues to sign only one-year partner grant contracts, to manage partner expectations and minimize any delays of payments to them.

'Non-fulfilled obligations by the partners for commissioned and competitive grants' is considered a low likelihood and low impact risk, given WHEAT experience in Phase I, but remains monitored on a quarterly basis.

## Section 2: Flagship projects

### FP1: Enhancing WHEAT's R4D strategy for impact

#### 2.1.1 Rationale, scope

##### Research Focus and Science Quality

Wheat is one of the three leading global cereals that feed the world and provides a global average of 500 kcal/day/per capita – a value that has remained constant over decades, despite shifts in diets and a growing global population. It is the staple food for hundreds of millions of people in the developing world (Shiferaw et al. 2013). It is the world's most widely cultivated cereal, with wheat production split roughly equally between the developing and developed world. Wheat agri-food-systems comprise both bread and durum wheat and wheat is variously processed prior to consumption. This makes wheat agri-food-systems (AFS) inherently complex, diverse and geo-politically charged.

An agri-food system (AFS) considers both agricultural and agro-industrial sectors and how both “interact closely with other production and service sectors. This broadens the vision of agriculture and recognizes the importance of economic and production activities that take place outside the primary production process, as well as highlighting the impact of the political, environmental and social environment on these activities.” (Santacoloma et al., 2009). WHEAT Flagship Project 1 (FP1) provides a coherent horizontal guiding platform to help WHEAT embrace an integrated AFS approach in general, and grasp the implications for its international research-for-development (R4D) in particular.

Realizing the potential of agricultural development for poverty alleviation and food security is challenging (IBRD, 2007; Christiaensen et al., 2011). An AFS approach broadens the perspective beyond the traditional and narrow focus on the farm and the farmer, including the enabling environment and the forward and backward linkages along the value chain, all the way from input supply through processing and value addition to the final consumer. At the same time the wheat AFS provides valuable focus and corresponding entry point for R4D.

AFS inherently put emphasis on the supply-demand nexus. Subsistence autarkic wheat-based systems producing wheat solely/primarily for household self-sufficiency in isolation are increasingly scarce. They also provide limited prospects for economic development and poverty alleviation. Instead, the sheer wheat demand still offers huge developmental dividends for smallholder producers able to produce surplus wheat across the developing world. Wheat may be generically categorized as a staple food crop – but for millions of resource poor farmers it is seen as a cash crop, inherently scalable, accessible and viable.

WHEAT has a large area of influence in the developing world. Alexandratos & Bruinsma (2012) predict that wheat food consumption per capita will continue to rise in SSA, South Asia, Latin America; while leveling off and eventually declining in the Near East/North Africa, China and the developed countries, with little growth globally. The same study predicts wheat will become the leading staple in developing countries – overtaking rice. In those countries, the bulk of wheat (and rice) is produced in the land-scarce regions of Asia and the Near East/North Africa. They foresee wheat production growth to 2050 of only 0.87 % p.a. (incl. 0.86% yield improvement and 0.01% land expansion) – well below the CGIAR SRF target and far from the growth needed to feed one extra billion people each in Asia and in Africa by 2050. The geography and agro-ecology of wheat presents particular challenges for linking supply and demand and developing local value chains in wheat AFS. The wheat consumption growth in some developing regions will be accompanied by continued growth in wheat imports. Wheat will continue to

account for about one half of total net imports in developing countries – and the only staple with foreseen growth in imports in each of the developing regions.

WHEAT has a diverse area of influence. The scope for further wheat AFS development in the developing world remains great – but implications differ given wheat AFS specifics, different dynamics and different stakeholders. AFS actors operate in diverse contexts shaped by agro-ecological circumstances, market access and development, population pressure and institutional arrangement and governance structures. This calls for a better understanding of the supply-demand nexus of wheat AFS and associated agricultural innovations within its temporal, spatial and social dimensions. In other words, further research and understanding of the R4D implications and nuances of wheat AFS – and close integration and strategic alignment with national and regional priorities and comparative advantage.

The context in which WHEAT operates is evolving. Both future needs of our beneficiaries as well as the context in which they will operate are shaped by a number of factors: megatrends (global drivers of change), pressures and events; and these are forcing women and men of different age groups, civil societies and countries to reassess priorities and interventions. Drivers of change include changes in agro-ecological production potential and comparative advantage of different crops in different locations; changes in diets; and changes in the socio-economic and politico-institutional environment which influence innovation, research supply (private sector, ARIs, NARS) and social inclusiveness (women, youth). The evolving context thereby calls for systematically re-assessing R4D priorities and implications, including market opportunities and comparative advantages within wheat AFS.

Wheat AFS and many of the grand challenges are directly interlinked. FP1 enhances WHEAT R4D strategy for impact by enhancing our understanding and thus directly assesses the implications of various Grand Challenges (see Table FP1-1).

**Table FP1-1. WHEAT FP1 and the societal grand challenges.**

<b>Grand challenge<sup>1</sup></b>	<b>WHEAT FP1 contributions</b>
GC1 - Competition for land from multiple sources	Research addresses competition for land and extensification, intensification and diversification of wheat AFS. FP1 helps understand the R4D and targeting implications. Migration and urbanization are integral to the foresight work and how these transform agriculture and rural landscapes.
GC2 - Soil degradation	Understanding barriers to and enabling conditions for adoption of sustainable intensification (SI) practices and communicating these with relevant stakeholders will enhance adoption and help to curb land degradation. Targeting work addresses spatial dimensions of soil and water degradation, and options for resource conserving technologies.
GC3 - Overdrawn and polluted water supplies	Understanding role and scope of water savings through the adoption of SI practices in (irrigated) wheat based AFS. Research addresses spatial dimensions of water overexploitation for better targeting and prioritization of interventions.
GC5 - Climate change and agriculture	Climate change and its potential impact on wheat AFS integral to the foresight analyses. Assessing SI practices, improved wheat germplasm (drought & heat tolerant) and other climate-smart agricultural practices will reduce production risk; sharing such results with decision makers and development partners will create awareness about climate change adaption prospects in wheat AFS.
GC7 - Nutritious and diverse agri-food systems and diets	FP 1.4 assesses the role of wheat as major source of protein and energy in global AFS and associated implications for international R4D. FP 1.2 provides empirical evidence of the role of SI practices, germplasm and bio-fortification in wheat AFS in enhancing nutrition, food security and diet diversity.
GC8 - Post-harvest losses	Value chain work identifies options to address post-harvest losses and enhance food safety.
GC9 - Employment and income opportunities created for men, women and youth	Value chain work identifies new entrepreneurial and job opportunities. Increased socially inclusive adoption facilitated through understanding of major barriers and enabling factors will increase demand for technologies and increase surpluses; this in turn increases employment and income opportunities in wheat AFS, including for input supply, production and processing.

<sup>1</sup> Summary titles of grand challenges listed in CGIAR Strategy & Results Framework 2016–30 (SRF, 2015)

### 2.1.2 Objectives and targets

WHEAT aims to strengthen a strategic, international approach of public-private partnerships for wheat research-for-development (R4D) to sustainably strengthen resource-poor women and men farmers of different age groups and poor consumers in wheat AFS. WHEAT's strategy for impact should be based on a solid understanding of its potential impact and comparative advantage and consequent priorities in the target areas. Ex ante analysis should make future potential impacts explicit and help in thinking through implications and impact pathways. Ex post analysis should make actual achieved impacts explicit – including unintended consequences. Both ex ante and ex post analysis will help illustrate WHEAT's value for money to the international community and to refine priorities. Its strategy for impact should be cognizant of social inclusiveness throughout – thinking through the implications to ensure intended resource-poor beneficiaries of different age groups are reached and documenting and learning from its achievements in the context of social inclusiveness. Its strategy for impact should assess changes in context to identify new opportunities and changes in comparative advantage and refine priorities accordingly. WHEAT's strategy for impact should hinge on its comparative advantage with strategic consideration to the dynamics in demand and use of wheat and research supply (NARS, ARIs, private sector) to establish and refine priorities in its target areas.

WHEAT Flagship Project 1 (FP1) strategizes WHEAT's R4D to enhance impact in wheat AFS. FP1 aims to do this by better understanding the supply-demand nexus of agricultural innovations in wheat AFS within its temporal, spatial and social dimensions. FP1 inherently recognizes and researches the complexity of wheat AFS, their interconnections with environmental and socio-economic factors and the consequences of globalization. FP1 will enhance WHEAT's understanding of the big picture and household-level implications in wheat AFS. Through maintaining an overview of WHEAT's work, FP1 is able to keep an eye on strategic priorities to avoid mission drift.

FP1 enhances WHEAT's R4D across all the Flagships, informing strategies for impact through foresight and targeting, learning from adoption and impacts, strategic and transformative gender research, and identifying value chain opportunities. This FP will utilize and expand on WHEAT's rich understanding about livelihoods, AFS, markets, agro-ecology, nutrition, social inclusiveness and other socio-economic phenomena to help WHEAT prioritize and adjust based on the new evidence. FP1 revolves around multi-disciplinary research to prioritize, target, understand and enhance wheat interventions for greatest impact within an AFS perspective. It thereby integrates socio-economic research with germplasm improvement, agronomy and value addition. This flagship links analysis of completed technology diffusion, with current technology pipelines in all stages of development and informs the technology development process of its key findings to enhance impact. By so doing, FP1 will play key role not only in guiding WHEAT research and hence maximize the returns to WHEAT investment but also in creating conducive policy, institutional and market environments that enhance adoption and impacts of WHEAT innovations at scale – thereby increasing WHEAT's ability to achieve its goals.

FP1 maximizes the value-for-money for WHEAT as a whole by providing horizontal guidance to WHEAT and supporting the internal coherence among all FPs through four specific objectives, each being the basis for a Cluster-of-Activities (COAs):

1. To inform WHEAT's R4D strategy through foresight and targeting.
2. To assess the effectiveness and impact of WHEAT's interventions for improved production and productivity, and strengthened food and nutrition security.
3. To enhance WHEAT's gender and social inclusiveness.
4. To identify wheat value chain opportunities to enhance livelihoods.

The investment made in FP1 will generate multiple outcomes and contributions to sub-IDO (Figure FP1-1). By providing horizontal guidance to WHEAT and its outcomes-to-impact, FP1 also contributes to the full range of WHEAT outcomes generated by the other FPs. FP1 documents and enhances WHEAT's contribution to CGIAR 2022 (and 2030) targets as specified in the CGIAR SRF, through ex-ante and ex-post impact assessment activities, with particular focus on: (i) Number of farm households adopting improved wheat varieties and improved crop management practices; (ii) Number of people (by gender) assisted to exit poverty; (iii) The rate of yield increase for wheat; (iv) Number of people (by gender) meeting minimum dietary energy requirements; (v) The increase in water and nutrient use efficiency in agro-ecosystems; and (vi) The area of forest saved from deforestation.

FP1 plays a critical cross-cutting role in reinforcing many of the SRF guiding principles in WHEAT, including, *inter alia*, representing and demonstrating its value for money, increasing operational efficiency, generating public goods with multiple benefits, providing attractive investment opportunities and accelerating impact at scale with a particular focus on women and youth (including both young men and young women). Its support will improve the use of scarce research resources, accelerate the uptake of innovations and enhance benefits and social inclusiveness for resource-poor producers and consumers in wheat AFS in Africa, Asia and Latin America. The geographic focus of FP1 follows WHEAT's target geographies with a prevalence of wheat AFS and international development potential (with focal countries including Afghanistan, Bangladesh, China, Egypt, Ethiopia, India, Iran, Kazakhstan, Kenya, Lebanon, Mexico, Morocco, Nepal, Nigeria, Pakistan, Rwanda, Sudan, Tanzania, Tunisia, Turkey, Uzbekistan and Zambia).

### 2.1.3 Impact pathway and theory of change (for each individual FP) – max 1.5 p

The theory of change for FP1 Enhancing WHEAT's R4D Strategy for Impact was developed during a workshop with the Flagship project teams from both WHEAT and MAIZE. A participatory approach was used to capture all views, experiences and known evidence into the theory of change. The workshop participants were able to increase their understanding of the CGIAR Strategy and Results Framework and awareness of results-based management concepts. The workshop was also structured to encourage sharing and learning across both CRPs.

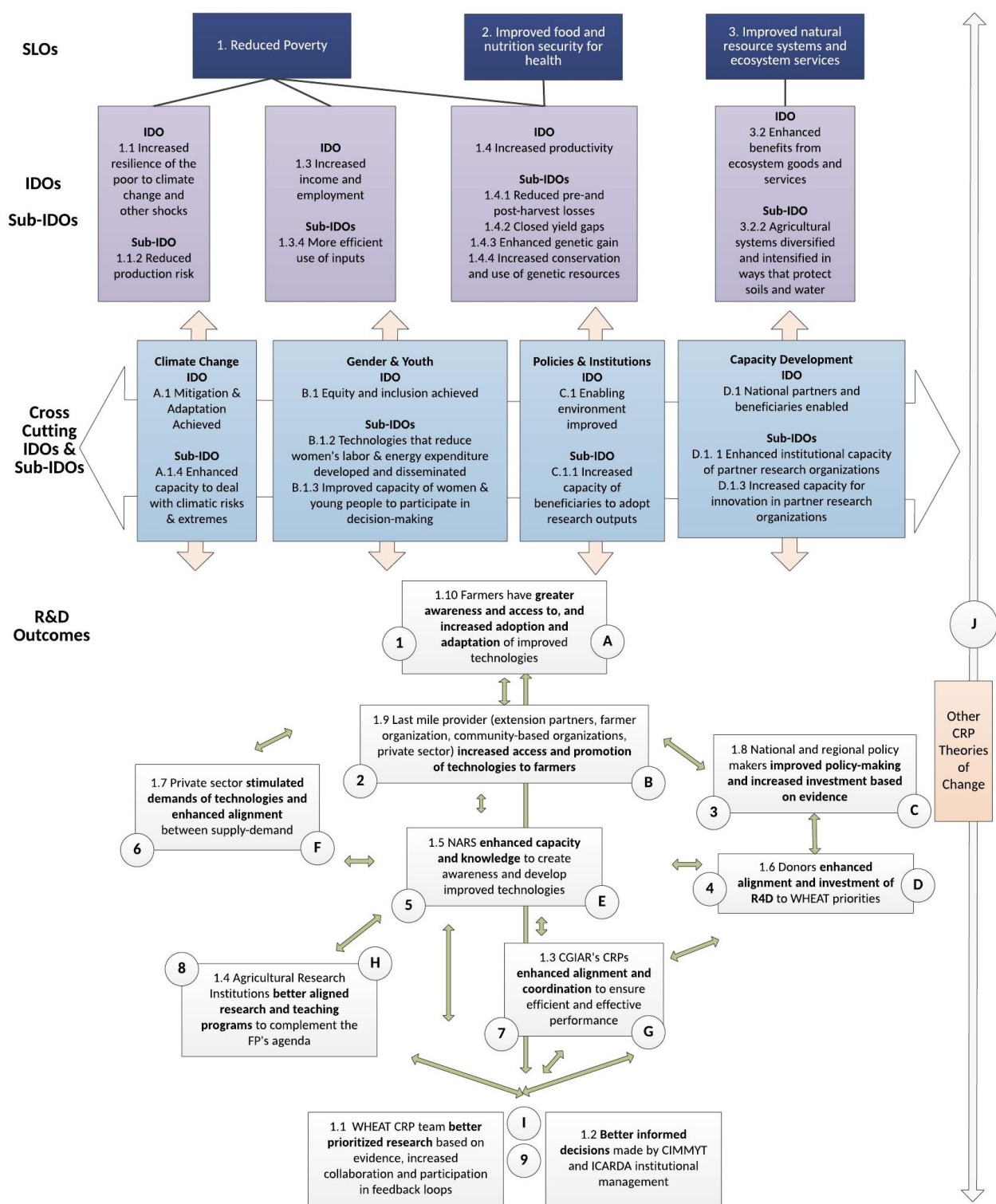
Using the CGIAR Results Framework's sub-intermediate development outcomes (IDOs) the team agreed to focus on all sub-IDOs and cross-cutting sub-IDOs chosen by WHEAT's other Flagship projects given that FP1 supports and contributes to all of them. These included eleven sub-IDOs and six cross-cutting sub-IDOs (Fig.FP1-1), including four sub-IDOs core to the FP: a) increased value capture by producers; b) increased capacity of partner organizations; c) improved capacity of women and young people to participate in decision-making; and d) increased capacity of beneficiaries to adopt research outputs. Other sub-IDOs were noted by the team as important to programming given that they overlap with the above sub-IDOs of focus.

Based on these areas of focus, the team agreed that FP1 contributes to reducing poverty (SLO 1), improving food and nutrition security for health (SLO 2), and improving natural resource systems and ecosystem services (SLO 3) by increasing resilience of the poor to climate change and other shocks (IDO 1.1), increasing income and employment (IDO 1.3), increasing productivity (IDO 1.4), improving diets for poor and vulnerable people (IDO 2.1), enhancing benefits from ecosystem goods and services (IDO 3.2), and enhancing the cross-cutting issues of climate change (A), gender and youth (B), policies and institutions (C) and capacity development (D).

A number of research and development outcomes were identified and a pathway of change was created demonstrating the causal relationship between outcomes and sub-IDs. During this process, partners involved in the pathway of change were identified. The theory of change identified the CRP team and management, NARS researchers, policy-makers, donors, private sector and other last mile providers (e.g. extension agents, rural development NGOs, traders) as first users. The ultimate beneficiaries are resource poor producers and consumers, with a strong focus on finding avenues that ensure majority benefits to women and youth. Current and proposed interventions and associated outputs to support the achievements of the outcomes were mapped. Assumptions describing the contextual underpinnings of the theory as well as the risks that may have the potential to undermine success were documented.

The theory of change identified ten interlinked R&D outcomes for FP1. Central to the FP1 mandate, a first outcome would be a WHEAT CRP team that better prioritized research based on evidence, increased collaboration and participation in feedback loops. This would further better informed decisions made by the institutional management of the lead centers. In addition, FP1 would help to enhance the alignment and coordination of the CGIAR CRP portfolio to ensure efficient and effective performance, including docking with integrating CRPs and complementarities with other AFS CRPs. Research and teaching programs of advanced research institutions would also be better aligned to complement the FP's agenda. Taken together the foregoing outcomes would enhance NARS's capacity and knowledge to create awareness and develop improved technologies. The private sector would also stimulate technology demand and enhance alignment between supply and demand. On the other hand, FP1 is expected to enhance donor alignment with WHEAT priorities and R4D investments. This in turn would result in improved national and regional policy making and increased investment based on evidence. Taken together, the preceding outcomes would increase the access and promotion of technologies to farmers through last mile providers; and as final outcome farmers have greater awareness and access to, and increased adoption and adaptation of improved technologies.

This theory of change will be the foundation for the monitoring, evaluation and learning plan. The monitoring plan will consist of a continuous process of collection and analysis of data based on a set of indicators directly related to the performance of the CRP at the output and outcome levels; the key assumptions of the theories of change; and the critical risks. The theory of change will also be the basis for evaluating the FP as well as reflecting on lessons and program improvements. Finally, the impact pathways are an integral part of WHEAT's impact assessment strategy that sets clear priorities for focusing such assessments (in FP 1.2) and provides an analytical framework and elaborates on their use in planning and documenting scaling up of results and impact.



Assumptions and Risks	Interventions and Outputs
<p><b>A</b></p> <ul style="list-style-type: none"> <li>Farmers are aware and have access to improved technologies</li> <li>Farmers see value in improved technologies</li> <li>Improved technologies are relevant, affordable, profitable and suitable to farmer needs</li> </ul>	<p><b>1</b></p> <ul style="list-style-type: none"> <li>Identify and share within CRP adoption constraints and incentives, and costs-benefit analysis of technologies <ul style="list-style-type: none"> <li>Outputs: Constraints, incentives and cost-benefit information and associated data; dissemination documentation</li> </ul> </li> <li>Evaluate difference approaches of awareness creation and dissemination and share best practices within CRP <ul style="list-style-type: none"> <li>Outputs: Best practices; dissemination documentation</li> </ul> </li> </ul>
<p><b>B</b></p> <ul style="list-style-type: none"> <li>Partners have capacity, infrastructure and are willing to scale out technologies</li> <li>Risks: <ul style="list-style-type: none"> <li>Existence of an enabling environment for scaling out</li> <li>Lack of and change in funding and political support</li> </ul> </li> </ul>	<p><b>2</b></p> <ul style="list-style-type: none"> <li>Conduct formalized needs and capacity assessments of partnering last mile providers, identify gaps and best fits and share findings within CRP <ul style="list-style-type: none"> <li>Outputs: Needs and capacity of last mile providers, gaps and best fit organizations; dissemination documentation</li> </ul> </li> <li>Develop and provide targeting information, targeting capacity building and extension material packages <ul style="list-style-type: none"> <li>Outputs: Information and associated data; training and associated materials; dissemination documentation</li> </ul> </li> <li>Conduct research on scaling out pathways to enhance dissemination of adoption <ul style="list-style-type: none"> <li>Outputs: Research information and associated data; dissemination documentation</li> </ul> </li> </ul>
<p><b>C</b></p> <ul style="list-style-type: none"> <li>Existence of enabling policy environment and government support to make policy based on evidence</li> <li>Policy makers are receptive to research information and use it</li> <li>Risk: Frequent conflicting and competing priorities</li> </ul>	<p><b>3</b></p> <ul style="list-style-type: none"> <li>Identify opportunities for CRP to influence policy making and share within CRP <ul style="list-style-type: none"> <li>Outputs: Opportunities documented; dissemination documentation</li> </ul> </li> <li>Develop and provide policy advice to multiple audiences (CRPs, multilateral organizations, donors, local and regional governments) to influence policy-making <ul style="list-style-type: none"> <li>Outputs: Policy briefs; advice; dissemination documentation</li> </ul> </li> </ul>
<p><b>D</b></p> <ul style="list-style-type: none"> <li>Donors share our priorities and vision, and are willing to collaborate and share knowledge</li> <li>Donors have the capacity to collaborate</li> <li>Benefits of collaboration outweighs transaction costs</li> <li>Risks: <ul style="list-style-type: none"> <li>Priority changes away from agricultural research for development</li> <li>CGIAR and CRP mission drift away from mission, values, capacity, priorities</li> </ul> </li> </ul>	<p><b>4</b></p> <ul style="list-style-type: none"> <li>Collect, document and share within CRP donor intelligence (e.g., motivation, mission, priorities, indicators)</li> </ul>
<p><b>E</b></p> <ul style="list-style-type: none"> <li>Partners see value and are willing to collaborate</li> <li>Existence of an enabling environment and government support</li> <li>Risks: <ul style="list-style-type: none"> <li>Lack of financial and human capacity of NARS</li> <li>Conflict of interests</li> <li>Over-commitment or lack of commitment</li> <li>Staff turnover</li> </ul> </li> </ul>	
<p><b>F</b></p> <ul style="list-style-type: none"> <li>Existence of an enabling environment for private sector involvement</li> <li>Private sector is willing to collaborate and share knowledge</li> <li>Private sector has the capacity to collaborate</li> </ul>	

Assumptions and Risks	Interventions and Outputs
<ul style="list-style-type: none"> <li>• Benefits of collaboration outweighs transaction costs</li> <li>• Risks:               <ul style="list-style-type: none"> <li>○ Fails to see opportunities for diverse groups / interests</li> <li>○ Potential for emergence of ethical issues</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>○ Outputs: donor intelligence; dissemination documentation</li> <li>• Prepare marketing / communication products on research findings and benefits of WHEAT products and share with donors               <ul style="list-style-type: none"> <li>○ Outputs: Policy briefs; marketing / communication products; dissemination documentation</li> </ul> </li> </ul>
<p><b>G</b></p> <ul style="list-style-type: none"> <li>• CPRs are willing to collaborate and share knowledge</li> <li>• CRPs have the capacity to collaborate</li> <li>• Benefits of collaboration outweighs transaction costs</li> <li>• Risks:               <ul style="list-style-type: none"> <li>○ CGIAR and CRP mission drift away from mission, values, capacity, priorities</li> <li>○ Limited investment to develop capacity and collaborate</li> </ul> </li> </ul>	<p><b>5</b></p> <ul style="list-style-type: none"> <li>• Conduct formalized needs and capacity assessment of partnering NARS and identify gaps               <ul style="list-style-type: none"> <li>○ Outputs: Identified needs and capacity, and gaps</li> </ul> </li> <li>• Develop and provide training, services and mentoring               <ul style="list-style-type: none"> <li>○ Outputs: Training and associated materials; services documentation; dissemination documentation</li> </ul> </li> </ul>
<p><b>H</b></p> <ul style="list-style-type: none"> <li>• ARIs are willing to collaborate and share knowledge</li> <li>• ARIs have the capacity to collaborate</li> <li>• Benefits of collaboration outweighs transaction costs</li> </ul>	<p><b>6</b></p> <ul style="list-style-type: none"> <li>• Develop and provide strategic advice to CRP on best practices in collaborating with the private sector               <ul style="list-style-type: none"> <li>○ Outputs: Advice; products; data; dissemination documentation</li> </ul> </li> <li>• Develop and provide information on emerging marketing opportunities and on CRP products and services to the private sector               <ul style="list-style-type: none"> <li>○ Outputs: Policy briefs; information and associated data; dissemination documentation</li> </ul> </li> </ul>
<p><b>I</b></p> <ul style="list-style-type: none"> <li>• Existence of an enabling environment for collaborating, networking, communicating, knowledge sharing, innovation, critical thinking, taking risks and learning from failures where:               <ul style="list-style-type: none"> <li>○ Feedback and constructive criticism is encouraged and operationalized across the institutions</li> <li>○ Time, resources and incentives exist</li> <li>○ Management provide active and continuous support, guidance and direction</li> <li>○ Benefits of collaboration outweighs transaction costs</li> </ul> </li> <li>• Existence of an effective communication approach</li> <li>• Risks:               <ul style="list-style-type: none"> <li>○ Lack of ability to retain talent and hire the right people</li> <li>○ Lack of effective tools for collaboration</li> <li>○ Internal performance evaluation processes are not adaptable to support collaboration</li> </ul> </li> </ul>	<p><b>7</b></p> <ul style="list-style-type: none"> <li>• Identify cost-effective opportunities for enhancing collaboration and complementarity with other CRPs and share within CRP, preferably via integration site plans               <ul style="list-style-type: none"> <li>○ Outputs: Opportunities documented; dissemination documentation</li> </ul> </li> <li>• Share research findings with other CRPs               <ul style="list-style-type: none"> <li>○ Outputs: Research information and associated data; products; dissemination documentation</li> </ul> </li> <li>• Contribute to joint initiative, preferably via integration site plans               <ul style="list-style-type: none"> <li>○ Outputs: Knowledge; products; data; dissemination documentation</li> </ul> </li> </ul>
<p><b>J</b></p> <ul style="list-style-type: none"> <li>• Risks:               <ul style="list-style-type: none"> <li>○ New emerging pests and diseases</li> <li>○ Financial, social and political instability</li> </ul> </li> </ul>	<p><b>8</b></p> <ul style="list-style-type: none"> <li>• Define and regularly revise a collaborative research agenda               <ul style="list-style-type: none"> <li>○ Outputs: Collaborative research</li> </ul> </li> </ul>

Assumptions and Risks	Interventions and Outputs
<ul style="list-style-type: none"> <li>○ Climate change</li> </ul>	<p style="text-align: right;">agenda (e.g., areas for research, associated institutions)</p> <ul style="list-style-type: none"> <li>⑨ • Comprehensive and regularly updated foresight and targeting approach (i.e., analysis) based on CRP needs <ul style="list-style-type: none"> <li>○ Outputs: Approach; regularly updated data; FP needs</li> </ul> </li> <li>• Foresight and targeting information provided to CRP <ul style="list-style-type: none"> <li>○ Outputs: Foresight and targeting information and associated data; dissemination documentation</li> </ul> </li> <li>• Conduct and share with CRP cost-benefit analysis of interventions <ul style="list-style-type: none"> <li>○ Outputs: Cost-benefit information and associated data; dissemination documentation</li> </ul> </li> <li>• Conduct analysis on research prioritization and share advice and recommendations to CRP <ul style="list-style-type: none"> <li>○ Outputs: Prioritization information and associated data; dissemination documentation</li> </ul> </li> <li>• Provision of technical support <ul style="list-style-type: none"> <li>○ Outputs: Technical materials; training and associated materials</li> </ul> </li> <li>• Provide internal and external capacity building in the integration of gender and youth <ul style="list-style-type: none"> <li>○ Outputs: Training and associated materials</li> </ul> </li> </ul>

Figure FP1-1. FP1 Theory of Change.

#### 2.1.4 Science quality

FP1 enhances WHEAT's R4D strategy for impact and as such takes due to cognizance of the need of scientific rigor to ensure the robustness of its scenarios, assessments and products to achieve the intended outcomes. Evidence will be a lynchpin in adjusting internal and external priorities and perceptions. FP1 will need to generate robust, scientifically credible and compelling evidence and use them to make recommendations that will win the confidence of the target audience. FP1 strives for excellence and novelty in science, and to maintain science quality, Scopus-recognized peer reviewed journals remain the preferred publication outlet for its international public knowledge goods.

FP1 encompasses a small multidisciplinary team of pragmatic system thinkers and R4D professionals around wheat AFS with a high contribution from the social sciences (foresight, impact assessment, gender, value chain) as well as such disciplines as geo-spatial sciences and modeling (crop, bio-economic).

FP1's science occupies a unique niche – grounded in reality, multidisciplinary and with a clear international R4D focus on wheat AFS. As such it contrasts and complements academia and integrating CRP's like PIM. The diverse publication outlets reflect FP1's niche – yet maintaining scientific quality. In a recently commissioned external review by the CGIAR, the WHEAT lead center was recognized for having the highest field-weighted citation impact in social sciences (2.36), the highest share in top 10% highly cited papers in social sciences (41%), and the highest number of publications in agricultural and biological sciences (Elsevier, 2014). This is matched by choosing partnerships with outstanding universities and research think tanks – both within and outside the target geographies. Still, science quality in many of the target geographies is uneven and can imply significant investments in capacity development. <http://wheat.org/download/wheat-publications/> provides a complete list of publications by WHEAT scientists (FP1 – FP4) and separately for FP1.

Within the confines of FP1's unique niche – we continue to use proven scientific methods and adapt to the needs and resources available without compromising scientific quality. Given the multidisciplinary team many scientific methods draw across disciplinary divides including the complementary use of quantitative-qualitative approaches. Given the R4D focus and niche much of the scientific novelty is the application and adaptation of approaches. FP1 will build on existing partnerships and pursue new partnerships to enhance the use of cutting edge and latest advances in theory and methods that will increase the credibility of evidence generated and recommendations made by FP1. Increasing availability of datasets also opens up opportunities of repurposing data. Building on WHEAT-1 and other available datasets, we are merging and analyzing multi-country and complex data sets (“big data”), particularly in relation to foresight and targeting, impact assessment and gender.

FP1 will deliver well informed analysis with balanced depth and breadth of topical and scale coverages of wheat AFS. A solid understanding of past trends will facilitate making projections about the future scenarios in social, economic, demographic, policy, biophysical, climatic, technological and other relevant environments under which WHEAT will operate. Scenario development will assess and simulate the wide range of likely scenarios that may impact wheat AFS and counterfactuals of WHEAT intervention scenarios. This will draw on multidisciplinary approaches and established tools (such as the IMPACT model), and strive to incorporate more dynamic and stochastic dimensions to increase the relevance and precision of predictions.

FP1 will also employ a variety of novel and complementary methods for the measurement of adoption and impacts. It will also contribute to the literature by comparing different adoption estimation methods. It will take care to circumvent analytical pitfalls including attribution problems and specification related problems (e.g. simultaneity, endogeneity and selection bias). FP1 will strive to

maintain balance between the use of latest advances (e.g. in quasi-experimental approaches and operationalizing experimental designs) and the limited resources available – while ensuring the strategic coverage of the target agro-ecologies, regions, and social groups (poor men and women, youth).

Gender strategic research will build on latest advances and employ novel quantitative, qualitative and mixed methods. Systematic sex and age-disaggregation in data collection will refine ability to pursue gender analysis within households. Value chain studies will comprise market and business development and use mixed methods to assess, among others, input and output market inefficiency, market distortions, horizontal and vertical wheat value chain coordination and integration, comparative advantage and social inclusiveness. Therefore, FP1 will aim at making methodological advances in all these respects and contribute to the literature while also enhancing the impact of WHEAT innovations in wheat AFS.

FP1 builds on a body of previous Phase I and transition work:

- **Foresight and targeting:** Recent published WHEAT work from CIMMYT and ICARDA includes work in relation to germplasm (Hyman et al, 2013; Morgounov et al 2013; Pardey et al. 2013) and sustainable intensification (Schulthess et al 2015). Climate change is an integral dimension, particularly in terms of implications for wheat production in the developing world (Neufeldt et al, 2013; Stirling et al., 2014).
- **Adoption and impact:** International agricultural research has helped shape the current global wheat outlook (Shiferaw et al., 2013), with good adoption and impact of improved CGIAR wheat (Lantican et al. 2016). Ethiopia is a central success story and case in ongoing impact assessment work, both in terms of traditional varietal studies using representative panel data (Shiferaw et al., 2014) as well recent explorations into the use of DNA fingerprinting for unambiguous varietal identification (ongoing, to be published in WHEAT-2). Recent published wheat related adoption/impact work from CIMMYT and ICARDA includes selected germplasm studies (Ali et al 2015; Ghimire et al, 2012; Krishna et al 2016; Mazid et al 2015) and sustainable intensification practices (Ali et al 2016; Aravindakshan et al 2015; Aryal et al 2015a, 2015b; El-Shater et al 2016; Keil et al 2015; Krishna & Veettil, 2014; Krupnik et al, 2015a, 2015b; Rahut et al in press; Sapkota et al, 2015; Singh et al, 2012; Teshome et al 2016, in press; Yigezu et al., 2013, 2015). Another body of published work looks at tradeoffs and gradients associated with adoption of wheat innovations, particularly sustainable intensification (Erenstein, 2012; Erenstein et al., 2012; Valbuena et al, 2012, 2015).
- **Gender and social inclusiveness:** Recent published WHEAT work from CIMMYT and ICARDA includes studies looking at gender and climate change (Beuchelt & Badstue, 2013; Mehar et al 2016).
- **Value chain opportunities:** Recent published WHEAT work from CIMMYT and ICARDA includes assessments of alternative wheat markets (Mason et al 2015); opportunities related to seed supply (Ali et al 2015; Ghimire et al, 2012; Krishna et al 2016); and institutional innovations that interact with WHEAT innovations (Qureshi et al 2015; Mittal & Mehar, 2012, in press).

### 2.1.5 Lessons learnt and unintended consequences

FP1 helps WHEAT achieve its impacts and contribution to SRF targets within the available resources and mandate. FP1 helps the transformation of a commodity focus in phase-1 to an AFS focus in phase-2. FP1 has been reorganized to reflect organizational learning and more strategic focus as compared to phase-1. Foresight and targeting are significantly strengthened – to help foster a more pro-active research portfolio and more rigorous prioritization in and across WHEAT FPs systematically based on strategic foresight. In part the foresight and targeting draws on the close collaboration with PIM, but includes strengthening of both internal capacity and other strategic partnerships to provide both timely and nuanced responses and a broader suite of approaches. Climate change is a clear driver taken into account – both in relation to a close collaboration with CCAFS and as cross-cutting in WHEAT-2. A tradition of collaboration and empirical realism allows FP1 to qualify and understand how changes at multiple levels are changing the R&D landscape and local AFS priorities and implications. Crisis's grab the headlines and shape political priorities – but it is the incremental changes over time that shape the next crisis before it unfolds. FP1 aims to better understand and document these with the necessary evidence base to help reshape priorities and investment needs – including the changing R&D landscape and the public good niches that provide the highest value for money.

The CoA around adoption and impact was refocused and aligned with the WHEAT impact assessment strategy – including a clearer focus on learning and feedback loops to enhance impact. This CoA also looks into any unintended consequences of wheat innovations and corresponding R&D implications for WHEAT AFS – including socio-economic, environmental and institutional. Being an integral part of the CRP provides the necessary inside views and nuances while adhering to objectiveness and scientific quality. The significance of gender (women and youth) for successful delivery is increasingly mainstreamed into the scaling work in FP3 and FP4. Resource constraints implied that the WHEAT gender team was constrained and stretched in Phase I – but with time we were able to strengthen the available funding for the gender team during the transition phase with new bilateral resources. Youth was implicitly considered as part of gender in WHEAT I – but received additional impetus in the pre-proposal call and is an area being strengthened in 2016 so as to become an integral part in WHEAT II, building and incorporating lessons from the Phase I Dryland Systems CRP and strategic partners. A new CoA on identifying value chain constraints and opportunities to enhance smallholder livelihoods has been added.

FP1 also drew more lessons from the Phase I and extension period implementation. For one, FP1 fully endorses the CRP second portfolio and the increased alignment and docking with other CRPs – a significant improvement over Phase I (see FP1 partnerships section). Indeed, the CRP portfolio more clearly shows the complementarities between the CRPs, in much the same way as FP1 complements the other WHEAT FPs. Still there is need to manage transaction costs and keep the eye on the ball so that we continue to deliver. There are also clear advantages of having FP1 internal to the CRP – able to provide the higher level cross-FP view, with the other FPs more thematically focused. FP1 primarily comprises social sciences – but it is not a disciplinary silo; and there are clear cross-linkages with other FPs.

Funding for WHEAT has been a perpetual constraint and calls for strengthening its business case – although efforts to do so were undermined by the continuously evolving funding cuts and uncertainty. W1&2 still provides essential coherence to the FP1 portfolio – but its strategic use is somewhat curtailed by the annual uncertainty and the limited amount. It does enable to seed new areas (e.g. commissioning studies) but is inherently limited in its ability to build up the strategic in-house capacity and partnerships with the time and freedom to focus on the real strategic issues.

## 2.1.6 Clusters of activity

### FP 1.1 Informing R4D strategies through foresight and targeting

Foresight analysis, ex-ante impact assessment and targeting are crucial research components enhancing the understanding of the evolving context in which WHEAT operates. Given the research-to-adoption lag, trends of future beneficiary needs as well as technology, biophysical, socioeconomic, policy and institutional opportunities and constraints should accurately inform current R&D investment priorities. Furthermore, WHEAT must take into account the plausible and probable biophysical, socio-economic and politico-institutional context at the time when technologies, including varietal improvement, come to fruition. Both the future needs of WHEAT beneficiaries as well as the context in which they will operate are shaped by a number of factors: global drivers of change, pressures and events (e.g. weather extremes, new biotic stresses, sharp changes in food prices).

WHEAT's diverse portfolio of innovations that are at different developmental stages (discovery, validation, and scaling-out) and the spatial and dynamic dimensions of wheat AFS call for due consideration of tradeoffs (e.g. effects on poor producers vs. poor consumers, intensification vs. environmental risk) and the identification of spatially diverse needs and opportunities and associated implications for recommendation domains and innovation targeting. The information so generated will then be used to prioritize interventions and locations. For all major WHEAT innovation pipelines (FP2 to FP4) product development and placement/targeting are to be based on systematic and forward-looking (up to 2022) analyses and monitoring as they pass from discovery through validation and scaling-out.

FP 1.1 will build on increasing amounts of georeferenced data and modeling approaches. The global drivers of change require the use of global analysis tools while the effects of the drivers, pressures and events have varying regional, national and local repercussions. This implies that different sets of tools are also used to analyze the effects at different levels of aggregation. We recognize at least four levels of aggregation where analysis is needed in order to make predictions and inform research priority setting. The first is the global level, the second is the meso regional/national level, the third is the community/landscape level and the fourth is the household/individual level (both resource poor producers and consumers). Each level requires different tools, techniques and methodologies, both quantitative as well as qualitative in order to assess the future for R&D. Ex-ante impact assessment will particularly focus on the potential contributions to the CGIAR 2022 (and 2030) targets. The CoA envisages an initial foresight exercise and subsequent updates and refinements to (i) identify potential opportunities, threats and game changers for wheat AFS; (ii) assess how major drivers like climate change and rural transformation will alter wheat AFS in the developing world; and (iii) assess future preferences of wheat producers and consumers and implications for wheat innovations.

The analysis conducted in FP 1.1 is closely linked to WHEAT's other FPs. Foresight will inform the breeding pipeline and germplasm delivery (FP2 and FP3) about plausible and probable changes in key traits and products that may become important in the future; and similarly inform innovation pipelines for sustainable intensification and scaling (FP4). Within FP1 there is close collaboration with the other CoAs, sharing tools, techniques and methodologies and drawing on the current and historic findings related to changing circumstances related to technology adoption, value chains, and social inclusiveness related to gender, age and other discriminating characteristics of target beneficiaries. Especially the gender-youth nexus which has been less prominent in past global and meso-level models, will receive full attention. FP 1.1 will thus assess the changes in socio-economic, politico-institutional, and technological environments both within and outside the agricultural sector and assess implications for WHEAT innovations in terms of targeting agro-ecologies, regions, traits, and social groups and guide WHEAT investment for maximum impact.

### **FP 1.2 Enhancing learning, adoption and impacts**

Recent trends in resource availability for R&D and donor demands for immediate and sustained impacts make it increasingly critical to provide tangible evidence on value for money. FP 1.2 will therefore provide proper documentation of current levels of adoption and impacts, germplasm performance and sustainable intensification and analysis of pathways, opportunities and constraints for furthering large scale adoption in wheat AFS. It will also provide evidence of WHEAT's achievements and its contribution to the overall SRF targets, validation of the theories of change/-impact pathways, and basis for immediate/future learning at all scales. Adoption and impact studies will assess the roles of macro-level policies, institutions, markets, social and gender relations, and agro-ecologies to identify (with FP 1.4 and FPs 2, 3 and 4) feasible options and incentive and disincentive effects in the whole wheat value chain. It will also conduct detailed micro analysis to identify farm and farmer characteristics associated with adoption (e.g. assets, environments, relations, technology attributes, time and consumption preferences and risk behavior). FP 1.2 will therefore play a key role in developing better understanding of adoption processes and making robust, evidence based, practical and actionable recommendations that meet the needs and priorities of the targeted research, policy and institutional audience in wheat AFS. By so doing, FP 1.2 will help in: 1) increasing the effectiveness of WHEAT R4D interventions through the development of better-targeted innovations and focused scaling; 2) designing more effective strategies and creating conducive environments for adoption and impacts of WHEAT innovations at scale; and 3) guiding priority setting and targeting under FP1.1 - all of which will increase the likelihood of WHEAT achieving impact.

This CoA will continually institutionalize gender (and age)-disaggregated data through close and systematic monitoring of progress towards achieving wider and equitable adoption and impacts of technological and institutional innovations that are being scaled-out. The impact assessment strategy will specify the analytical framework and minimum data at all appropriate levels and scales. The CoA will use the latest advances in adoption and impact assessment tools to generate relevant and credible evidence (using both quantitative and qualitative methods as appropriate). In collaboration with the community of practice in general and PIM in particular, FP 1.2 will also aim at making methodological contributions to the literature particularly in the area of adoption and impact measurement in AFS context. It will also collaborate with SPIA to explore innovative approaches (e.g. DNA fingerprinting) for determination and documentation of adoption and better estimation of impact. Criteria for selection of impact indicators will be aligned to SRF 2022 (and 2030) targets. For outcomes and impacts, progress indicators will be developed and monitored at an agreed frequency during the period until impact.

The CoA envisages a two-tier assessment of WHEAT innovations. The macro level will focus on WHEAT germplasm use across the developing world, with a systematic stock taking of varietal releases, WHEAT attribution and estimated adoption. This builds on earlier and recently re-initiated global efforts (Lantican et al. 2005), supplemented by regional studies (e.g. SIAC-Asia). At the micro-level, systematic impact studies will build on a WHEAT I initiative for the collection of consistent, comparable and multi-country panel data sets for building useful and comprehensive database that will be readily available for easy aggregation and multi-scale analysis using different methodological options. Building on the experience of WHEAT I and to enhance documentation and facilitate learning and experience sharing, FP 1.2 will maintain balance between regions and countries with different levels of current/potential adoption and impacts. Current adoption and impact assessments in Ethiopia, Morocco, Uzbekistan and Turkey will provide the impetus for similar work in the future.

### **FP 1.3 Enhancing gender and social inclusiveness**

Acknowledging the existence and paying due attention to differences in sex, age, and social and economic status is key in developing inclusive and effective livelihoods strategies in any R&D endeavor.

To enhance gender and social inclusiveness there is a need for: 1) strategic and integrative gender research which aims at answering fundamental and overarching questions related to equity, equality, access and empowerment and mechanisms for attaining favorable gender outcomes; and 2) gender mainstreaming which focusses more on how to make R4D gender-sensitive at all levels so as to ensure inclusive and equitable benefits. While WHEAT pursues a combination of strategic, and gender mainstreaming research, FP 1.3 will mainly focus on strategic research providing overall strategic leadership for gender research and guidance for systematic integration of a gender and social inclusion perspective across all WHEAT Flagships. The CoA addresses a number of overarching research questions (Table FP1-3) using a mix of quantitative and qualitative analysis in WHEAT gender and socio-economic research. It envisages that by 2022 gender/social inclusion lenses will be routinely applied to major WHEAT innovation pipelines and assessments. FP1.3 will make differentiated recommendations on choice of interventions and guide scaling-out strategies to systematically support social inclusion and the empowerment of women and youth in wheat value chains by 2022.

**Table FP1-2. Overarching gender research questions for WHEAT FP1.**

<b>FP1: Enhancing WHEAT's R4D strategy for impact</b>
<ul style="list-style-type: none"> <li>• How do the roles, resources, constraints and priorities of women and men of different age groups differ in wheat AFS? What are the implications of this, e.g. for technology development and diffusion?</li> <li>• How do gender relations and access to resources influence adoption of new wheat technologies by women and men of different age groups? And how does introduction of new technologies influence gender relations?</li> <li>• How to ensure that introduction of improved wheat technologies benefits both men and women of different age groups?</li> <li>• What is the capacity for gender responsive technology generation and dissemination of R&amp;D partners, including advisory services, input- and service providers, and seed enterprises?</li> <li>• What are the gendered impacts of wheat R4D, who benefits, and how?</li> </ul>

WHEAT Phase I achieved a strong momentum focusing on establishing gender and social inclusion as a prioritized research area for the CRP. In Phase II FP1.3 will focus mainly on consolidating the systematic and rigorous application of established quantitative and qualitative gender and social research methods in the context of wheat AFS. Strategic gender research under FP1.3 will therefore build on past and ongoing work such as GENNOVATE initiative; understanding gender in wheat-based livelihoods for enhanced R4D impact; gender and small-scale mechanization (Eerdewijk and Danielsen 2015); and current work under many projects including the AfDB supported SARD-SC project in 12 African countries.

By prioritizing and channeling investments, FP 1.3 will strengthen gender in WHEAT frameworks and procedures (e.g., project cycle, operational policies and M&E). It will also strengthen overall capacity to identify and address gender issues in wheat AFS through partnerships (e.g. with KIT and the Gender and Development Networks) and the development of different mechanisms (e.g. gender competency framework and modular gender equality and professional capacity enhancement programs). This CoA will also inform the priority setting and targeting work under FP1.1 and aim at generating policy and institutional recommendations that enhance equitable and inclusive development in wheat AFS.

#### **FP 1.4 Identifying value chain opportunities to enhance smallholder livelihoods**

Traditional farming systems in the developing world are commonly perceived as being only a means of subsistence rather than a viable business. The reality however is that, though at varying degrees, almost all farm households are involved in marketing of at least a portion of their produce. Creating sound business models with good market linkages where input utilization, technology generation and adoption, and marketing decisions are demand-driven with due consideration of the needs and preferences of all actors along the value chain is a prerequisite for improving agricultural livelihoods. Given their dynamic nature, value chains evolve in response to globalization, urbanization, rural transformation, policies and consumer preferences. Therefore, WHEAT's R4D agenda needs to be informed and adapt to changes in urban-rural exchange, emerging market(ing) opportunities and current and potential constraints including the evolution of the trends, quantity and quality demands, and market segmentation for local value addition for both bread and durum wheat. To this effect, FP 1.4 will conduct pro-poor, gender-responsive market and value chain analyses (VCA) to identify constraints and opportunities to enhance smallholder livelihoods in wheat AFS. It will explore opportunities for smallholder farmers to become more competitive in the market, to raise their productivity and returns from farming, and to foster pro-poor growth in wheat AFS. Particularly, it will identify opportunities for women and the young, who often also are actively engaged in post-harvest processing and marketing.

Conducting thorough VCA requires a lot of resources and time. Therefore, the VCA analysis work under FP 1.4 will be strategically divided into two complementary steps. Rapid value chain assessment with a proper gender lens will be conducted to provide a rapid yet systematic scoping and classification of opportunities and bottlenecks in wheat AFS and identify initial entry points that are equitable and gender sensitive. Benchmarking surveys of wheat value chains in selected countries will more rigorously analyze wheat AFS in terms of the existing structure, current and potential opportunities/constraints including capacity development opportunities, market infrastructure, availability of finance, and gender relations. Such VCA will identify priorities and design effective interventions for WHEAT R&D, with due attention for the wellbeing of poor men and women, producers and consumers and youth in wheat AFS. The geography of wheat presents particular challenges for linking supply and demand and developing local value chains in wheat AFS. Alexandratos and Bruinsma (2012) predict that wheat food consumption per capita will continue to rise becoming the leading food staple in SSA, South Asia, and Latin America. Wheat consumption growth in some developing regions will be accompanied by continued growth in wheat imports, posing concerns that this may spur governments to pursue self-sufficiency through domestic production without due attention for economics and comparative advantage (SSA and WANA are cases in point).

FP 1.4 will conduct farm-to-fork VCA in both established and emerging wheat producers and assess implications for WHEAT priorities. In traditional wheat economies, economic development and urbanization are seeing increasing demands for quality by processors and consumers and associated value chain opportunities; as well as much needed opportunities for the youth to ease migratory pressures and civil unrest. Sub-Saharan Africa has an increasing shortfall between wheat consumption and production and whose sizable and costly imports of wheat grain present income opportunities for smallholder farmers in selected agro-ecologies – with recent such efforts in Rwanda and Zambia (ASARECA and IFAD funded projects) as well as 12 other SSA countries (SARD-SC project funded by AfDB). The main outcome of this work is to provide WHEAT development partners with evidence based information that could be used to develop interventions along the value chain for the improvement of livelihoods in wheat AFS. Also, knowledge generated in this work could help better target breeding (incorporating preferred traits by farmers (men and women), processors, feed millers, agro-processors and consumers). This CoA also identifies and assesses input value chain opportunities, which then

dovetails into work related to developing seed markets under FP3; and non-seed input value chain development work, such as mechanization and associated business model development under FP4.

### 2.1.7 Partnerships

FP1 aligns with the CRP WHEAT partnership strategy. FP1 occupies a unique niche to generate international public goods to enhance WHEAT's R4D strategy for impact. Being led by scientists from the two lead wheat-centers in the CGIAR provides a distinct comparative advantage – providing a unique AFS focus and R4D perspective, and providing an objective and neutral partnership platform to link with strategic partners across the globe. Enhancing WHEAT's R4D strategy for impact hinges on multi-disciplinary collaborative research across programs and institutions. Central to FP1's mandate are multifaceted, inclusive and strategic partnerships within the confines of a unique AFS perspective, i.e. the “wheat focus” and its theory of change.

Internal to the CRP and central to its mandate, FP1 provides horizontal guidance to WHEAT and supports and contributes to all the other FPs. Whereas FP1 is inherently multidisciplinary, it has a high contribution from the social sciences, which partner with other disciplines to address strategic R4D issues in wheat AFS. These internal partnerships vary by CoA. FP1's foresight and targeting work has clear linkages with the discovery and upstream work in FP2 and FP3; as well as with the system dynamics in FP4. FP1's adoption, learning and impact work increases in relevance from the proof-of-concept level to downstream scaling out levels in FP3 and FP4. Gender and youth are most obvious in the downstream levels of the latter 2 FPs – but need due attention in the higher levels.

External to the CRP, FP1 aligns with AFS CRPs (e.g. Maize, Rice, DCL) and docks with integrative CRPs (e.g. PIM, CCAFS and A4NH). This includes specific collaborative projects, site integration and to ensure synergies in meeting the SRF goals. Partnership with DCL will be strengthened to capitalize on its strategic components of the former Dryland Systems CRP and to draw on its relevant systems work and learnings (including youth strategy). The docking of foresight work with PIM has a particularly strong foundation that will be pursued. PIM thereby focuses foresight at the higher multi-commodity level whereas WHEAT brings the more granular and focused AFS level. WHEAT thereby provides a useful refinement and disaggregation of R&D implications for technologies and innovations; of the major drivers as they apply to wheat AFS; and of ground level realities and agro-ecologies. New opportunities to strengthen docking with PIM beyond foresight are being pursued. Similarly there are ongoing discussions to explore new opportunities with CCAFS in relation to joint resource mobilization and with A4NH in relation to food system innovations and understanding of changing diets.

Non-CGIAR partners include an array of advanced research institutes (ARI's) and national agricultural research systems (NARS) in target geographies (Table FP1-4). There is a long tradition of partnerships with NARS across the target geographies – particularly strong where the CRP lead centers have staff on the ground but spilling over into neighboring geographies. Some of these partnerships are directly embedded in larger bilateral projects lead by other FPs – but offering active partnership networks that facilitate wide consultation and follow up. Regional partner consultation also occurs through commissioned studies (e.g. ongoing wheat markets foresight study with ReNAPRI network in ESA), conferences/meetings (e.g. 2014 global stakeholder meet in Turkey; 2015 wheat conference in Australia) and through regional organizations (e.g. ASARECA; CCARDESA; APAARI). Particularly the partnerships with ARIs have evolved and been strengthened during the transition phase. Guiding the partnerships are the added value of partners in terms of scientific contribution and enhancing the probability of impact, associated complementarities, and synergies with in-house capacity and needs.

**Table FP1-3. Partners by CoA for WHEAT FP1.**

CoA	Type	Partner name	Key contribution	
1.1	CGIAR	PIM/IFPRI	Foresight and bio-economic modelling (Global Futures; PIM 1.1)	
		CCAFS	Bio-economic modeling	
	ARI	Cornell U (Coffman et al, BGRI)	Wheat rust surveillance (Durable Rust Resistance in Wheat)	
		U of Minnesota (Pardey et al)	Impact and foresight of Wheat; Ex-ante assessment leaf rust & yellow rust	
		Wageningen UR (Ruben, Wals et al)	Poverty, food security and nutrition linkages; geo-spatial framework for mapping wheat production and consumption, upscaling and impact assessment	
		U of Nebraska (Cassman), WUR (van Ittersum)	Geospatial framework/supporting database from the Global Yield Gap Atlas	
		U Florida (Asseng et al.)	Crop modeling	
		Oak Ridge Nat. Lab (Jahn et al.)	Data analysis and integration	
	NARS	Key countries in Asia, Africa and LA (see 1.2 below)	Research implementation, including context-specific knowledge, expertise and policy linkages	
	1.2	CGIAR	PIM/IFPRI	Impact assessment community of practice (PIM 1.2)
ARI			DArT Australia	DNA fingerprinting
NARS/SRO		Key countries in Asia, incl India (ICAR-NCAP); Pakistan (PARC, NARC); Bangladesh (BARI); China (CAS); Turkey; Uzbekistan; Tajikistan; Iran	Research implementation, including context-specific knowledge, expertise and policy linkages	
		Key countries in Africa, incl Ethiopia (EIAR); Kenya (Tegemeo; KALRO); Morocco (INRA); Egypt; Rwanda; Zambia; Nigeria		
		Mexico (INIFAP, CP)		
		SROs (ASARECA; CCARDESA; APAARI)		
1.3		CGIAR	PIM/IFPRI	Gender tools, collaboration, community of practice
			ARI	Royal Tropical Institute (KIT)
			Inst of Development Studies (IDS, Sumberg et al)	Youth
		ARI	Universities of Glasgow Caledonian (Jafry et al); Western Ontario	Research collaboration, comparative advantage with regards to specific knowledge and skills, networking, brokering
	NARS		Key countries (S and Central Asia; Africa; see 1.2 above), BDIARI, Turkey	
	Development, extension, NGOs	ILO; Int. Centre for Women's Leadership, Canada; GIZ; WOCAN; Grameen; KPNK; Fondo para la Paz, Uzbekistan Institute of Market Reform	Research implementation, Context specific knowledge and expertise, subject matter expertise, research-into-use collaboration	
	1.4	CGIAR	PIM/IFPRI	Value chain analysis tools (PIM 3)
A4NH			Food systems	
Regional		ASARECA; CCARDESA	Wheat value chain opportunities in eastern and southern Africa	
ARI		Michigan State U (Jayne et al); U of Pretoria; ReNAPRI network	Wheat markets foresight in eastern and southern Africa	
		NARS	Key countries in Asia, Africa and LA (see 1.2 above)	Research implementation, including context-specific knowledge, expertise and policy linkages

### 2.1.8 Climate

Climate change is one of the societal grand challenges and a cross-cutting theme for the CRP WHEAT overall. FP1 enhances WHEAT's R4D strategy for impact and as such takes due cognizance of climate change and its implications, particularly for adaptation. FP1 helps assess how climate change could transform wheat AFS and associated food security and resilience. Most obvious perhaps is climate change as part of foresight analysis (CoA 1.1) – an integral driver of the evolution and stability of wheat production over the coming decades. Climate change also increases weather variability and the incidence of stresses and thereby the riskiness and potential returns to wheat production and innovations. FP1 assesses the adoption and impacts of various climate-smart agricultural practices generated by WHEAT including improved wheat germplasm (drought and heat tolerant) and sustainable intensification (e.g. laser land leveling). FP1 also takes due cognizance of interactions between climate change and social equity, including implications for gender, social inclusion and youth in terms of differential location, asset base and/or roles in wheat AFS. Finally, climate change affects wheat value chains, be it in terms of the geography of production, processing and consumption or driving the demand and markets for associated innovations (e.g. agri-business models for seed and service providers). Some of the work will be pursued in collaboration with CCAFS, other work directly as an integral part of WHEAT. FP1 will share its results with decision makers and development partners and create awareness about climate change adaption prospects in wheat AFS.

### 2.1.9 Gender

FP1 will align with the WHEAT gender strategy, not least as FP1 is the institutional home for both the WHEAT gender team and gender strategy. It is also home to a dedicated CoA, 1.3, focused on strengthening the integration of gender, youth and social inclusion into wheat AFS research. The approach combines strategic gender research and integration of gender into technical wheat research across all FPs, including the other CoA's in FP1. To support and facilitate this process a special component of the CoA is dedicated to strengthening capacity for gender responsive approaches and mainstreaming of gender into operational frameworks and procedures. In order to strengthen the evidence base for gender analysis, FP1 has standardized sex-disaggregation in all its people-level data collection and analysis, including in relation to ex-ante and ex-post impact assessments. The findings of gender research in FP1 feed into and inform research priority setting and targeting across WHEAT.

Overall FP1 contributes to gender equality and social inclusion in wheat AFS R4D by strengthening the evidence base through gender research, foresight analysis, adoption studies, impact assessments and value-chain development; as well as through evidence based policy recommendations and research targeting and priority setting. In addition to housing the WHEAT core gender team, FP1's other social scientists are active gender and youth ambassadors to ensure the social inclusiveness of WHEAT.

### 2.1.10 Capacity Development

FP1 will align with the WHEAT approach to Capacity Development (see Annex 3.3) and CGIAR Capacity Development Framework. Capacity development will revolve around increasing the capability of partner organizations and beneficiaries to innovate, learn and adapt with focus on mainstreaming of strategic thinking, theories of change, and gender sensitive approaches. Other key elements include increasing organizational and institutional capacity in more fully understanding of impacts and R&D implications of wheat innovations.

Capacity will also be enhanced through sharing findings within the CRP, the provision of targeting information and extension material packages and other innovative training and learning. In conducting a collaborative research agenda and research on scaling out pathways to enhance dissemination of adoption, partner's capacity will be improved through exchange of information, lessons and insights and outputs. The dissemination of research information and associated data, marketing and communication products on research findings and benefits, policy briefs will also contribute to partners' capacity development as well as the provision of policy advice to multiple audiences (CRPs, multilateral organizations, donors, local and regional governments) to influence policy-making.

FP1 uses on-the-job collaboration, fellowships and exchange workshops, knowledge sharing methods and tools to strengthen multi-disciplinary approaches and analytical rigor. In particular, the FP1 will contribute to develop capacity in equity and inclusion by improving the capacity of young women and men to participate in decision-making and to facilitate their access to markets and value chains opportunities and job opportunities. Facilitated by its partnering with ARIs, FP1 also actively pursues opportunities to integrate students (preferably PhD) in the CoA's – welcoming internships and particularly thesis/dissertation research under WHEAT on priority topics.

### 2.1.11 Intellectual asset and open access

FP1 will align with the WHEAT intellectual asset and open access management, and as such adhere to the associated CGIAR and institutional principles. FP1 generates international public goods to enhance WHEAT's R4D strategy for impact and the underlying principle is to make these as easily and widely available. Under FP1, scientists develop tools for data management, -stewardship and -analysis, to improve modeling and make better use of empirical data. These will be designed with OA/OD in mind (e.g. provide access). Researchers will make their well-documented yet adequately anonymized and non-confidential raw data (e.g. household surveys) available to other scientists through Dataverse. Prior to uploading to Dataverse data may be shared on a case by case basis through a data sharing agreement. Although the focus is on international public goods, any underlying confidential data - including sensitive private sector perspectives and trade data - will be respected and treated as such and associated publications will be adequately synthetic and anonymized. Publications are a major FP1 output and these will be made easily accessible. To maintain science quality, Scopus-recognized journals remain the preferred outlet, and to the extent possible papers will be published as open access therein. Where resources limit the possibility of open access, efforts will be made to facilitate access to the underlying research through pre-prints and individual requests within the allowed space. To ease access, main findings will also be shared through other communication media, including policy briefs with adequate cross-referencing to the underlying detailed studies.

### 2.1.12 FP management

FP1 is managed jointly between the two lead centers – with both joint FP coordination and co-CoA leads. The co-leadership allows both centers to have a clear co-leading role and provides clear focal points within each organization for each CoA and the FP as a whole. Co-leadership is further warranted by the geographic complementarities between the two lead centers. Co-leadership also eases integration with WHEAT’s other FPs – critical in view of FP1 providing horizontal guidance.

**Table FP1-4: FP and CoA Leaders**

FP/CoA Structure	FP1 Coordinators and CoA leaders	
	CIMMYT	ICARDA
FP1 Enhancing WHEAT’s R4D Strategy for Impact	Olaf Erenstein	Yigezu Yigezu
1.1 Informing R4D strategies through foresight and targeting	Gideon Kruseman	Aymen Frija
1.2 Adoption, impact and learning	Aziz Karimov	Yigezu Yigezu
1.3 Gender and social inclusiveness	Lone Badstue	Dina Najjar
1.4 Value chain analysis	Aziz Karimov	Girma Tesfahun Kassie

### 2.1.13 Budget summary – see FP budget template

## FP2: Novel diversity and tools for improving genetic gains and breeding efficiency

### 2.2.1 Rationale, scope

#### Research Focus and Science Quality

FP2 harnesses new scientific opportunities to develop and validate tools and to provide the “fuel” of characterized genetic diversity that is mainstreamed to enhance the efficiency of germplasm improvement efforts in FP3. Rates of genetic gain in breeding activities of FP3 are accelerated by such novel tools and methods; for example, the discovery and deployment of allelic diversity and molecular markers for key traits; the development of more accurate, high throughput phenotyping methods and “pipelining” of data analysis methods; the development and optimization of breeding methods (e.g. genomic selection and high-throughput proxy trait selection); or tools that simplify storage, analysis and visualization of more comprehensive data sets. As a result, FP2 is an essential “tool discovery, validation and deployment” step in the impact pathway of WHEAT, linking priority setting (FP1) to germplasm development (FP3), use of such germplasm within the sustainable intensification of wheat-based systems (FP4) and for scale-out (FP3.7, 4.4). Significant progress in tool development and mainstreaming has been achieved during WHEAT Phase I, including through the following projects:

- MasAgro Bioversidad (Seeds of Discovery), resulting in genotyping-by-sequencing of nearly 50% of the CGIAR wheat landrace and wild-relative accessions, plus phenotypic information for several key traits for core sets. CIMMYT and ICARDA together hold around 200 000 accessions in their gene banks.
- The CIMMYT hosted and BBSRC/USAID-led International Wheat Yield Partnership (IWYP), the Heat and Drought Wheat Improvement Consortium (HeDWIC) and the Biological Nitrification Inhibition (BNI) projects are discovering and validating physiological mechanisms and allelic diversity to enhance breeding efforts to develop new wheat cultivars with increased yield, tolerance to the expected effects of climate change and more efficient use of fertilizer and water resources.
- Feed the Future Innovation Lab for Applied Wheat Genomics (with Kansas State University), the Durable Rust Resistance in Wheat (DRRW) and the Genomics and Open source Breeding and Informatics Initiative (GOBII), both with Cornell, are enabling pioneering uses of high density genomics information for mainstreaming in wheat breeding programs, and supporting the optimal integration of breeding technologies in WHEAT.
- The Integrated Breeding Platform (IBP), allowing the implementation of efficiency-enhancing breeding applications in the public sector, including NARS and companies in low and middle-income countries.
- MasAgro Trigo (wheat) and other projects are developing and validating remote sensing, high-throughput, precision phenotyping approaches that promise to increase the rates of genetic gains in wheat breeding by increasing the heritability and selection intensity for key traits.

During WHEAT Phase I, we generated genomic profiles of almost 100,000 wheat samples. This achievement is now set to benefit from integration with the wheat genome sequence to be publicly released by the International Wheat Genome Sequencing Consortium in April 2016. The genomic profiles and molecular markers generated by FP2 can now be mapped to specific chromosome regions on the reference genome. This genomic anchoring provides a much improved framework to enhance the identification of novel, high value genetic variation associated with adaptation, stress response, pest resistance, improved yield, nutritional and processing quality.

## 2.2.2 Objectives and targets

**Expected contributions to CGIAR SRF.** The theory of change underlying FP2 shows how outputs contribute to specific sub-DOs: **Enhanced genetic gains** (through tools and methods that enable more efficient management of breeding programs; new/additional genetic variation; increased selection intensity and decreased cycle time in breeding programs); **Increased conservation and use of genetic resources** (databases and informatics tools that enhance accessibility of genotypic, phenotypic and other data, enhanced use of genetic resources, including those held in germplasm banks); **Enhanced capacity to deal with climatic risks and extremes** (through FP3 and FP4); **Enhanced institutional capacity of partner research organizations** (open access tools e.g. for electronic data capture or for data analysis and decision support; methods for enhancing efficiency in breeding, tools, methods for diversity assessment, identification and use of beneficial alleles; enhanced collaboration with partner organizations to develop research outputs; capacity development courses, workshops, graduate student mentorship, visiting scientists, etc.).

### **Key performance indicators for FP2 include:**

- Number of lines with novel diversity for key traits used by FP3 and other wheat breeding programs
- Number of breeder-ready markers/high-value haplotypes for prioritized traits identified and validated (under FP2) and deployed in breeding programs (FP3)
- Decision support tools developed, disseminated and used by WHEAT partners
- Number and types of open access data available, and statistics about their use
- Number of public/private institutions trained on enabling tools for increasing genetic gains
- Number of public/private institutions implementing novel breeding strategies developed under FP2
- Increase in selection accuracy due application of breeding technologies.

### 2.2.3 Impact pathway and theory of change

The FP Novel Diversity and Tools' theory of change was developed during a workshop with scientist teams from both MAIZE and WHEAT CRPs. A participatory approach was used to capture all views, experiences and known evidence into the theory of change. The workshop participants were able to increase their understanding of the CGIAR Strategy and Results Framework and awareness of results-based management concepts. The workshop was also structured to encourage sharing and learning across both CRPs.

Using the CGIAR Results Framework's sub-intermediate development outcomes (IDOs) the team agreed to focus on two sub-IDOs and three cross-cutting sub-IDOs:

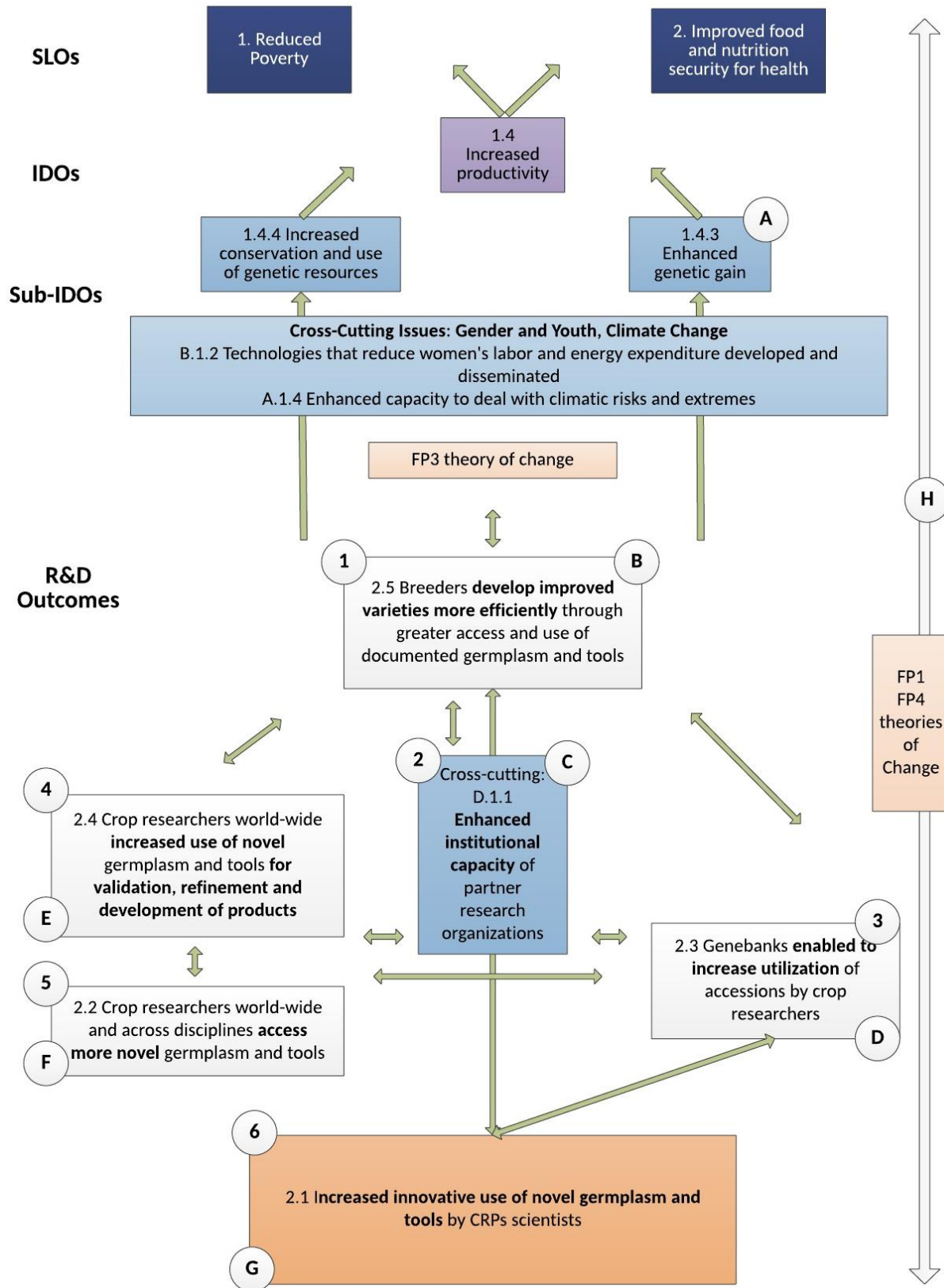
- 1.4.3 Enhanced genetic gain;
- 1.4.4 Increase conservation and use of genetic resources;
- A.1.4 Enhanced capacity to deal with climatic risks and extremes;
- B.1.2 Technologies that reduce women's labor and energy expenditure developed and disseminated;
- D.1.1. Enhanced institutional capacity of partner research organizations.

Other sub-IDOs were noted by the team as important to programming given that they overlap with the above sub-IDOs of focus. Regarding the sub-IDO 1.4.3 related to enhanced genetic gain, the team noted that this sub-IDO encompasses all elements of gain sought by the CRP, including yield, abiotic, biotic and quality traits.

Based on these areas of focus, the team agreed that this Flagship project contributes to reducing poverty (SLO 1) and improving food and nutrition security for health (SLO2) by the mean of increasing productivity (IDO 1.4) and enhancing the cross-cutting issues of climate change (A), gender and youth (B) and capacity development (D).

A number of research and development outcomes were identified and a pathway of change was created demonstrating the causal relationship between outcomes and sub-IDOs. During this process, partners involved in the pathway of change were identified. Current and proposed interventions and associated outputs to support the achievements of the outcomes were mapped. Assumptions describing the contextual underpinnings of the theory as well as the risks that may have the potential to undermine success were documented.

This theory of change will be the foundation for the monitoring, evaluation and learning plan. The monitoring plan will consist of a continuous process of collection and analysis of data based on a set of indicators directly related to the performance of the CRP at the output and outcome levels; the key assumptions of the theories of change; and the critical risks. The theory of change will also be the basis for evaluating the Flagship project as well as reflecting on lessons and program improvements.



Assumptions and Risks	Interventions and Outputs
<p><b>A</b> • Enhanced genetic gain encompasses all elements of gain sought by the CRP (e.g., yield, abiotic, biotic and quality traits)</p> <p><b>B</b> • Breeders are adequately funded and are willing to adopt and adapt documented germplasm and tools</p> <ul style="list-style-type: none"> <li>• Risks: <ul style="list-style-type: none"> <li>○ Relevant climate predictions are not precise</li> <li>○ Unanticipated combinations of abiotic stresses occur</li> <li>○ Unanticipated pests and/or diseases appear (biotic) requiring new research in germplasm and tools</li> </ul> </li> </ul> <p><b>C</b> • Conducive environment for capacity building</p> <ul style="list-style-type: none"> <li>• Existence of effective communication and dissemination capacity and systems</li> <li>• Effective assessment of the needs and capacity of partners (internal and external)</li> <li>• Risk: Staff turnover reduces capacity building efforts</li> </ul> <p><b>D</b> • There will be continuous demand for documented germplasm and tools</p> <ul style="list-style-type: none"> <li>• Technologies are cost-efficient</li> </ul> <p><b>E</b> • Crop researchers are adequately funded and are willing to use documented germplasm and tools</p> <ul style="list-style-type: none"> <li>• Feedback loops exist to ensure effective communication between CRPs scientists, crop researchers, breeders, and genebanks</li> <li>• Strong collaboration exists between CRPs scientists, crop researchers, breeders, and genebanks</li> <li>• Risks: Lack of uptake due to the existence of disincentives</li> </ul> <p><b>F</b> • CGIAR has the lobbying power – and uses it - to influence increased international exchange of germplasm</p> <ul style="list-style-type: none"> <li>• Target partner countries have/move towards international germplasm exchange policies and practices</li> <li>• Availability of resources and existence of capacity for dissemination, training and backstopping</li> </ul>	<p><b>1</b> • Develop and provide training to breeders in new methods</p> <ul style="list-style-type: none"> <li>○ Outputs: training and associated materials</li> </ul> <ul style="list-style-type: none"> <li>• Disseminate new documented germplasm by demonstrating yield gain potential via open access channels <ul style="list-style-type: none"> <li>○ Outputs: documented germplasm, data, dissemination documentation</li> </ul> </li> <li>• Develop marketing approaches, methods and skills to share tools and documented germplasm developed by FP2 <ul style="list-style-type: none"> <li>○ Outputs: marketing approaches, methods, and associated dissemination documentation; training and associated materials</li> </ul> </li> <li>• Identify and implement institutional incentives for knowledge sharing (e.g., data sharing measures) and incentivize via employee performance review, including support for publication <ul style="list-style-type: none"> <li>○ Outputs: measures for knowledge sharing, knowledge, dissemination documentation, employee performance review</li> </ul> </li> </ul> <p><b>2</b> • Develop and implement a capacity building strategy and plan</p> <ul style="list-style-type: none"> <li>○ Outputs: Capacity building strategy and work plan, associated capacity building documentation</li> <li>• Provide appropriate infrastructure support <ul style="list-style-type: none"> <li>○ Outputs: technical advice, infrastructure (e.g., hand held data logger, labs)</li> </ul> </li> <li>• Provide research support services <ul style="list-style-type: none"> <li>○ Outputs: documentation associated with services (e.g., double-haploids, markers, phenotyping)</li> </ul> </li> <li>• Technical backstopping <ul style="list-style-type: none"> <li>○ Outputs: documentation associated with backstopping (e.g., training, IT tools, biometrics)</li> </ul> </li> </ul> <p><b>3</b> • Develop and use informatics tools for diversity analysis</p> <ul style="list-style-type: none"> <li>○ Outputs: diversity analysis data</li> <li>• Identify and improve accession and passport information <ul style="list-style-type: none"> <li>○ Outputs: accession and passport data</li> </ul> </li> <li>• Rationalize dynamic core sets <ul style="list-style-type: none"> <li>○ Outputs: sets</li> </ul> </li> </ul>

Assumptions and Risks	Interventions and Outputs
<p><b>G</b></p> <ul style="list-style-type: none"> <li>• Funders acknowledge need for holistic solutions</li> <li>• Scientists have understanding of the needs of beneficiaries and of the context in which they live</li> <li>• Availability of resources and time to conduct needs and capacity assessments</li> <li>• Risks: <ul style="list-style-type: none"> <li>○ Donor funding and accountability structure may inhibit innovation</li> <li>○ Relevant intellectual property landscape might change</li> <li>○ Intellectual property issues may constrain use and dissemination of germplasm and tools</li> </ul> </li> </ul> <p><b>H</b></p> <ul style="list-style-type: none"> <li>• Existence of an enabling environment allowing scientists to take risks, innovate and learn from failures</li> <li>• Scientists have multidisciplinary curiosity</li> <li>• Risks: <ul style="list-style-type: none"> <li>○ Financial, social and political instability</li> <li>○ New emerging pests and diseases</li> <li>○ Climate change</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Explore and complete global diversity in other collection <ul style="list-style-type: none"> <li>○ Outputs: accession and passport data, dissemination documentation</li> </ul> </li> <li>• Disseminate characterization of germplasm <ul style="list-style-type: none"> <li>○ Outputs: characterized germplasm, dissemination documentation</li> </ul> </li> <li>• Create databases and consolidate data to manage the information <ul style="list-style-type: none"> <li>○ Outputs: databases, data</li> </ul> </li> </ul> <p><b>4</b></p> <ul style="list-style-type: none"> <li>• Develop and provide training and services (e.g., backstopping) <ul style="list-style-type: none"> <li>○ Outputs: training and associated materials; services documentation</li> </ul> </li> <li>• Support partners to properly plan for sustainably taking over complex tools (e.g., Green Global Foundation) <ul style="list-style-type: none"> <li>○ Outputs: advice, tools, dissemination documentation</li> </ul> </li> <li>• Develop and implement tool deployment strategies and specialists <ul style="list-style-type: none"> <li>○ Outputs: deployment strategies, training and associated materials</li> </ul> </li> <li>• Build customer satisfaction and feedback loop between partner researchers and CRP and between FPs <ul style="list-style-type: none"> <li>○ Outputs: surveys or other customer satisfaction tools, and associated responses</li> </ul> </li> </ul> <p><b>5</b></p> <ul style="list-style-type: none"> <li>• Conduct formalized needs and capacity assessment <ul style="list-style-type: none"> <li>○ Outputs: Identified needs and capacity</li> </ul> </li> <li>• Develop and share value proposition/business models <ul style="list-style-type: none"> <li>○ Outputs: models and associated dissemination documentation</li> </ul> </li> <li>• Develop and share an integrated holistic product and process description (e.g., protocol and documentation; training and application; documented germplasm, data and markers; accession and passport data) and incentivize via employee performance review</li> <li>• Prepare and share comprehensive germplasm development documentation as a service to next users (including meta data development for IWIN) <ul style="list-style-type: none"> <li>○ Outputs: protocols and associated dissemination documentation, training and associated materials, germplasm</li> </ul> </li> </ul>

Assumptions and Risks	Interventions and Outputs
	<p>data and markers, accession and passport data</p> <ul style="list-style-type: none"> <li>• Develop communication channels and networks (internal and external) to share product description <ul style="list-style-type: none"> <li>○ Outputs: communication channels and materials; networking tools</li> </ul> </li> <li>• Advocate (jointly with CRP FPs and other CRPs) for open access to data and documented germplasm <ul style="list-style-type: none"> <li>○ Outputs: advice, position papers</li> </ul> </li> <li>6 • Develop/refine breeding approaches for targeted environments and beneficiaries (e.g., incorporate GS, DH, hybrids, gene editing) <ul style="list-style-type: none"> <li>○ Outputs: breeding approaches</li> </ul> </li> <li>• Improve existing and develop new phenotyping tools (e.g., remote sensing, sensory, image-based non-invasive) and other tools as deemed appropriate <ul style="list-style-type: none"> <li>○ Outputs: phenotyping and other tools</li> </ul> </li> <li>• Improve existing, develop and perform genotyping tools (e.g., sequencing, GBS) <ul style="list-style-type: none"> <li>○ Outputs: genotyping tools</li> </ul> </li> <li>• Characterize breeding target environments (e.g. agro-ecological zone) and target beneficiaries <ul style="list-style-type: none"> <li>○ Outputs: breeding target environments characterized, breeding target beneficiaries identified</li> </ul> </li> <li>• Conduct high quality phenotyping in well managed field environment, including confined field trials <ul style="list-style-type: none"> <li>○ Outputs: phenotyping trial data</li> </ul> </li> <li>• Biotechnology to generate new diversity (e.g., genome modification, genome editing, mutation) <ul style="list-style-type: none"> <li>○ Outputs: germplasm data</li> </ul> </li> <li>• Perform pre-breeding (e.g., wide-crossing, targeted pre-breeding driven by trait discovery, using different approaches, use of exotics) <ul style="list-style-type: none"> <li>○ Outputs: pre-breeding germplasm data</li> </ul> </li> <li>• Discover, document and share characterization of germplasm driven by traits, biotic, abiotic factors, including quality and agronomic needs <ul style="list-style-type: none"> <li>○ Outputs: germplasm data and associated dissemination documentation</li> </ul> </li> <li>• Discover, document and share markers for unique alleles/haplotypes <ul style="list-style-type: none"> <li>○ Outputs: marker data and associated dissemination documentation</li> </ul> </li> <li>• Fostering effective networking with other</li> </ul>

Assumptions and Risks	Interventions and Outputs
	initiatives, especially upstream <ul style="list-style-type: none"> <li>○ Outputs: Scientific information regularly shared and received</li> <li>● Develop and implement integrated germplasm information system (genealogy, phenotypic, genotypic, sensor, and environmental data)               <ul style="list-style-type: none"> <li>○ Outputs: Integrated germplasm information system</li> </ul> </li> </ul>

**Figure FP2-1. Theory of Change for Novel Diversity and Tools.**

### 2.2.4 Science quality

<http://wheat.org/download/wheat-publications/> provides a complete list of publications by WHEAT scientists (FP1 – FP4) and separate for FP2 + FP3 and summarizes the strong FP2&3-related publications record of WHEAT scientists (see also chapter 2.3.4, Table FP3-2 for more details on journals). Separately listing FP2 from FP3 publications would result in much duplication because, with few exceptions, publications address priority questions and include scientists working in both FPs.

Examples of high quality science in FP2 include:

- Establishment of multi-disciplinary trait teams to improve communication and collaboration through stages of the discovery-validation-deployment pipeline of new tools from FP1 to FP4 (across FP2).
- Pioneering work and collaboration with other CRPs (DCLAS, GRiSP, MAIZE) on informatics tools to integrate complex, large data sets into decision support tools in the frame of the IBP (FP 2.1).
- World-class physiology, working with a global network of partners to dissect complex traits and identify targets for gene discovery (FP 2.2).
- High-density genotyping of tens of thousands of gene bank accessions and landraces, partnering with world class genomics and informatics initiatives, such as the International Wheat Genome Sequencing Consortium and The Genome Analysis Centre, to enable gene discovery and allele mining for priority traits (FP 2.2)
- Identification of selection imprints to guide pre-breeding efforts to introgress useful novel diversity while retaining haplotypes of proven value (FP 2.2 and 2.3)
- Partnering with the private sector to use genome editing technology to create novel variation for the breeding pipeline (FP 2.3).
- Exploration of novel uses of high fidelity, high throughput phenotypic data, e.g. collected using drones, to enhance genetic gains in wheat breeding (FP 2.2 and 2.4).
- Development and validation of cutting-edge, novel biometrics analysis methods, especially in the areas of genomic selection and high-throughput proxy trait selection (FP 2.4).
- Cutting-edge research to apply multi-variate prediction models to inform selection of parents and progeny in breeding programs (FP 2.4).

### 2.2.5 Lessons learnt and unintended consequences

**Major lessons learned from previous research are:** 1) Additional investments in data management and informatics capacity are needed to maximize benefits from the large and complex data sets being generated. 2) Enhanced integration of activities with other FPs is essential, especially with FP1 to support priority setting and with FP3 to validate the usefulness and to mainstream FP2 products (particularly innovative phenotyping tools and methods); 3) Pre-breeding efforts need to be well coordinated among existing FP2 projects and with FP3 breeding programs to ensure complementarities, synergies and lateral learning; this has been widely demonstrated by the success of synthetic derived varieties in bread wheat and by the usefulness of landraces and wild *Triticum* in durum wheat. Establishing inter-FP special trait teams will further expand this successful approach.

### 2.2.6 Clusters of activity (CoA)

Four CoAs collaborate to validate and make available germplasm, tools and methods to enhance the efficiency and rate of genetic gains in breeding programs:

FP 2.1: Data management, informatics, and breeding support tools. Novel tools to collect, curate, manage and extract knowledge from large and complex data sets are keys to the success of WHEAT.

FP 2.2: Novel genetic diversity through trait dissection, gene discovery and genetic engineering. Identifies key traits for which it explores, characterizes, mines and enhances the genomic diversity available to breeding programs.

FP 2.3: Pre-breeding for efficient use of novel diversity in mainstream breeding programs. Tools developed by FP2.1 and 2.4 are used to incorporate novel diversity for key traits from unimproved backgrounds into (semi-)elite genetic backgrounds for use by breeders.

FP 2.4 Innovate and integrate technologies to accelerate genetic gains. Develops, validates and collaborates with FP2.1 to pipeline prediction methods that incorporate genomic, pedigree and phenotypic data to accelerate genetic gains in WHEAT breeding programs.

#### **FP 2.1: Data management, informatics, and breeding support tools**

FP 2.1 sources and adapts integrated systems for storing and accessing data, and informatics tools for processing and analyzing data to support research and breeding work of WHEAT, which increasingly uses large data volume applications. It uses standards, tools, and systems that integrate diverse and fast evolving data types to help enhance genetic gain and increase the conservation and use of genetic resources. Many tools will be developed in collaboration with the Genetic Gains Platform (GGP). Strategic interventions and challenges are addressed through:

Data management and interoperability to enable knowledge extraction: The CGIAR is rapidly developing open-access “germplasm data banks” to complement its germplasm bank resources. Centralized databases are necessary to store the data generated through WHEAT diversity analyses and breeding research. Approaches are being developed with partners (e.g. Crop Ontology, Planteome, the CGIAR Data Management Task Force, IBP, and IPPN) to enhance data annotation and curation processes using controlled vocabulary terminology and internationally recognized standards. Priority research areas include:

- Co-developing resources via the GGP with partners and deploying standard pedigree and phenotypic data capture, annotation, and storage tools such as the BMS and KDSmart.

- Collaborating with the GGP and ARIs including Cornell and Kansas State Universities, TGAC, and DivSeek to address the challenges posed by the heterogeneity of genotyping platforms used by WHEAT researchers.
- Contributing to the development of software and processing protocols for high-throughput phenotyping and remote sensing image analysis, annotation, and use in breeding and discovery.
- Instituting systems for collating and storing weather and soils data from experimental sites.
- Identifying meaningful ways to incorporate gender- and youth-based preference data for germplasm into breeding management informatics systems.
- Setting up pipelines for sharing data in open access repositories and across an interconnected web of informatics systems.

Informatics tools to mainstream efficient decision-making to accelerate genetic gains: Given escalating data volumes, new tools need to be implemented and optimized to help scientists manage, interpret and extract knowledge and quickly make data-based decisions. This includes tools for combining and visualizing different data types and for employing the newest biometric models. Work will include:

- Validate and share new analytical pipelines (e.g. from GGP and CoA2.4) for genomic selection, high-throughput proxy trait selection, and use of selection indices and prediction models.
- Provide software to enable novel pipeline creation by WHEAT scientists.
- Identify ways to mine data from external sources, e.g. by displaying WHEAT data in genome browsers that are continually updated with the discoveries of SNP/functional gene associations based on research in rice, Arabidopsis, maize, etc.

Although many tools will be developed externally, CoA2.1 will invest to deploy, maintain, and upgrade software, and to build linkages between different systems. Training will be conducted in data standards, curation protocols, software systems, and tools deployed to the WHEAT community.

## **FP 2.2: Novel genetic diversity through trait dissection, gene discovery and genetic engineering**

This CoA applies physiology, genotyping, phenotyping, gene editing and informatics approaches to characterize wheat genetic resources for use by researchers and breeders. Genetic opportunities to enhance yield potential and tolerance to stresses will be explored by extending the genetic and physiological understanding of key traits and genes in wheat and other species. This understanding of determinants of key traits provides targets for characterization of genetic resources to identify germplasm, haplotypes and alleles of value for breeding. Genetic engineering and gene editing are selectively applied to create genetic variation. Interventions and issues include:

Trait exploration and gene discovery for yield potential and closing the yield gap: Increasing wheat's photosynthetic efficiency would allow farmers to increase yields on same land, using no more water, fertilizer or other inputs. Specific activities and outputs include: 1) Research to understand the genetic and mechanistic bases and regulation of crop growth processes in the face of environmental fluxes will identify traits, gene networks and haplotypes for use in breeding; 2) investigation of epigenetics will formulate recommendations about whether and how subjecting plants to stress (e.g. drought) can condition their progeny to better cope with stress; 3) develop and validate standardized field phenotyping protocols with collaborators worldwide; and 4) develop and provide donor germplasm for breeding, and germplasm panels for research.

Trait exploration and gene discovery to combat climate change: FP 2.2 works closely with FPs 2.1, 2.3 and FP3 to deliver new, more resilient germplasm to farmers. Research leverages knowledge on adaptive traits (Richards 2006; Reynolds and Tuberosa 2008) to develop best-bet solutions for their application in breeding, and refines stochastic approaches in enzymology, metabolomics, genomics, and expression analysis, leading to faster identification of functional genes (Lopes et al. 2015). Application of genomics and phenotyping platforms (Babar et al. 2006; Reynolds et al. 2009; Gutierrez et al. 2010; Tattaris et al. 2013; Chapman et al. 2014) will deliver more precise models to understand and improve climate change adaptation. Useful trait-allele combinations will be identified and developed (e.g. Cossani and Reynolds 2012; 2015).

Systematically assess gene bank resources to identify germplasm and genomic regions of value: Evaluate genetic resources using genotypic, phenotypic, GIS, passport and pedigree analysis to identify germplasm with valuable genetic variation for prioritized traits. Systematic assessment includes definition of core sets and panels of germplasm; selection-sweep analysis to identify genomic signatures potentially associated with desired characteristics; identification of underutilized gene pools; discovery of haplotypes, genes and alleles for key or value-adding traits (e.g. to enable affordable hybrid technologies); and phenotyping germplasm to identify high value materials for breeding.

Establish transgenic capacity for use in gene discovery and validation: High throughput wheat transformation will be established in at least one elite line. A pipeline will be developed to identify and validate genes for agronomic traits and disease resistance.

### **FP 2.3 Pre-breeding for efficient use of novel diversity in mainstream breeding programs**

Climate change, and particularly heat and drought stress, will continue to erode genetic gains for staple crops worldwide (Challinor et al. 2014; Asseng et al. 2015). Significant increases in yields are feasible if translational research can be harnessed to decades of investments in plant biotechnology (e.g. <http://www.plantstress.com/>) using collaborative models (Reynolds et al. 2016). WHEAT develops and works through worldwide partnerships, including the International Wheat Yield Partnership, the Heat and Drought Wheat Improvement Consortium (HeDWIC) and the JIRCAS-coordinated Biological Nitrification Inhibition (BNI) Consortium. WHEAT leads focused pre-breeding efforts to ensure impact from emerging technologies. Pre-breeding efforts build on: Published models of genetic strategies to improve wheat yield potential and adaptation (e.g. Cossani and Reynolds 2012; Reynolds et al. 2012); panels of diverse and underutilized genetic resources, encompassing landraces, synthetics, and elite lines based on screening of 70,000 accessions from the World Wheat Collection, and selections developed using FIGS, molecular diversity, and phenomics approaches; genome wide and QTL analysis of wheat's response to diverse environments (e.g. Lopes et al. 2014; Pinto et al. 2010); research/breeding platforms in the Mexican desert equipped with state-of-the-art remote sensing and precision phenotyping apparatus (e.g. Araus and Cairns 2014), complemented by newly established phenotyping platforms in Morocco and Sudan; the international wheat improvement network (IWIN), enabling testing of lines across a range of target environments (Braun et al. 2010), to feed into models of new plant types; and strategic physiological approaches showing promising genetic gains at IWIN sites (Reynolds et al. 2015).

To deploy promising traits/alleles into elite backgrounds for use in breeding and delivery pipelines, research will focus on:

1. With FP2.1, develop and implement models of GxE interaction to design crossing strategies for new plant types;
2. Develop improved and better-standardized field phenotyping protocols in partnership with collaborators worldwide (e.g. <http://libcatalog.cimmyt.org/download/cim/96144.pdf>; Araus and

- Cairns 2014; Chapman et al. 2014);
3. With FP2.2, identify and use novel genetic sources for expression of adaptive/productivity traits, e.g. photosynthesis (Prins et al. 2016);
  4. With FP2.2, conduct genetic analyses to quantify impacts of new trait constellations in different backgrounds (e.g. Griffiths et al. 2015) and apply findings in pre-breeding;
  5. With FP2.4, MAS focusing especially on markers associated with more than one stress, e.g. heat+drought (Pinto & Reynolds 2015); and
  6. With FP2.4, develop and validate genomic selection models (e.g. Rutkoski et al. 2016).

#### **FP 2.4 Innovate and integrate technologies to accelerate genetic gains**

FP2.4 develops and validates prediction methods that incorporate genomic, pedigree, and high-throughput phenotypic data to accelerate genetic gain for quantitative traits by increasing parent and/or progeny selection accuracy and/or decreasing breeding cycle duration (Falconer and Mackay 1996). Breeding projects making selections for generation advancement and for new parents using both old and new methods will be used to validate models and methods for pipelining by FP2.1 for use by breeders. FP2.4 has three research streams:

Biometrics research to develop models that enhance efficiency of breeding programs: The growing diversity of readily available high fidelity, high throughput data presents exciting opportunities to enhance efficiency and genetic gains in breeding. Models that accurately predict performance under multiple environmental conditions by using covariates such as maximum and minimum temperature and precipitation will reduce the need for costly testing. Models also enable prediction of performance under many scenarios, including environments anticipated from climate change. Models will accelerate the selection of lines to distribute to partners. Interventions include: a) Develop models for genomic-enabled prediction for diverse breeding populations, including gene bank accessions and elite populations; b) develop predictive models that incorporate GxE interaction, including weather data; c) increase the accuracy of predictive models by combining GxE with high density molecular markers and pedigree information; d) develop statistical genomic models that incorporate non-normally distributed, categorical response traits (e.g. disease symptom scores); and e) improve the accuracy of GS models by using high-throughput phenotypic data and multi-environment performance data.

Target: By year five, GS models, which incorporate environmental co-variates, will be 10% more accurate than models that do not incorporate environmental covariates.

Develop and validate genomic selection (GS) approaches for wheat breeding: GS uses genome-wide marker data and phenotypic data to predict breeding values and accelerate rates of genetic gain for quantitative traits that have not been extensively phenotyped (Meuwissen et al. 2001; Heffner et al.; Bernardo and Yu 2007; Wong and Bernardo 2008). WHEAT scientists are testing use of F3 and F4 recurrent GS to reduce the time between recurrent recombination and increase rates of genetic gain. Prediction models to be investigated include: a) GxE interaction models incorporating genome-wide markers and pedigree; b) multivariate models combining genomic or pedigree relationship estimates and data for several traits including high-throughput yield proxy traits suited for HTPTS (see below); and c) new relationship matrices models, including those generated using data from images and sensors. The network of high-throughput phenotyping platforms (FP3.2) will be critical for generating high-quality data for this work.

Develop and validate high-throughput proxy trait selection (HTPTS) for wheat breeding: HTPTS is a prediction-based selection approach being pioneered by WHEAT with partners. HTPTS allows rapid and inexpensive data collection for traits correlated with yield, e.g. canopy temperature and normalized difference vegetation index (NDVI) using aerial surveillance vehicles. HTPTS and GS use similar

prediction models and methods; however, if pedigree relationships are available, HTPTS does not necessarily require genome-wide genotyping, making it up to 20 times cheaper than GS, at current prices. Similar approaches using traits that are inexpensive to measure as predictors for the primary trait of interest have produced very promising results in animal breeding (Pszczola et al. 2013). HTPTS will be evaluated for yield under optimal conditions using small plots for large numbers of selection candidates, for which genome-wide genotyping is not currently feasible. HTPTS could lead to a dramatic increase in selection accuracy and to a major reduction in breeding cycle duration.

Target: Prediction accuracy of GS-HTPTS is 0.4 by year 5 and 0.8 by year 10.

**Table FP2-1. Additional FP2 outputs under uplift budget.**

CoAs	Uplift budget-funded key deliverables
FP2.2	Partnership with experienced private sector partner(s) will facilitate the establishment and implementation of gene editing capacity. Initial targets would be disease resistance and herbicide tolerance.
FP2.3	Expand scope of heat & drought research (HeDWIC) Expand scope, reduced timelines for BNI research to reduce N2O emissions and improve NUE (BNI Consortium)
FP2.4	Optimal selection indices for wheat breeding: As predictions are increasingly used to enable selection based on multiple traits, selection indices become increasingly important because breeding value predictions from GS and HTPTS are statistically biased and cannot be interpreted as actual trait values. Multi-trait prediction models produce predictions that can be weighted to generate an optimal selection index to maximize gain for total genetic value (including all traits) (Mrode 2014). Although multi-trait prediction models are routine in animal breeding, they are not yet routine or easy to use in crop breeding. Efficient biometric applications of these models on a large scale are not available. Multi-trait prediction models and strategies for their implementation will be evaluated via simulation studies to recommend their use in wheat breeding programs. Trait value functions are also important for improving multi-trait selection since they describe the relationship between a single trait and the overall value of an individual trait, and are used to calculate the net merit of an individual or the net merit of the progeny of two individuals, enabling the identification of “designer crosses” that combine the key traits to maximize progeny value (Allaire 1980). Once economic trait value functions are defined, algorithms that identify the best cross combinations will be evaluated to enable faster decisions and better allocation of resources. The improvement in efficiency of selection for multiple traits will be assessed using simulation studies.

## 2.2.7 Partnerships

FP2 relies heavily on partnerships with advanced research institutions and leading service providers. (Table FP2-1, sections 1.7, 1.8 and annex 3.7). The Seeds of Discovery Project is undertaken by MAIZE and WHEAT, sharing the development of strategies, learning and bioinformatic approaches and tools. Many research institutes collaborate with WHEAT on physiology and climate change adaptation research (docking with CCAFS).

**Table FP2-2: Partners in FP2**

Partner type	Partner name	Key contribution
ARI	Kansas State University	Project leadership, genome-wide genotyping, and high-throughput phenotyping, data analysis pipelines. Many activities supported by a KSU led project “Feed the Future Innovation Lab for Applied Wheat Genomics”
ARI	Cornell Uni	Breeding methodology research, prediction modeling, software development for genomic data management and utilization, project leadership. Activities supported by Cornell led Durable Rust Resistance in Wheat Project (DRRW)
ARI	Michigan SU, U of Nebraska, Colegio de Postgrad., Mex	As above, key for the work on developing new genomic selection models, especially those that can integrate environmental covariates
ARI	GOBII (Cornell)	Genotyping, processing (imputation algorithm development), storing capacity, plus information extraction tool development.
CGIAR	BMS/IBP	OS integrated system for managing genealogy and phenotypic data
ARI	John Hutton Institute, UK,	Genotypic / phenotypic data visualization platforms; public data warehouses;
ARI	U. Barcelona, Lleida, Nottingham	Spike Photosynthesis, crop phenology, growth regulators
ARI	ORNL-US, TGAC-UK	Genotypic data analysis, computing power, data storage and integration
ARI	U of Queensland; CSIRO, Cornell	Genomics, genetics and breeding software development, crop simulation modeling,
ARI	USDA, NIAB, IPK, AWCC	Germplasm conservation expertise
ARI	GRDC-Australia	Focused identification of germplasm strategy (FIGS) for mining genetic res.
ARI	U of Minnesota	Big data analysis and knowledge extraction from novel combinations of data, e.g. economics and genomics.
NARS S. Asia	BISA, AARI-Pak, ICAR-India	GS, HTPTS and combined GS-HTPTS prediction; testing heat tolerance; partnership critical for testing this “cooperative GS model training” approach before it is expanded to other traits, environments, stresses and partners
NARS, ARI	UK: Nottingham U, JIC, US: KSU, JIRCAS, IPK, several others	Introgress novel diversity from wheat related species into wheat (bread or durum wheat). CIMMYT and ICARDA breeders transfer trait into elite wheat lines for global distribution and use as parental lines
NARS	Hosting Prec. Phenotyping platforms (see FP 3.2)	Expand cooperative GS model training; partners are key for generating the data needed to enable prediction many important traits across varied environments
NARS Researchers	Asia, Africa, L-America Global	Perform precision phenotyping and provide data Users of WHEAT Diversity Portal

### 2.2.8 Climate change

The purpose of FP2 is to develop novel diversity and tools for improving genetic gains and efficiency of breeding programs. Given the large magnitude and wide range of challenges from climate change to wheat production, the majority of efforts in FP2 are focused to better equip breeding programs (with germplasm and tools) to address these challenges. Several projects within FP2 address specific traits or issues associated with climate change, for example the International Wheat Yield Partnership (IWYP), the Heat and Drought Wheat Improvement Consortium (HeDWIC) and the Biological Nitrification Inhibition (BNI) projects are discovering and validating physiological mechanisms and allelic diversity to enhance breeding efforts to develop new wheat cultivars with increased yield, tolerance to the expected effects of climate change and more efficient use of fertilizer and water resources.

### 2.2.9 Gender

The focus of this Flagship can appear far removed from the farmer and consumer interface. Although the relevance of the gender dimension becomes clearer as we move further down-stream in the technology development process, the concern with end-user needs, challenges and preferences is pertinent at the upstream level. This is where key decisions regarding overall direction and priorities of research are made, which, in turn, have bearing on what (- and whose) issues will be addressed.

Relevant research questions for FP2 include:

- How can we ensure that efforts to increase genetic gain benefits both men and women wheat farmers and consumers in particular contexts?
- What traits are relevant for key beneficiary groups, and (how) are they related to gender? For example, heat tolerance is particularly relevant to poor women in wheat-based livelihoods, because they tend to be most vulnerable to shocks.
- How can research on the gendered nature of wheat production leverage and add value to the analysis of native trait variation and trait pipeline development?
- How can downstream gender research and -analysis findings along continuum from discovery of new knowledge to achievement of systemic change inform up-stream targeting and decision making?

FP2 will draw on research on traits and trait combination preferences of men and women wheat farmers and consumers in particular contexts (from FPs 1 & 3), to inform its targeting and priority setting. Building on this, FP2 will consolidate the consideration of trait combinations of particular interest to women farmers in its portfolios. This may also include research on novel trait variation and molecular pipelines that address nutritional quality and other issues, for example herbicide tolerance (for less drudgery). FP2 aligns closely with FP3, with FP1 priority setting and trait targeting inputs: Gender and social inclusion implications of target traits are carefully considered when deciding on appropriate traits to focus on.

### 2.2.10 Capacity development

Capacity development is at the heart of FP2, both for co-development and learning and during mainstreaming of successful tools. It involves short-term training and workshops on topics including data curation and stewardship, software tools for breeding program management, statistical analysis methods and tools, genomic data analysis and use of HTPTS and selection indices. Current and planned graduate student supervision includes topics such as the use of physiological trait dissection for gene discovery. Analysis and use of genomics data for allele mining and effective use of genetic resources, identification of molecular effectors, development and validation of methods for enhancing rates of genetic gain, e.g. genomic selection and high throughput phenotyping. Visiting scientist opportunities serve to develop WHEAT partner institutions' capacity on relevant topics.

### 2.2.11 Intellectual asset and open access management

Under FP2 & 3, scientists develop tools for data management, data stewardship (including open access), and data mining or analysis; to enhance breeding efficiency that results in faster genetic gains. These will be designed with OA/OD in mind, from a technical and user perspective. Researchers will make their well described raw data available to other scientists through Dataverse. Under FP2-3, scientists also disseminate germplasm and related data, based in international regulations.

### 2.2.12 FP management

FP2 is managed jointly between the two lead centers – with both joint FP coordination and co-CoA leads. The co-leadership allows both centers to share ownership and responsibilities and provides clear focal points within each organization for each CoA and the FP as a whole.

**Table FP2-3. FP and CoA Leaders.**

	<b>FP2 Coordinators and CoA leaders</b>	
<b>FP/CoA Structure</b>	<b>CIMMYT</b>	<b>ICARDA</b>
FP2: Novel diversity and tools for improving genetic gains and breeding efficiency	Kevin Pixley	Ahmed Amri
2.1: Data management, informatics, and breeding support tools	Kate Dreher	tbd
2.2: Novel genetic diversity through trait dissection, gene discovery and genetic engineering	Kanwarpal Dhugga	Ahmed Amri
2.3: Pre-breeding for efficient use of novel diversity in mainstream breeding programs	Matthew Reynolds	Michel Ghanem
2.4: Innovate and integrate technologies to accelerate genetic gains	Jessica Rutkowski	tbd

### 2.2.13 Budget summary – see FP budget template

## FP3: Better varieties reach farmers faster

### 2.3.1 Rationale, scope

FP3 continues to be globally the most important provider for improved wheat germplasm utilized by NARS either as parents for cultivar development or direct release as varieties. In all of the primary WHEAT target regions (S-Asia, W-Asia, MENA, SSA, L-America) between 50-70% of all cultivars released between 1994 and 2014 are derived from CGIAR germplasm (Lantican et al. 2016). WHEAT germplasm is widely used due to its high yield potential, yield stability, disease resistance and adaptation to changing environments, which is of particular importance in the face of GCC, when at one location tremendous variation is observed over years for rain, temperature and biotic stress occurrence and small-scale farmers often limited to grow only one variety.

An important function of FP3 is to develop lines that carry new traits identified in FP2. Once these traits are introgressed in elite wheat lines, they are distributed in trait specific and international nurseries and can be used by breeding programs around the world for crossing or variety release. This minimizes duplication of efforts and assures also smaller NARS have fastest possible access to new traits. This function becomes increasingly important, since many gene bank accessions are better characterized for phenotype and genotype and an increasing number of new alleles / traits will become available through FP2 research for verification in FP3. New technologies, e.g. gene editing, require specific infrastructure and expertise beyond the capacity of many NARS. FP3 will make these traits available to all co-operators in form of elite lines that carry also other relevant traits, so that most breeding programs can use these lines immediately for crossing and variety development without the need for time consuming backcrossing.

FP3 geographic impact is global (see chapter 1.1, Tables 2 & 3). The focus is on increasing productivity and profitability of wheat based systems in developing countries (Lantican et al. 2016, Dixon et al. 2009). First users are usually breeders, whilst the ultimate beneficiaries are farmers, adopting better varieties, and consumers, benefitting from affordable prices and higher quality products.

The major challenges are to increase the genetic gains from around 0.5% p.a. by 40% to 0.7% p.a., despite global warming. Predictions for global warming are for average increases of 0.04 °C per year. At a 5-7% yield reduction per 1°C increase, warming will push down yield by 0.2% - 0.3% p.a., which makes it even more challenging to achieve the target of 0.7% p.a. Warming also results in shorter crop cycles, so productivity per day needs to increase.

In many rotations, wheat is the lowest value crop and production of other crops is optimized (e.g. longer duration of cotton, rice). Consequently, optimal sowing date of wheat is delayed and grain-filling occurs under severe heat stress. Breeding wheat varieties with 40-50% higher yield potential that can cope with GCC induced stresses is a formidable task and requires global co-operation, such as found in the International Wheat Yield Partnership (IWYP) or the Heat and Drought Wheat Improvement Consortium (HeDWIC). These yield gains need to be achieved while maintaining the high level of disease resistance and meeting end-users quality standards. CRP-WHEAT is already running the biggest wheat breeding program on Genomic Selection in the public domain. WHEAT continues to evaluate the latest technologies and applies them for wheat improvement, once proved useful. This is an important role for WHEAT, as many smaller NARS look to WHEAT for advice on which technologies to use.

Precision phenotyping is paramount for efficient selection and is the basis for gene discovery. FP3 CoA 3.2 will expand the precision phenotyping platform network. Testing at platform locations also provides NARS with earlier access to genetically diverse material, resulting in more genetically diverse lines selected for use in varieties.

Providing farmers faster access to new varieties is the 2<sup>nd</sup> major challenge. Lantican et al. 2016 have shown that the average age of varieties grown by farmers in developing countries is greater than 10, often 15 years. FP3.2 will focus on shortening this period through provision of earlier access to the germplasm and strengthening co-operation with private seed producers. It has to be recognized that in developing countries the private sector is focusing on seed production of varieties bred by the public sector or CGIAR. In the targeted developing countries there are presently no more than five private companies that operate wheat breeding programs at a scale that is competitive with public sector. This needs to be considered when PPPs are discussed.

### 2.3.2 Objectives and targets

To meet future food demands, annual yield gains must increase from below 1% to 1.4% yr<sup>-1</sup>. Genetic yield gains are presently at about 0.5% yr<sup>-1</sup> (Fischer et al., 2014) and will need increase to 0.7% per year, an increase of 40%. Additional 0.7% yield increase will need to come from improved on-farm agronomic practices. Wheat is sensitive to high temperatures and models (Lobell et al 2011) and yield trends in farmers' fields in Northern Mexico suggest a 5-7% yield reduction for every 1°C temperature increase. A temperature increase of 2°C by 2050 will require annual yield gains of 0.4% just to maintain 2015 yield levels.

Wheat is a water use efficient commodity. Under irrigation, it currently takes around 900 l water to produce 1 kg grain. Using most water efficient cultivars in combination with optimal agronomy and irrigation systems, a water use efficiency of around 450 l/ kg grain can be achieved, a 50% water savings over current rates. WHEAT will also develop germplasm- and agronomy-based targets regarding tolerance to salinity in irrigated areas, with a focus on CWANA and South Asia.

Diseases, pests and viruses cause annual wheat losses of around 20%, ranging from 10 to 30% depending on the region (Oerke 2006). For 2014, this comes to 140 M tons at a value of \$30 billion. WHEAT research and breeding will focus on diseases and pests that are of importance on large areas or represent a major potential risk. Wheat blast, through 2015 confined to Latin America, where it can cause significant yield losses, was identified on 20% of Bangladesh's wheat area in 2016 and is also found in India. This represents a potential major threat for wheat production and wheat food security in warm areas of S-Asia and requires immediate attention. Through use of new molecular approaches, WHEAT's priority is to maintain genetic diversity for resistance, to avoid genetic vulnerability to evolving and migrating pathogens and pests, while building upon the gains already achieved globally in wheat improvement.

Household and consumer preferred grain processing and end use quality traits are paramount, since urbanization will lead to an increasing demand for wheat that meets requirements of the industrial milling and baking industry.

FP3 primary outcomes contribute directly to SLO 1 and SLO 2 and work towards specific sub-IDOs described in 2.3.3. Enhanced genetic gain is delivered via high-yielding, stress resilient Zn and Fe enriched varieties with appropriate end-use quality. Reduced production risk is reached through abiotic and biotic stress tolerance, which also contributes to reduced pre- and post-harvest losses, including those caused by climate change, and faster and higher genetic gains on farmers' fields.

Progress towards these sub-IDOs will be measured through: a) rate of production gains at national level in targeted countries and regions; b) rate of annually realized genetic yield increases from WHEAT relative to checks in breeding and international nurseries; b) genetic gains in tolerance to abiotic stresses relative to best checks) years of durable resistance achieved against diseases and pests measured as time varieties remain resistant and reduced frequency of major epidemics, in particular rusts; d) number of programs implementing novel breeding strategies developed under WHEAT; e) number of people assisted to exit poverty and f) number of people meeting minimum dietary energy requirement, in particular for women and children (with A4NH). Progress will also be measured by implementing external evaluation recommendations four and six, as well as following up on the BMGF-funded Review of CIMMYT's Global Breeding Wheat Program<sup>1</sup>.

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<sup>1</sup> A BMGF Review of CIMMYT's Breeding Program noted the strong foundations, on which improvements to breeding will build: "The breeders are also very aware of the need for fast cycle systems and use SSD and 'shuttle breeding' to great effect. The cycle time for varieties is just 5 years. The breeders are also quick to introduce high-yielding lines into their crossing programs." See: Accelerating Plant Breeding Program Outcomes: Findings from CIMMYT review visit March 26 to April 1, 2015.

Seven CoAs under FP3 contribute to development of high-yielding, stress tolerant and nutritious wheat germplasm. In FP3.1 (breeding), research products from FP2 and all other FP3 CoAs are brought together. The out-scaling of FP3.1 developed cultivars is done under FP3.7, where mechanisms and strategic partnerships are developed that enable seed of farmer-preferred improved varieties to reach smallholder farmers in the shortest possible time.

To assure a seamless transfer of new alleles identified in FP2, research teams are formed across the two FPs for specific research topics, e.g. yield, heat, drought, disease resistance, nutrition, genomic selection, in which scientists work together. The formation of such teams was a major recommendation of the WHEAT External Evaluation (see Annex 4.4).

WHEAT contributes to SLO-level nutrition and health impacts via A4NH. Improved nutrition, food safety and health aspects are addressed by FP3.4, FP3.5 and in collaboration with A4NH/HarvestPlus on nutrition/ micro-nutrient content. To accelerate genetic gains, FP3 links with Genetic gains Platform.

### 2.3.3 Impact pathway and theory of change

FP3, Better Varieties Reach Farmers Faster's theory of change was developed during a workshop with the WHEAT Flagship project team. A participatory approach was used to capture all views, experiences and known evidence into the theory of change. The workshop participants were able to increase their understanding of the CGIAR Strategy and Results Framework and awareness of results-based management concepts. The workshop was also structured to encourage sharing and learning on a variety of topics.

Using the CGIAR Results Framework's sub-intermediate development outcomes (IDOs) the team agreed to focus on three sub-IDOs and two cross-cutting sub-IDOs:

1.1.2 Reduced production risk;

1.4.1 Reduced pre- and post-harvest losses, including those caused by climate change;

1.4.3 Enhanced genetic gain;

A.1.4 Enhanced capacity to deal with climatic risks and extremes;

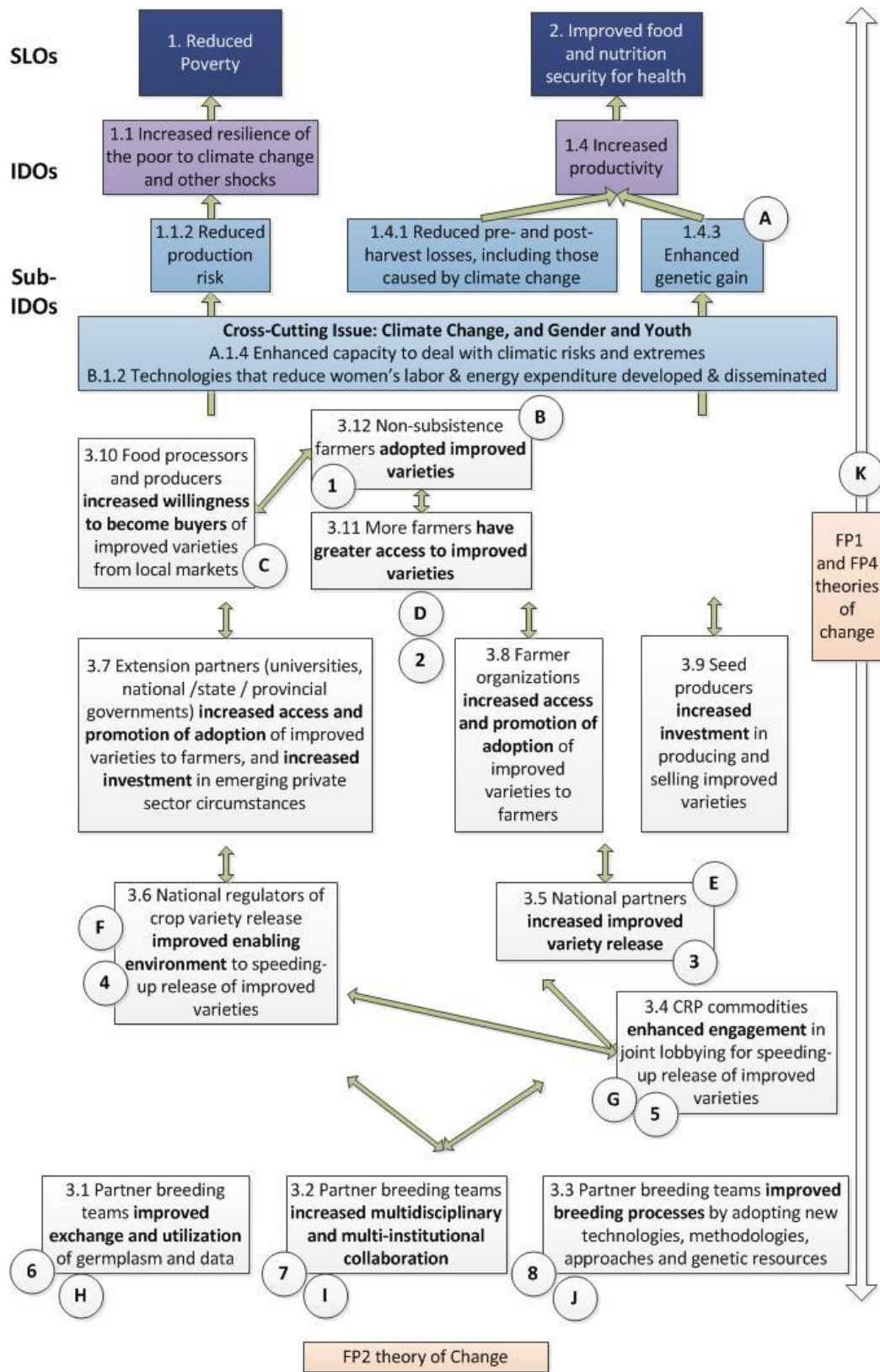
B.1.2 Technologies that reduce women's labor and energy expenditure developed and disseminated.

Other sub-IDOs were noted by the team as important to programming given that they overlap with the above sub-IDOs of focus. Regarding the sub-IDO 1.4.3 related to enhanced genetic gain, the team noted that this sub-IDO encompasses all elements of gain sought by the CRP, including yield, abiotic, biotic and quality traits. As for sub-IDOs A.1.4 and B.1.2 related to climate change, and gender and youth, the team indicated that these cross-cutting issues would be integrated largely through a focus on relevant traits and tools.

Based on these areas of focus, the team agreed that this Flagship Project contributes to reducing poverty (SLO 1) and improving food and nutrition security for health (SLO2) by the mean of increasing resilience of the poor to climate change and other shocks (IDO 1.1), increasing productivity (IDO 1.4), and enhancing the cross-cutting issues of climate change (A), and gender and youth (B).

A number of research and development outcomes were identified and a pathway of change was created demonstrating the causal relationship between outcomes and sub-IDOs. During this process, partners involved in the pathway of change were identified. Current and proposed interventions and associated outputs to support the achievements of the outcomes were mapped. Assumptions describing the contextual underpinnings of the theory as well as the risks that may have the potential to undermine success were documented.

This theory of change will be the foundation for the monitoring, evaluation and learning plan. The monitoring plan will consist of a continuous process of collection and analysis of data based on a set of indicators directly related to the performance of the CRP at the output and outcome levels; the key assumptions of the theories of change; and the critical risks. The theory of change will also be the basis for evaluating the Flagship project as well as reflecting on lessons and program improvements.



Assumptions and Risks	Interventions and Outputs
<p><b>A</b> Enhanced genetic gain encompasses all elements of genetic gain sought by the CRP (e.g., yield, abiotic, biotic and quality traits)</p>	<p><b>1</b> Enable different partners to provide improved varieties to farmers Outputs: dissemination and marketing documentation Capacity development of farmers</p>
<p><b>B</b> Farmers will be available to sell improved varieties Seed systems produces sufficient seeds for farmers Profitability of the improved varieties Market prices are stable and attractive to farmers Risks: Variability of local wheat prices and instability of global prices</p>	<p>Outputs: Training materials, training sessions, dissemination and marketing documentation</p> <p><b>2</b> See FP4 and FP1 interventions</p>
<p><b>C</b> Quality and availability of improved varieties are attractive to buyers Profitability of improved varieties Improved varieties driven by markets, and by nutrition and health needs</p>	<p><b>3</b> Communicate summarized data and ensure feedback loop Outputs: data, dissemination documentation Fundraise to support speeding-up release of improved varieties Include promotional information of improved varieties in innovative platforms</p>
<p><b>D</b> Farmer organization can make profit with associated services Seed production/systems will become more commercially attractive Existence of an inter-CRP collaboration Existence of an enabling policy and legislative environment to increase access to improved varieties and seed commercialization</p>	<p>Outputs: Dissemination and marketing documentation, policy briefs Implement participatory variety selection extension interventions Outputs: data, dissemination and marketing documentation</p> <p><b>4</b> Contribute to policy dialogue Provide capacity development to decision-makers on breeding realities, value addition, timelines, and research and development</p>
<p><b>E</b> Existence of opportunities to speed-up improved varieties release National partners use CGIAR trial data to speed-up improved variety release National partners see value, and are willing and capable to implement incentive systems (e.g., royalty systems) Global precision platforms contribute to speeding-up release adoption of improved variety</p>	<p>Outputs: Policy briefs, advice, dissemination documentation</p> <p><b>4</b> Document and analyze legislative systems, and develop common mechanisms and best practices for variety release in target countries <b>5</b> Outputs: legislative system, mechanisms and best practices overviews and documentation</p>
<p><b>F</b> Existence of opportunities to speed-up improved variety release CGIAR influence national decision-makers</p>	<p><b>5</b> Monitor and lobby jointly with other CRPs to support enabling policy and legislative environment for germplasm exchange Outputs: dissemination documentation, advice and policy briefs</p>
<p><b>G</b> CRPs have sufficient time and budget to work together</p>	
<p><b>H</b> Regulators enable and support exchange of data and germplasm Existence of an enabling policy and legislative environment Risks: National regulators increase importing and exporting fees</p>	<p><b>6</b> Disseminate summarized data Outputs: data, dissemination documentation Access capacity and prioritize partners Outputs: partner capacity assessments, list of prioritize partners Process data from prioritized partners Outputs: reviewed data</p>
<p><b>I</b> Partner have human and financial resources and capacity to collaborate Risks: Partners have limited investment to develop</p>	<p><b>7</b> Implement precision phenotyping platforms (genomic</p>

<p>capacity</p> <p><b>J</b> Partners see value and are willing to use new technologies, methodologies, approaches and genetic resources</p> <p><b>K</b> CRP WHEAT understands contextual issues related to pests, disease and pathogens</p> <p>Risks:  New emerging pests and diseases  Financial, social and political instability  Climate change</p>	<p>selection, multi-location, multi-traits)  Outputs: information about precision phenotyping, dissemination documentation  Provide capacity development  Outputs: training material, training sessions,  Establish and improve value chains between NARS and markets  Outputs: value chains, regular assessment and identification of areas for improvement of value chains  Establish and share standards and options  Outputs: standards and options, dissemination documentation</p> <p><b>8</b> Develop, test and share new breeding technologies, methodologies, approaches and genetic resources  Outputs: technologies, methodologies, approaches and genetic resources, testing data, dissemination documentation  Discover and share new genes for breeding  Outputs: genes and associated data, dissemination data  Monitor and share information regarding pests and diseases  Outputs: pests and diseases data, dissemination data</p>
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**Figure FP3-1. Flagship project impact pathway and theory of change.**

### 2.3.4 Science quality

The quality of science applied in FP3 is illustrated by the global utilization of CGIAR germplasm for wheat improvement. CGIAR derived wheat lines are released in every wheat growing country in the developing world and cover more than 50M ha. Fifty percent of all cultivars released worldwide between 1994 and 2014 are derived from CGIAR wheat lines (Lantican et al 2015). The high adoption rate and wide cultivation is an indicator for the efficiency and strength of the science applied for wheat improvement. The quality of science is also evident from table FP3-1. 416 papers were published by FP2 and FP3 scientists from 2012 – 2015; for 118 articles FP scientists were senior author. 312 articles were in refereed journals and 127 papers were published in journals with an impact factor greater 3. <http://wheat.org/download/wheat-publications/> provides a complete list of publications by WHEAT scientists (FP1 – FP4) and separate for FP2 and FP3.

**Table FP3-1. Statistics for refereed articles published by FP2&3 scientists from 2012-2015.**

Impact factor of journal	No publications	Articles with FP3 senior author	% senior author
NA	56	13	23
10-42	6	0	0
5-9.99	15	7	47
3-4.99	106	38	36
2-2.99	64	18	28
1-1.99	99	27	27
0.1-0.99	70	15	21
Total	416	118	28

Examples of new, novel and cutting edge science in FP3 include:

- CGIAR wheat researchers published first on genomic selection in wheat (Crossa et al., 2007). The largest GS experiment of a public program on GS in wheat is carried out in a joint project with KSU and Cornell.
- Genomic and MAS incorporation of new genes for resistance to biotic and abiotic stresses. MAS is deployed to pyramid major and minor resistance genes for more durable disease resistance. Advances in adult plant resistance gene cloning (Laguda et al. 2015) and introgression (cis-genes) will be exploited to combine adult plant resistance and major genes in cassettes that will prevent segregation and reduce chance for resistance break down dramatically.
- Modern tools, (applied from FP2) including genome-wide selection, high-throughput marker-assisted selection, high-throughput phenotyping and advanced statistical analysis of multi-location evaluation data to enable faster integration of desirable traits and improved breeding efficiency, especially for complex traits such as grain yield under optimum drought and heat conditions.
- Doubled haploid and Single Seed Descent will be routinely used in breeding efforts, where it increases selection-efficiency (faster gains/time or reduced costs; Li et al., 2013). Australia developed speed breeding of up to 6 generations per year will be evaluated (Hickey, 2015).
- Field-based selections, whenever this remains the most efficient approach, and shuttle breeding, will continue to be used. Multi-location, multi-year testing of germplasm, will remain central to our breeding programs (Braun et al., 2010).
- Use of new synthetic wheat wild relative introgressions to improve biotic and abiotic stress tolerance, photosynthesis (yield potential) and quality (Plant Breeding Review, 2012)

Different strategies of managing diseases/pests involving host resistance, chemical control, cultural practices, and biological control including integrated disease/pest management will be deployed to mitigate biotic stress threats.

- Fusarium head blight: The strategy is to combine multiple mechanisms of resistance through screening in the field, greenhouse, and laboratory. Haplotyping and MAS will be utilized to pyramid resistance genes. Hot spot testing will confirm the effectiveness and stability of resistance. For mycotoxin (DON) testing, qPCR and NIR are used together with ELISA.

- Breeding for resistance to tan spot, spot blotch, Septoria tritici blotch and Stagonospora nodorum blotch is very complex as in nature they occur in different combinations. Multiple resistance mechanism/genes/QTLs for each of the diseases have been identified and gene pyramiding, including minor genes, will be achieved to develop durable resistance. Future challenges lie in incorporating both types of resistance (toxin insensitivity and non-toxin insensitivity) to develop durable resistant cultivars.
- Sources of resistance in wheat and its wild relatives have been identified to key insect pests including Hessian fly, Sunn pest, Russian wheat aphid, green bug, stem saw fly, cereal leaf beetle. Host plant resistance (HPR) is the foundation for pests management, but we will continue to develop and explore other IPM options to complement HPR such as cultural practices and biological control.
- Collaborations with NARs and ARIs will be enhanced to assess and manage the pathogen variability in relation to resistance gene-breakdown, fungicide resistance and new race evolution. A Global Pests and Diseases Observatory in consultation with NARs and ARI will be made functional.

Development in the use of breakthrough technologies with significant impact in other crops have just started being utilized in wheat (Host-induced Gene silencing, CRISPR) and are being closely monitored and applied wherever applicable. Initial research is in FP2 but it is anticipated that some of these technologies become main-stream by 2022. Precision Phenotyping Platforms: Technologies for high-throughput phenotyping, large-scale data management and mechanistic physiological crop modeling are becoming increasingly available, and will promote high quality results and long-term utility. A network of up to 15 precision field-based Wheat Phenotyping Platforms (PWPP) is planned to be developed with co-investing NARS (Table FP 3-2). Collaborations with NARS have a comparative advantage in location-specific research areas, considering the mandate, infrastructure, expertise and location of these partners. They will provide in-situ laboratory and field facilities, equipment and staff with linkages to NGOs and the private sector to promote synergism. The proposed co-investing structure will promote the sustainable development of NARS capacities.

### 2.3.5 Lessons learnt and unintended consequences

The 2014 external evaluations of WHEAT by the IEA and of the CIMMYT breeding program by the Bill & Melinda Gates Foundation identified four high priorities for improvement

**Breeding Scale:** With yield improvement ever harder to achieve the breeding program needs to expand to test more lines in yield trials. The breeders are very familiar with the key traits (agronomic/ quality/ disease) required but yield testing is still the only reliable method to find the highest yielding crosses and best lines within those crosses. There are investments in remote sensing and genomic selection, which may in the future reduce the reliance on field yield testing, but at present plot harvesting and weighing are the only *proven* means of estimating yield. With the expansion of yield testing – since 2005 the number of plots in yield trials has doubled – the genetic gains have also increased. Clearly, the genetic gains that FP3 will realize are closely linked to the investments in breeding. This applies to CRP-WHEAT as it does to NARS breeding programs. If an uplift budget is provided, the yield testing will be further expanded.

**Integrating physiology into the main stream breeding program:** CIMMYT has probably the most inventive and focused physiology program in the world. There is already evidence that some lines selected through the physiology program have given some increments in yield (Cereal Systems Initiative of South Asia (CSISA) Phase II Review (2015)). An understanding of crop physiology, particularly related to novel introgressions and biomass production from pre-breeding activities will be very important in the future. Currently there is not a strong enough relationship between the breeding program and the physiology group. This issue has also been flagged by ISPC and is currently addressed through formation of trait focused teams, in which scientists with complementing expertise work on a specific challenge.

**Database development:** At the moment there is no integrated database into which both genotypic and phenotypic information can be aligned. However the BMGF funded GOBII (Genomic and Open-Source Breeding Informatics Initiative) should meet these needs. The Breeding Management System (BMS) is scheduled to become 'on stream' for field book and data management as of autumn 2016.

**Funding Strategy:** Currently most of FP3 research is driven by projects which are funded over short periods, usually 3 sometimes (though rarely) 5 years and some on annual renewal basis. For breeding programs this funding mechanism is undesirable. Breeding programs are long-term investments and the most successful programs around the world have one major common denominator – long-term breeder involvement and long-term funding. The whole area of funding needs an urgent review.

It was also noted that the current tendency for special project funding with a very narrow focus on a specific objective makes it very difficult to operate a wheat breeding program that is designed to develop elite lines that combine all relevant key traits. For example, Ethiopian farmers expect varieties that have high and stable yield, resistance to stem and yellow rust, Septoria and Fusarium head scab and possess adequate end-use quality and white grain color. CRP W1 and W2 funds are paramount for addressing traits that are not covered through bilateral or W3 funds, currently Septoria and Fusarium head scab.

The goal of WHEAT must be to increase genetic gain – at a rate which surpasses the historical norm – but at present the breeders are not in a position to take the necessary steps to make this happen. Ideally donors should be encouraged to allocate funds to WHEAT and specify in which 'flagships' they want to invest but leave the allocation to activities decided by WHEAT.

### 2.3.6 Clusters of activity

#### **FP3.1 Global breeding partnerships for bread and durum wheat – researchable issues**

Providing new genetic variability is a unique strength of WHEAT, as no other providers, public or private, maintains the reputation of the International Wheat Improvement Network that facilitates the sharing and collaborative evaluation of wheat germplasm. FP3.1 is where new traits are made available in elite lines. Together with seeds, important agronomic, quality and molecular data are provided. Due to GCC, increasing climate variability is experienced at same locations over years. Smallholder farmers, working on small fields, are frequently not able to sow a range of agronomically and genetically diverse varieties to mitigate against rain or temperature fluctuations. The varieties they use need to be inherently buffered against these variations and combine yield and yield stability, heat and drought tolerance, resistance to cereal rusts, target environment dependent diseases and pest resistance, meet quality and processing requirements and have a high nutritional value. WHEAT pursues an integrated approach of combining biotic and abiotic stress tolerance to address the key production and productivity constraints. Future actions in breeding to deliver higher genetic gains will include:

1. Further targeting of crosses- reducing numbers but increasing sizes of segregating populations- by utilizing data generated through enhanced agronomic/physiological and molecular characterization of wheat parents under a range of environments at breeding sites and phenotyping platforms.
2. Testing and utilizing high value cross predictions through genomic prediction models.
3. Implementing a strong integration of multi-trait breeding focus to develop superior yielding wheat varieties with better climate resilience, durable disease resistance and end-use quality.
4. Number of lines tested in yield trials will double (more than doubled already since 2005) utilizing visual as well as predicted performance through high-throughput phenotyping, pedigree and genomic prediction models.
5. Strengthening NARS capacity to test and utilize elite lines for utilizing in their breeding programs.

#### **FP3.2 Global network for precision field-based phenotyping**

The aim is to accelerate genetic gains by applying precise phenotyping approaches, standardized protocols, and novel screening tools to generate higher quality phenotypic data to fully utilize the potential of MAB. NARS will also have earlier access to more diverse germplasm for faster release of superior varieties. Scientists will be trained in new screening technologies and the use of standardized precision phenotyping protocols. This will also foster sharing of knowledge and germplasm.

Measured traits relate to stress structure or function ranging from cellular to whole-plant levels (Ghanem et al. 2015). Physiological phenotyping will be used in developing higher-yielding cultivars, with increased heat and drought tolerance. Recent advances in DNA sequencing has resulted in rapid sequencing of entire genomes at declining costs and increasing speed. However, the way genetic instructions from genes translate into traits is still unclear and phenotypic data will continue to be a powerful predictor of important biological outcomes (Houle et al. 2010). Investments in high quality phenotyping are needed to realize the potential of genome sequencing as a route to rapid advances in breeding, delivered by interdisciplinary teams and collaborative projects.

#### **FP3.3 Durable rust resistance and monitoring**

FP3.3 research pursues a global mandate, with a focus on developing rust resistant germplasm for Africa, Asia, Latin America and CWANA (Singh et al., 2011). Pardey et al. (2013) and Beddow et al. (2015) have calculated that rusts research investments of annually \$108M are warranted. High-yielding rust

resistant varieties are delivered to NARS partners, who assure their adaptation, release them and give access to resource poor farmers, who do not need to use crop protection fungicides. Core outputs are:

- Improved, precise phenotyping to generate more reliable data to breed for durable rust resistance, delivered by robust phenotyping platforms for three rusts (Ug99, aggressive yellow rust strains; dynamic leaf rust) in Ethiopia, Kenya, Mexico and Turkey.
- New resistance genes transferred into elite wheat lines.
- Marker assisted and genomic breeding used to pyramide genes for rust resistance.
- Develop and distribute through international nurseries germplasm with rust resistance and when resistance genes known, this information is provided with seed and can be accessed online.
- Genetic basis of resistance to three wheat rusts broadened in varieties and advanced breeding lines.
- Global rust tracking of movement and distribution of major rust races  
<http://rusttracker.cimmyt.org/>.

A key linkage to the phenotyping platforms (FP3.2) is increased NARS capacity to produce reliable phenotypic data (Pardey et al., 2013). This will greatly facilitate developing comprehensively improved germplasm. FP3.3 scientists will make use of latest marker technology to identify markers linked to resistance genes, MAB to bring in new genes in to widely adapted varieties and stacking of multiple resistance genes as cis-gene cassettes to inherit as a single Mendelian trait. Researchers will combine resistance to all rusts, by selecting best lines resistant in different environments, and develop pathogenomics and rust diagnostic kits for detection of pathogenic variabilities.

#### **FP3.4 Resistance and monitoring of major diseases and pests for food security and safety**

FP3.4 will develop diseases/pest resistant germplasm that will mitigate the threat of biotic stresses. Cost-effective and high throughput disease/pest screening protocols will be integrated into breeding programs to develop cultivars with durable resistance against a combination of diseases and pests. Host-pathogen/pest interactions will be dissected and changes in fungal pathogen/pest population monitored to develop holistic management of diseases and insect pests.

Due to changes in climate and agricultural practices, including adaptation of conservation agriculture and more maize-wheat rotations, many diseases (e.g. FHB, leaf spots and blights, soil-borne diseases and insect-pests) have increased to epidemic proportion, lowering production. The first reports of wheat blast in Bangladesh (20% of total wheat area is affected) and India add a new challenge and emphasize the need for continuous disease surveys. The major non-rust diseases and pests affecting production and how they are likely affected by climate change are shown in more detail in Annex 4.2. FP3.4 will focus on:

- Developing disease/pest resistant germplasm resilient under changing agricultural practices and climate.
- Identification, characterization and introgression of new resistance genes to diseases/pests and of multiple resistance mechanisms into elite germplasm and pyramiding them with known resistance genes into elite germplasm, using novel breeding strategies.
- Monitoring and assessing the disease/pest causing pathogen populations. Development of a global pests and diseases observatory, for global co-ordination to develop monitoring of the emergence of new races of wheat pathogens; disease assessment and identification of their causal pathogen, and understanding the population biology of the pathogen/pest.

Understanding the epidemiology of wheat blast in S-Asia and identify sources of resistance for use in breeding programs.

### **FP3.5 Nutrition, processing quality and health**

Under FP3.5, WHEAT will expand its research on quality, to incorporate nutritional and health dimensions: Greater availability and consumption of high fibre and high resistant starch wheat, including through greater whole meal flour consumption. FP3.5 research components are shown below:

- Use high-throughput methodologies to predict or evaluate quality traits to identify genes and factors ensuring high values and stable processing and end-use quality in different environments, including with lower use of nitrogen and micronutrient fertilizers, to develop varieties with higher natural gluten quality.
- Research supporting greater acceptance of whole meal flour. Wheat contains many healthy components (micronutrients, dietary fiber, B vitamins, folic acid etc), but most are concentrated in the outer layers of the grain and the embryo and are present at low concentrations in refined flour. Whole meal accounts for 80-95% of the grain and should be used for food production wherever possible, to retain high levels of bioactive components. In collaboration with INRA France.
- Identify lines with enhanced healthy properties. More than half a billion adults are obese (WHO, 2008). In developing countries, obesity often co-exists with malnutrition and stunted growth. Obesity rate increases are higher in women than in men Traits researched are high content of resistant starch with UC Davis, USA and U. Cordoba, Spain and wheat with high dietary fiber content with Rothamsted, UK, to reduce risk of chronic diseases and lessen obesity.
- Contribute to increasing dietary fiber in human diets. Thousands of lines will be analyzed for processing and end-use quality traits to apply Genomic selection (with FP2.5) and using molecular markers (with KSU and CAAS). Screening of diverse genetic resources will be a key activity (with FP2.2), using high-throughput tools, such as EDXRF (energy-dispersive X-ray fluorescence spectrometry).
- Develop biofortified wheat with enhanced iron (Fe) and zinc (Zn) grain concentration and bioavailability in wholegrain and white flour (Govindan and Singh, 2012). Delivered via A4NH.

### **FP3.6 Enable molecular breeding**

The genetics and genomics area has made rapid advances. Multinational companies already deploy molecular breeding approaches routinely applying large sample volumes, automated genotyping systems, data management and software pipelines. Low cost, fast turn-around genotyping platforms and using novel sequencing technologies are future key requirements.

Researchable issues are a) adopting latest genotyping technologies for routine MAS and genomic selection (GS) deployment; b) using novel sequencing technologies for rapid gene identification and functional marker development and c) design and test new marker deployment strategies.

FP 3.6 will focus on:

- Adopt a streamlined SNP genotyping facility across CGIAR centers which is also accessible to national programs.
- Evaluate bioinformatics tools developed in the GOBII initiative. The package will need to include a database for any SNP data, links with the BMS to access phenotypes, designs that optimize pyramiding of gene-diagnostic markers, support to select favorable haplotypes and parents and GS and other analytical pipelines.

- Design markers for high-throughput SNP genotyping by mining existing genotypic and phenotypic datasets and convert identified molecular markers into SNPs and search for new variants in genes with proven importance (e.g., TaSNRK, ERECTA).
- Rapid gene discovery and functional marker development using new sequencing technologies and the reference sequence including epigenetic marks.
- Deployment of targeted amplicon sequencing. Genotyping targets allele independently. As more alleles are identified, it will become preferable to re-sequence target genes instead of genotyping each individual allele.
- Marker-assisted approaches in controlled greenhouse environments that will dramatically reduce the time introducing new alleles into elite backgrounds. Incorporation of gene loci in future GS models via high-throughput genotyping and imputation.
- More rapid gene introgression and selection using MABC together with high density genotyping options in linked backcross populations, single seed decent or DH populations, and GS models that include gene-diagnostic markers as fixed effects.

### **FP3.7 Efficient seed delivery systems / Seed systems innovation**

This CoA supports the development of more efficient, gender-responsive seed targeting and delivery systems. Seeds are the vehicle to transfer genetic gains to farmers. Wheat farmers can re-use their own seed without facing immediate yield reductions, because wheat is a self-pollinated crop. Thus, the average weighted age of varieties on farmers' fields in many countries is greater than 10 years (Table FP3-7). Long lags in seed delivery further delays adoption of new varieties. Considering an annual genetic gain of 0.7% and the fact that many varieties become susceptible to diseases, an average variety age of more than 10 years equals significant income losses for smallholders.

Wheat seed production was and is mainly in the public sector, which is less responsive to small-scale farmers' needs and preferences. Incentives for private sector investments have been low. Royalty systems do not exist in most WHEAT target countries. New, highly virulent rust races (Ug 99, Yr27) have driven the need to establish robust seed systems for rapid scaling out, to replace susceptible varieties in countries that suffered from rust epidemics. CoA 3.7 will focus on

- Seed systems analysis, including farmer behavior, seed demand and marketing, economics of production, mechanisms to fast track varietal releases, accelerated seed multiplication and dissemination and provide policy advocacy for investments and incentives for emerging private sector in seed delivery.
- Analysis of economics and returns (to farmers) from wheat varietal replacement in an interval of two, three, four and five years.
- Innovation in seed provisioning approaches or methods and risk management; Engaging seed companies (public or private) to produce Foundation or Basic seeds, instead of breeders themselves.

New options for fast-track release of varieties and their dissemination, to lower the risk and costs in terms of varietal break down/degeneration. This requires that national varietal release regulators

A key challenge for FP3.7 is researcher capacity. Under the uplift budget scenario, WHEAT would build capacity by appointing at least 4 seed systems specialists; 2 in Asia, one each in Africa and Latin America.

**Table FP3-2. Comparison of weighted average age (years) of wheat varieties grown in farmers' fields, 1997 and 2014.**

Age	1997 <sup>a</sup>	2014 <sup>b</sup>
<6	Zimbabwe, Afghanistan	Argentina, Czechia, Georgia, Hungary, Kenya, Lebanon, Spain, Ukraine
6-8	Argentina, Brazil, Chile, China Pakistan,	Afghanistan Brazil, Egypt, Ethiopia , Pakistan, Paraguay, Rwanda, Tajikistan, Uruguay, Zimbabwe
8-10	Bolivia, Colombia, Iran, Nigeria, Uruguay, Zambia	W. Australia, Azerbaijan, Bangladesh, Canada, China, Iran, Italy, Japan, Latvia, Mexico, Nepal, Pakistan, Romania, Tanzania, USA, Uzbekistan, Zambia
10-12	Ecuador, Morocco, Paraguay	Armenia, Bolivia, Egypt, Kazakhstan, Nigeria, Turkmenistan, South Africa, Tanzania, Uganda, Switzerland, Turkey
12-14	India, Kenya, Lebanon, Mexico, Syria, Yemen	Albania, Belarus, India, Israel, Portugal, Serbia, Slovenia, Russia (Omsk),
>14	Algeria, Bangladesh, Egypt, Ethiopia Jordan, Nepal, Peru, Sudan, Syria, Tunisia Turkey	Algeria, Bhutan, Ecuador, Jordan, Kyrgyzstan, Morocco, Sudan, Syria, Tunisia

Source: <sup>a</sup>Heisey, Lantican and Dubin 2002; <sup>b</sup>Lantican et al. 2016.

### 2.3.7 Partnerships

FP3 partners with most NARSs in wheat producing countries as part of the International Wheat Improvement Network (IWIN, see chapter 1.1 Fig 3). International nurseries and data are shared with more than 250 cooperators annually. WHEAT also partners with ARIs in developing and developed countries, and contributes to the precision phenotyping platform network. FP3's co-operation on wheat breeding (research) with the private sector is mostly with companies in developed countries. At present there are at most 5 private wheat-breeding programs in developing countries that operate fully-fledged breeding programs. Others focus on testing and multiplying seed of varieties by the public sector and the CGIAR. Close links with other CoAs and CRPs will assure rapid and enhanced use of genetic potential. Partners per FP3 CoAs are shown in the Tables FP3-3a to FP3-3e below:

**Table FP 3-3a. Key partners in FP 3.1.**

Partner type	Partner name	Key contribution
NARS	NARS Asia, Africa, Latin America and developed countries	Testing and data, provision of international screening nurseries and yield trials; releasing and promoting new varieties
NARS	CAAS China	Molecular markers, modeling and breeding simulation
ARI	Kansas State University, Cornell University	Genomic selection for breeding
International coordination	(G20) Wheat Initiative	Breeding Methods, Information System, Modelling, Abiotic and Biotic Stress, Phenotyping, Quality, Durum Wheat, NUE, Germplasm Conservation & Use

**Table FP 3-3b. Partners in FP 3.3.**

Partner type	Partner name	Key contribution
NARS, CGIAR	EIAR (Ethiopia), KALRO (Kenya), ICARDA-Izmir	Research on Ug99, stem rust, yellow rust
ARI	BGRI (Cornell)	Leads global initiative, coordinates expertise globally
ARI, Universities	USDA-ARS CDL (U. Minnesota), USDA-ARS CDL (Washington State U.), UC Davis, 2Blades, CSIRO, U. of Sydney, Genome Analysis Centre UK, GRRF, Aarhus U DK, JKI, GER	Stem, yellow and leaf rust. Identify molecular markers linked to resistance genes and the development of R-genes cassettes

**Table FP 3–3c. Partners in FP 3.4.**

Partner type	Partner name	Key contribution
<b>NARS &amp; ARIs</b>	Australia, Bangladesh, Canada, China, Ethiopia, India, Japan , Kyrgyzstan, Lebanon, Morocco, Nepal, Tajikistan, Tunisia, Uruguay, USA,	Conduct multi-location trials for international disease/pest specific nurseries, e.g. FHBSN, ISEPTON and HLBSN
<b>NARS</b>	Precision phenotyping platform partners	Conduct multi-location trials
<b>ARI</b>	NSW-DPI, Narellan-Australia, DArT-Australia, HAAS, Wuhan-China, K-BioScience-UK; Purdue U USA, Kansas State U, USA	Genotyping partners for molecular analysis
<b>ARI</b>	Cornell U, Ghent U, JIC-UK, U of Vermont, CABI Bioscience UK, Michigan State U, USA  SFASU, Texas, USA	Genomic and association mapping; Biopesticides for Sunn pest management Enhancement of beneficial insects; Devel. of inhibitor for the Sunn pest enzyme
<b>Universities</b>	Queensland; Ghent; Bonn, Kassel; Morocco: IAV; Turkey Ankara, Cukurova, Bolu, Nigde; UK JIC, Nottingham; USA: Colorado, WSU	Build capacity by hosting Master and PhD students
<b>Private sector</b>	Syngenta	IPM options to reduce disease damaging threshold

**Table FP 3–3d. Partners in FP 3.5.**

Partner type	Partner name	Key contribution
NARS	Small Grain Inst. S-Africa	End-use quality analysis. Genetic and environmental control of quality traits. HPLC to identify glutenins composition and concentration to affect quality stability.
ARI	Rothamsted Research, UK	HEALTHGRAIN project; knowledge on bioactive components (dietary fiber, phytochemicals, etc.) that currently CIMMYT or ICARDA do not have.
ARI	INRA, France,	Grain processing, milling and analysis of milling fractions; improving the acceptability of high extraction rate and whole grain flour.
NARS	Tunisia, India, Turkey, Pakistan,	Conduct multi-location trials for quality analysis; build quality research capacity.

**Table FP 3–3e. Partners in FP 3.6.**

Partner type	Partner name	Key contribution
<b>Genotyping Services</b>	LGC genomics; Douglas Scientific; Trait Genetics KSU; Cornell; DArT;	WHEAT outsources genotyping whenever possible. No genotyping method currently meets all needs. Therefore AFS-WHEAT works with various providers
<b>CRP, CG-centers</b>	MAIZE, GRISP, ICRISAT, ICARDA	Molecular marker technologies and bioinformatics. GOBII and the shared genotyping platform are examples
<b>ARI</b>	John Innes Centre, CSIRO, IWGSC, ETH-Zurich, U of Minnesota	Expertise in gene identification R&D especially for adaptive traits and rust resistance
<b>ARI</b>	Kansas State U, Cornell U, Michigan State U, IPK, U of Giessen, U of Queensland, USDA-ARS.	Integration of gene-based and genome wide markers, Genomic Selection, marker-introgression:

### 2.3.8 Climate change

WHEAT will work with CCAFS on research activities relating to (i) climate sensitive breeding strategies. Their collaboration will address the following key questions:

- How can genotypic responses to climate be better understood through use of current and future crop and climate databases and modeling tools? (led by CIMMYT)
- What are the predictable aspects of climate that need to be taken into account when breeding for future climates? (Led by CCAFS)
- How can previous research and breeding efforts accelerate rapid adaptation of cropping systems in climate affected regions? (led by CIMMYT)

Promising climate-resilient material, including those identified during CCAFS Phase I from analysis of historical IWIN data, will be evaluated more intensely in climate vulnerable sites in Asia and Africa. Wherever appropriate, this research will take place in CCAFS climate smart villages where outputs together with other FP4-driven management practices will be evaluated under a climate lens.

For more detail, see Annex 3.7.

### 2.3.9 Gender.

FP3 prioritizes product development which addresses the needs and preferences of both women and men farmers of different social groups and age ranges. FP 3 will consolidate the use of on-farm trials and demos and farmer field days to systematically collect feedback from both men and women of different social groups and ages, drawing on existing guidelines for integrating gender into PVS. This will contribute to streamlining systematic sex-disaggregation in data collection and analysis related to farmer feedback to improved varieties. FP3's crop improvement portfolio incorporates specific quality traits is of particular relevance from a gender perspective, e.g. micro-nutrient content (especially zinc, iron), baking quality, freshness, grain hardness/softness (milling), shattering and ease of threshing. Weed competitiveness or early foliage development is another characteristic with potentially high

relevance where weeding is done by women and children - a trait already incorporated in CIMMYT's trials. FP3 will explore gender and other social identities as customer attributes in relation to technology diffusion (e.g. varietal promotion, replacement; seed systems). FP3 will address these research questions:

- What are the traits or combinations of traits related to wheat that men and women farmers and consumers in different contexts and social groups prioritize? How are these similar or different for men and women? To what extent are they related to gender specific labor burdens? (e.g., weeding, post-harvest, nutrition).
- How, and to what extent are these needs, preferences and constraints considered in wheat breeding?
- What factors influence men's and women's ability to access, use and benefit from improved wheat varieties? Do these factors affect men and women in the same or different ways?
- How do farmers, especially women, access information about seed? What are key issues for developing gender sensitive variety promotion and decision support information?

#### 2.3.10 Capacity development

The focus of capacity development under FP3 is on strategic actions A and B described in Annex 3.3, to build capacity to improve national seed systems and to build a new generation of wheat scientists among NARS partners.

#### 2.3.11 Intellectual asset and open access management

Under FP 2 and 3, scientists develop tools for data management, data stewardship (including open access), and data mining or analysis; to enhance breeding efficiency that results in faster genetic gains. These will be designed with OA/OD in mind, from a technical and user perspective. Researchers will make their well described raw data available to other scientists through Dataverse. Under FP2-3, scientists also disseminate germplasm and related data, based in international regulations.

#### 2.3.12 FP management

FP3 is managed jointly between the two lead centers – with both joint FP coordination and co-CoA leads. The co-leadership allows both centers to share ownership and responsibilities and provides clear focal points within each organization for each CoA and the FP as a whole.

**Table FP3-4. FP and CoA leaders.**

FP/CoA Structure	FP3 coordinators and CoA leaders	
	CIMMYT	ICARDA
FP3.1 Global breeding partnerships for bread and durum wheat	Hans Braun	Michael Baum
FP3.2 Global network for precision field-based phenotyping	Carolina Saint Pierre	Michael Baum
FP3.3 Durable rust resistance and monitoring	S. Bhavani	K Nazari
FP3.4 Resistance and monitoring of major diseases and pests for food security and safety	P. Singh	M El-Bhoussini
FP3.5 Nutrition, processing quality and health	C. Guzman	
FP3.6 Enable molecular breeding	S. Dreissigacker	A Al-Abdallat
FP3.7 Efficient seed delivery systems / Seed systems innovation	Joachim Stahl CIM (GIZ) Scaling Out Expert	C. Kleinermann

As CIMMYT and ICARDA make progress towards establishing One Global CGIAR wheat program as of 2019, the currently CIMMYT-ICARDA shared FP and CoA Lead roles will be taken over by one scientist, employed by one or the other Center.

[2.3.13 Budget summary- see FP budget template](#)

## FP4: Sustainable intensification of wheat-based farming systems

### 2.4.1 Rationale, scope

Strategic efforts to boost wheat productivity can increase smallholders' food and income security, while also improving livelihoods, natural resource integrity, equity, nutrition and health, and resilience against biophysical or socio-economic shocks, all of which are urgent development priorities. Most smallholder wheat farmers' livelihoods do not however depend exclusively on wheat. Rather, their farming systems are generally characterized by complex strategies that integrate crop and livestock production, often with increasing reliance on off-farm income, and a strong risk management component that can hamper the adoption of innovations that focus on wheat yield alone.

FP4 focuses on sustainable intensification (SI) research in high-poverty concentration geographies, both subsistence and smallholder market-integrated wheat-based systems, in South and Central Asia, Latin America, Ethiopia, Morocco. SI encompasses a number of dimensions, including (a) production of more food, feed, fuel and/or fiber per unit of land, labor, and/or capital used, particularly by closing yield gaps and increasing yield per unit of time and area, (b) conservation of critical agroecosystem regulatory and provisioning services, and (c) farming system resilience to shocks and stresses, including those posed by climate change and poorly functioning markets, while (d) seeking to address social justice, gender equity, and youth inclusivity, and human well-being (Loos et al., 2014; Pretty et al., 2011; Vanlauwe et al., 2014; Zurek et al., 2014). Research within FP4 therefore offers the potential to simultaneously address a number of sustainable development objectives, all of which are central to SI. These include eliminating poverty and hunger, improving access to clean water, facilitating responsible production and consumption, addressing climate change, and protection of natural areas from conversion to agricultural use, while reversing land degradation.

Technologies, management practices, and agricultural innovation systems developed and deployed through this flagship will enable women, men and young farmers to improve livelihoods with farm-level incomes that contribute to the base of the agrifood system. The flagship will aid in the reduction of economic risk, produce more or less the same amount of wheat with fewer external inputs, despite climate change and other stresses, and with a healthier impact on the environment. FP4 target groups include poor farm households in systems where wheat is a major cereal contributing to food and income security. Research will be designed in such a way as to emphasize links with the remainder of the wheat agrifood system, and to leverage linkages with other flagships (particularly 5.1 and 5.2). The agro-ecologies in which resource-poor wheat farmers operate are typically characterized by socioeconomic and environmental heterogeneity -farmers tend to spread risks and diversity by depending on other commodities (cash crops, legumes, livestock), and off-farm income to sustain livelihoods. Therefore, regionally adapted agronomic solutions are key; there is no silver bullet to assure the sustainability of wheat agrifood systems. Under FP4, WHEAT maintains existing collaborations with other CRPs on 45 innovation platforms, most prominently GRiSP, MAIZE, PIM, Dryland Systems and CCAFS. At the core of FP4 are system analytical approaches, the products of which will leverage social, political and biophysical diversity at farm and landscape scales, working across regions:

- *Breadbasket regions where bringing sustainability to intensive production systems is urgent:* Increasing resource use efficiencies (irrigation water, nitrogen, phosphorous), maintaining high and stable yields (e.g. NW Mexico, the Indo-Gangetic Plains (IGP), Horn of Africa and southern Africa).
- *Regions at risk of heat-stress:* Global wheat yields are expected to decline under climate change. Productivity levels are already threatened by terminal heat stress in the tropics, where smallholder wheat farmers predominate (Koehler et al. 2013). FP4 tackles these problems

focusing on  $G \times E \times M$  interactions, and cropping systems that assure timely planting. For example, this occurs through mechanized rice harvesting and use of short-duration rice genotypes for early wheat establishment in the IGP (Krupnik *et al.* 2015), where 1.6 billion people – nearly 40% of whom live in extreme poverty – rely on wheat-rice rotations for food security (FAO 2014).

- *Regions with rainfed and partially irrigated systems:* In environments where farmers rely on unpredictable rainfall, or where pumped water resources are scarce and the energetic and economic costs of irrigation are high, conservation agriculture (CA) based management practices can boost water productivity and reduce energy requirements, thorough research is needed to fine and assure that smallholders are able to adopt CA practices.
- *Regions where input and output markets are limiting:* Investment in intensified cropping practices limited where appropriate input availability is low, or where output markets poorly developed. Research in FP4 responds using innovation systems approaches and methodologies to develop scalable interventions to overcome such limitations to the agri-food system.
- *Regions where labor resources are constrained:* Farmers are increasingly reliant on off-farm income and migratory labor. In particular, parts of the IGP for example, male-outmigration has led to the increasing feminization of agriculture, indicating a need to develop labor-efficient technologies using scale-appropriate agricultural machinery (Krupnik *et al.* 2014; Baudron *et al.* 2015).

## 2.4.2 Objectives and targets

### Flagship outcomes and structure

FP4 is designed around four mutually-reinforcing clusters of activities (CoAs) that address key objectives and targets:

- 4.1 Multi-scale farming system framework to better integrate and enhance adoption of sustainable intensification options;
- 4.2 Integration of technological and institutional options in rural livelihood systems;
- 4.3 Multi-criteria evaluation and participatory adaptation of cropping systems;
- 4.4 Partnership and collaborations models for scaling.

FP4's primary outcomes (see also Tables 3, 4 and 5, section 1.2) include three CGIAR results framework sub-IDOs: (1) More efficient use of inputs; (2) Closed yield gaps through improved agronomic and animal husbandry practices; and (3) agricultural systems diversified and intensified in ways that protect soils and water. Five CGIAR cross-cutting issues are also addressed through sub-IDOs: (1) enhanced capacity to deal with climatic risks and extremes; (2) improved capacity of women and youth in decision-making; (3) increased capacity of beneficiaries to adopt research outputs; (4) enhanced institutional capacity of partner research organizations (and others involved in sustainable intensification); and (5) increased capacity for innovation in partner research organizations (and others involved in sustainable intensification). WHEAT's FP4 theory of change (Figure FP4-1) systematically addresses threats to the agronomic basis of the wheat agri-food system, and is aligned with the CGIAR Strategy and Results Framework, with outcomes contributing through sub-IDO's to WHEAT's SLO contribution, including reduced poverty, improved food and nutrition security and improved natural resource systems and ecosystems services.

**Draft indicators and metrics, and monitoring framework for sustainable intensification (Table FP 4 -1; to be confirmed during the operationalization of the RBM framework).**

FP4 WHEAT indicators address both the ToC and W3 donor requirements. For SI, field level indicators are mainly related to “efficiency” and enhanced ecosystem services contributing to yield stability and resilience. Household level indicators focus on livelihood measures, including food security, income, investment (labor, cash), assets and social networks (capacity) each gender and age differentiated, while at community to landscape scales the focus is on ecological costs (land degradation, soil health), social equity, measuring investments by partners and donors to indicate procedural change in the food system. Select examples are given in the table below. Large economies of scale and improved M&E&L are expected from harmonizing SI indicator definitions and monitoring approaches across CRPs.

**Table FP 4-1. Indicators, metrics, and monitoring framework for sustainable intensification.**

Research Outputs	Scale			
	Field	Farm or system	Landscape	Institutional
Productivity research (soil, water, biotic); Systems research (optimization, adaptation, design for future) Markets & institutions; Enabling ‘Last mile providers’ (knowledge & capacity products);	<b>Shorter term</b> - Nutrient, water & labor use; - Nutrient, water & labor efficiency;  Indicators: Number of farm households adopting improved wheat varieties and/or improved crop management practices	<b>Shorter term</b> - Food sufficiency & security; - Income & Assets; - Investment & ROI of (system) technology;  Indicators: Number of men and women assisted to exit poverty	<b>Shorter term</b> - Availability of wheat; - Price change  Indicators: Number of men and women meeting minimum dietary energy requirements	<b>Shorter term</b> - No. extension workers trained; - No. farmers reached (early adoption); - Use of outputs/products by ‘providers’  Indicators: Evidence of knowledge into use by NARES (methods), extension, NGOs, and other development partners (training materials)
Tools & DSS (targeting, prioritization, trade-offs); M&L&E	<b>Longer term</b> Soil health (C, % org, nutrient balance)  Indicators: Land degradation/erosion /soil health indicators at the field level including populations and proxies for critical soil faunal species	<b>Longer term</b> System health (nutrient cycling, biodiversity, biomass)  Indicators: Land degradation/erosion/soil health indicators at the farm levels	<b>Longer term</b> - Land-use change; - Soil loss/ degradation; - Soil health (AFSIS); - Net productivity (vegetation, biomass); Ecosystem services (biodiversity, water)  Indicators: Increase in water and nutrient (inorganic, biological) use efficiency in agro-ecosystems, including through recycling and reuse.	<b>Longer term</b> - Use of outputs/products by ‘providers’; - Capacity/ performance of ‘providers’ (no. employees, loan repayment etc.); - Investment by value chain actors; Indicators: Livelihood and institutional indicators

### 2.4.3 Impact pathway and theory of change

The FP Sustainable Intensification’s theory of change was developed during a workshop with the Flagship project teams from both MAIZE and WHEAT CRPs. A participatory approach was used to capture all views, experiences and known evidence into the theory of change. The workshop participants were able to increase their understanding of the CGIAR Strategy and Results Framework and awareness of results-based management concepts. The workshop was also structured to encourage sharing and learning on a variety of topics and across both CRPs.

Using the CGIAR Results Framework's sub-intermediate development outcomes (IDOs) the team agreed to focus on three sub-IDOs and five cross-cutting sub-IDOs:

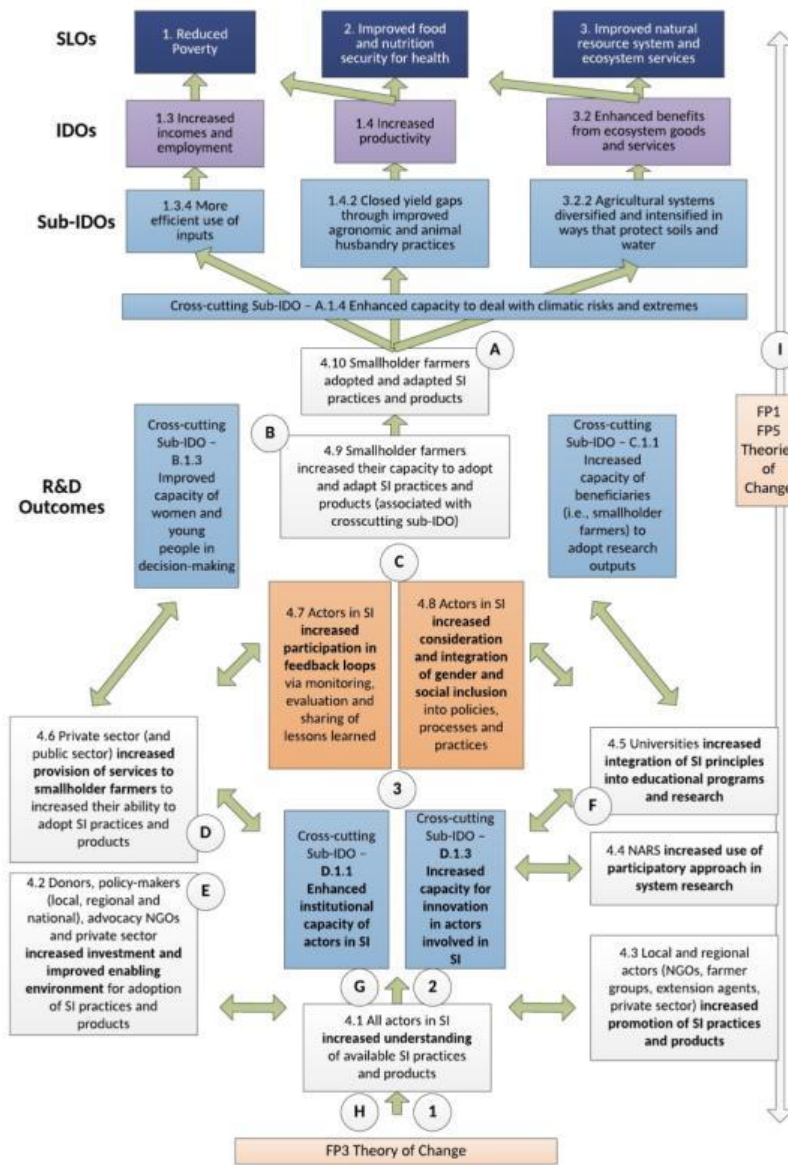
- 1.3.4 More efficient use of inputs;
- 1.4.2 Closed yield gaps through improved agronomic and animal husbandry practices;
- 3.2.2 Agricultural systems diversified and intensified in ways that protect soils and water;
- A.1.4 Enhanced capacity to deal with climatic risks and extremes;
- B.1.3 Improved capacity of women and young people in decision-making;
- C.1.1 increased capacity of beneficiaries to adopt research outputs;
- D.1.1. Enhanced institutional capacity of partner research organizations; and
- D.1.3 Increased capacity for innovation in partner research organizations.

Other sub-IDOs were noted by the team as important to programming given that they overlap with the above sub-IDOs of focus. The team identified several of the cross-cutting sub-IDOs as part of the research and development outcome component of the impact pathway, noting their importance in contributing to the achievement of immediate and intermediate outcomes.

Based on these areas of focus, the team agreed that this Flagship project contributes to reducing poverty (SLO 1), improving food and nutrition security for health (SLO2) and improving natural resource system and ecosystem services (SLO3) by the mean of increasing incomes and employment (IDO 1.3), increasing productivity (IDO 1.4), enhancing benefits from ecosystem goods and services (IDO 3.2) and enhancing the cross-cutting issues of climate change (A), gender and youth (B), policies and institutions (C), and capacity development (D).

A number of research and development outcomes were identified and a pathway of change was created demonstrating the causal relationship between outcomes and sub-IDOs. During this process, partners involved in the pathway of change were identified. Current and proposed interventions and associated outputs to support the achievements of the outcomes were mapped. Assumptions describing the contextual underpinnings of the theory as well as the risks that may have the potential to undermine success were documented.

This theory of change will be the foundation for the monitoring, evaluation and learning plan. The monitoring plan will consist of a continuous process of collection and analysis of data based on a set of indicators directly related to the performance of the CRP at the output and outcome levels; the key assumptions of the theories of change; and the critical risks. The theory of change will also be the basis for evaluating the Flagship project as well as reflecting on lessons and program improvements.



- (A)
- (B)
- (C)
- (D)
- (E)
- (F)
- (G)
- (H)
- (I)

### Assumptions and Risks

- SI practices and products are adaptable to other environments and systems.
- Smallholder farmers see benefits and are able to adopt/adapt SI practices and products
- Smallholder farmers see value in achieving more efficient use of inputs, closing yield gap, and diversifying and intensifying agricultural systems
- Smallholder farmers are aware and have access to SI practices and products
- Actors in SI are willing/able to participate in research, capacity building and/or improving the enabling environment for adoption of SI practices and products
- Common interest among actors
- Actors in SI act to contribute to gender responsiveness and social inclusion
- Private sector recognizes importance of SI
- Risks: business interest negatively effects the adoption of SI practices and products; potential for emergence of ethical issues
- Partners have interest and power to share the enabling environment
- Risk: Frequent conflicting and competing priorities negatively effects the research in and adoption of SI practices/products
- Co-research processes lead to integration of SI into educational and R4D programs
- CRP has understanding of the institutional landscape and has the means to influence it
- Actors in SI are reached
- Need and incentive for intensification
- SI practices and products address locally important challenges and opportunities
- Organization sufficiently recognizes or incentivises importance of knowledge sharing, innovation, and critical thinking
- Risks: Focus placed on publications instead of overall ToC results
- Risks: Financial, social and political instability, climate change

### Interventions and Outputs

- 1 Research:
  - Technological options for sustainable intensification of cropping systems
  - Sustainable farming systems and livelihood intensification strategies
  - Enabling policies and sustainable intensification landscape
  - Outputs: technologies, policies, decision support tools, extension programs, publications
  - Develop and implement communication and marketing strategy
  - Outputs: Communication and marketing strategy
  - Develop and implement a partnership/networking strategy
  - Outputs: Partnership/networking strategy
- 2 Provide training (on the job, workshops, short and long term training)
  - Arrange exchange visits
  - Brokering (management and dissemination) of knowledge (to all partners)
  - Contribution to the development of decision support materials
  - Contribute to business promotional materials
  - Business model development
  - Joint product development
  - Outputs: training material, promotional products, decision support tools, communication products
- 3 Creating of innovation platforms
  - Gender and social inclusion analysis and identification of appropriate interventions
  - Gender and social inclusion workshops
  - Outputs: innovative platforms, gender responsive and socially inclusive interventions, gender and social inclusion sensitization training materials

Figure FP4-1. Impact pathway and theory of change (ToC) for WHEAT FP4: Sustainable Intensification.

## 2.4.4 Science quality

FP4 builds on a solid scientific foundation from WHEAT Phase-1. The peer-reviewed publication list from the lead-CGIAR team (CIMMYT SIP and SEP programs under MAIZE, WHEAT and CCAFS) during 2012-Jan2016 period is given below. <http://wheat.org/download/wheat-publications/> provides a complete list of publications by WHEAT scientists (FP1 – FP4) and separately for FP4. It comprises 195 publications (many in journals having an impact factor above 2), and a number of additional high-impact journals in which one publication was logged, for example PNAS and Energy (9.674 and 4.844, respectively). A large majority of these publications are co-authored by CGIAR colleagues and collaborating scientists from ARIs and NARS (Table FP 4-2). The contribution of DS scientists to Phase II will further strengthen the scientific team involved in FP4.

**Table FP4-2. Journals in which the SI team has published more than twice since January 2012** (representing only 59% of all publications registered).

Journal	Number of pubs (co-authored by SI group)	Journal H-index	Impact Factor (2014)
Field Crops Research	35	89	2.976
Agriculture, Ecosystems & Environment	14	67	2.906
Agricultural Systems	13	110	3.402
Soil and Tillage Research	9	84	2.622
Crop Protection	6	67	1.493
Food Security	6	13	1.495
Experimental Agriculture	6	28	1.079
Food Policy	4	55	1.192
International Journal of Ag. Sustainability	4	15	1.659
Renewable Agriculture and Food Systems	4	29	1.355
Advances in Agronomy	3	74	3.893
Agricultural Water Management	3	70	2.286
Crop Science	3	100	1.575
Journal of Agricultural Economics	3	36	1.278
Nature Climate Change	3	50	14.547

There is a clear evolution regarding the scope of SI publications. In the early CRP-I period, focus was placed primarily on field level research. But since then, the publication portfolio has evolved to a more balanced one including increasingly SI oriented systems research at the farm/landscape level, utilizing multi-criteria analyses, modeling, and the stronger application of systems oriented methodological approaches to addresses the complexity of SI challenges (as seen from the number of papers in *Agricultural Systems* and *Agriculture, Ecosystems, and Environment*). Lessons learned in Phase-I indicated that interdisciplinary collaboration sheds light on the key factors limiting the successes of SI interventions, while also highlighting new opportunities for research and development to overcome them. To this end, the FP4 SI team is comprised of a mix of soil scientists, systems agronomists, farming systems analysts, and researchers involved in innovation systems and adoption research.

### Key research questions and approaches for FP 4.1 include:

- How can the development of farm typologies using a common methodology in pilot areas representative of the main wheat farming systems be used to tailor training and adoption messaging?
- What are the main causes of yield gaps at the landscape scale and what are the entry points for addressing them? Systematic networks of crop-cuts, remote sensing (e.g., use of UAV), and

collection of farmers' practices data, disaggregated by farm type, will identify the main causes of yield gaps and provide actionable recommendations for specific farm types.

- How can wheat-livestock systems be harnessed in the context of SI practice? What options to minimize tradeoffs and maximize synergies between crop and livestock sub-systems?
- How can water resources be more efficiently used to support SI at different scales?
- How can the alternative landscape configurations be designed for improved delivery and maintenance of ecosystem services (e.g., pest control, freshwater provision for irrigation in estuarine environments), nutrition and resilience (self-organization) be made actionable?

**Key research questions and approaches for FP 4.2 include:**

- How can tools and methods for the assessment of agricultural (innovation) systems and the participatory identification of socio-technical and institutional options for SI in multi-stakeholder configurations (incl. innovation platforms) be used more effectively?
- Why do (ICT-based) decision-support tools for farmers, service providers, extensionists and development actors success or fail, and how can they be improved? Research will identify where the most high impact opportunities for ICTs are, and then work to co-design decision-support tools with service providers operating different scales in agricultural (innovation) systems), while embedding them in existing stakeholder networks.
- How can new quantitative and qualitative methods for the assessment of the (uneven) adoption of socio-technical SI options into diverse livelihood systems be used to study and resolve their inequality effects? Acknowledging that agricultural change involves of both socio-institutional and technical components, FP 4.2 develops methods and tools to improve on current adoption studies that are too linear and focused on individual decision-making (Sumberg et al. forthcoming).

**Key research questions and approaches for FP 4.3 include:**

- How can wheat be adapted to = climate change, with emphasis on G x E x M interactions (WHEAT FP2.4, 3.1 collaboration; docking CCAFS FP 1)?
- How can yield gaps be most effectively bridged in the context of smallholder wheat based cropping systems? Research to bridge yield gaps will first proceed with the evaluation and deployment of appropriate criteria to scientifically assessed attainable yield targets in a diversity of production environments and farm typologies (building on FP 4.1). Long term research trials and field experiments are key to this research.
- Can potential yields of genotypes under specific circumstances be increased with agronomic management (what is the role of G x E x M in bridging yield gaps)? What are interactions of agronomic management on physiological processes (for example photosynthetic efficiency), and how much can be translated to yield?
- How can yields be increased while optimizing nutrient, water, and energy? Research devise management practices for water, nutrient and organic residues under different production systems and ecologies, and how this informs decision support tool and precision sensor development (linking to FP 4.2).
- How can farmers capture the interactions of management practices to reach attainable yield targets given nutrient (N, P, K), water requirements (spatial and temporal) and organics (residue retention) management for a range of cropping systems and agro-ecologies.

- How can soil resource degradation be best arrested? Plot-level and processes research will help identify synergies and tradeoffs of improved agronomic management practices in wheat systems.

**Key research questions and approaches for FP 4.4 include:**

- *How can multi-actor innovation networks be best used for scaling:* Research is needed to better understand scaling-up processes and ensure sustainability of institutional mechanisms and structures. Learning, internal and external, is a key process that will need to be institutionalized.
- *How can viable business models be developed to support SI:* To provide new insights into on what and how to concentrate on scaling-up processes through business models and *Business model appraisal, design and evaluation for the provision of technological products and services in support of smallholder intensification.*
- *How can knowledge management through ICT and social networking be used for scaling-up?* Understanding the complex interaction between the enabling environment and the business propositions for ICT services.
- What builds scaling partners' capacity to innovate, and how can this capacity be increased and leveraged for scaling? What are the roles of innovation systems and hubs in scaling? What are their limitations? Currently understudied, this research will provide new insights on the role of innovation brokers and other actors in building smallholders' entrepreneurship skills
- How can public-private partnerships and technology commercialization be used for scaling? The relationship between market-oriented production and productivity increases is not well understood. Findings are expected to reinforce the need to consider both input and output markets in support of SI.
- How can gender equity and youths' priorities be addressed in scaling up agricultural technologies and management practices? To reinforce our understanding of the adoption, adaptation and scaling- up processes, recognizing that market demand is a major trigger of innovation.

#### 2.4.5 Lessons learnt and unintended consequences

**Key lessons learned during Phase I:** Research during Phase I generated key insights into wheat SI technologies, indicating that (i) a great amount of data have been produced on  $G \times E \times M$  through trials that have not been fully capitalized upon, as a robust geospatial framework for more effective targeting and monitoring of research and impacts remains lacking, and (ii) assessment of agronomic technologies and management practices must go beyond yield and specific resource-use efficiency measures such as water and economic profitability, to incorporate more comprehensive analysis (Fischer et al. 2014). Such assessments must take into account socio-environmental criteria made possible by developing standardized protocols for multi-criteria assessments of advanced crop management technologies (see External Evaluation recommendations 1, 8 here). Dryland Systems CRP research indicated that improvements to the performance of a farming system requires attention to factors in addition to those that close yield gaps. These include how better management of land, water, crop and livestock diversity interact and can contribute to profitability, environmental conservation and resilience to abiotic and biotic stresses. Additionally, (iii) the nature and diversity of SI interventions can be overwhelming (Giller et al., 2010); therefore, systems approaches and tools are needed to generate clear research results, so that complex information can be translated for relevance, and can move into the hands of smallholders

and development partners more rapidly. Understanding farmer perception, farmer diversity, and the farm-level integration of technologies is therefore essential for success.

Beyond the field level, Phase I research has indicated that (i) the diversity of smallholder wheat based farming systems and communities influence the use of SI interventions within different wheat based agrifood systems, excluding “one-size-fits-all” or silver bullet “solutions.” In addition, (ii) tools and methods for better targeting are urgently needed, along with clear metrics to understand the contribution of interventions on smallholder livelihood strategies and resilience (López-Ridaura et al. 2002). Need exists (iii) to better understand smallholder farming systems diversity and trajectories (which influence adoption of SI interventions), and feedback between farming systems and the landscapes in which they operate. In addition, (iv) guidelines for knowledge sharing are crucial for stakeholder engagement in making SI recommendations actionable. This requires the use of innovation systems approaches to scale-out best-bet technologies. However, (iv) there is insufficient study of the efficacy and efficiency of innovation platforms and systems in the agrifood systems in which WHEAT operates. More research is thus needed on the dynamics, actors and interactions of locally embedded, sustainable innovations systems.

#### 2.4.6 Clusters of activity

FP4 consists of four Clusters of Activity (CoA). While FP 4.1 provides a farming system analytical framework to prioritize constraints and interventions towards the SI of wheat-based farming systems, and FP 4.3 evaluates such targeted interventions, using multiple tools and criteria, FP 4.2 provides the necessary decisions support tools and institutional environment to ensure that validated interventions provide livelihood and landscape benefits derived from SI. FP 4.4 then provides innovative models for scaling products and outcomes from FP 4.2 to considerable farming populations and wheat-based areas.

The four CoAs are tightly interlinked by integration of knowledge and feedback loops for methodological improvement (e.g. 4.1 will integrate information on agronomic performance from 4.3 into systems analysis and will, in return, provide targeting and prioritization guidelines for cropping systems scale research in specific agro-ecologies through 4.3). FP 4.1 will interact with FP 1.1 by using meta-level targeting information and will provide feedback for systems analysis information, FP 4.2 will institutional landscape insights to leverage scaling research and interventions under FP 4.4. FP 1.4, which monitors adoption figures and process indicators will receive feedback for methodological improvement and design, feeding back into FP4’s Monitoring Framework for SI. Finally, FP 4.3 will use promising germplasm for targeted environments and cropping systems from FP 3.1 and provide feedback on their performance considering G x E x M analyses (Herrera et al., 2013).

##### **FP 4.1 Multi-scale farming systems framework to better integrate and enhance adoption of wheat SI options**

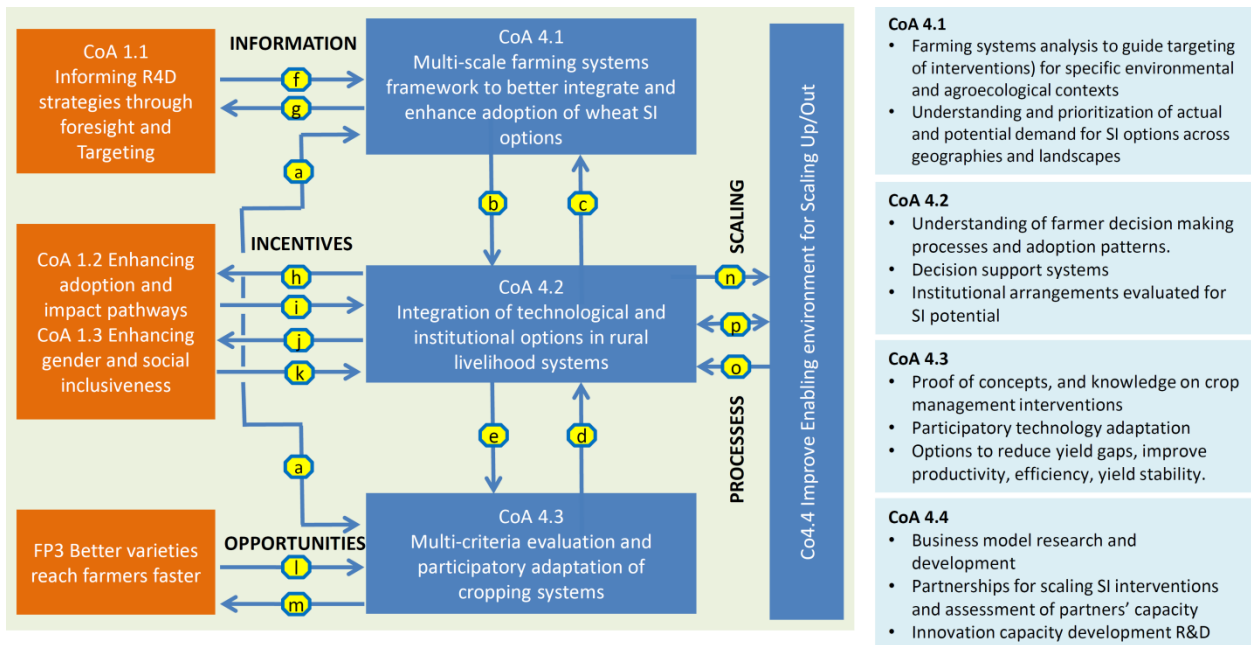
This CoA will produce a methodologically actionable multi-scale framework for farming systems analysis (1) to understand constraints and prioritize interventions, considering current and future demand, (2) to guide targeting of options (technical and institutional) in specific contexts (agro-ecological, socioeconomic, and institutional) and (3) to understand tradeoffs and synergies between options when combined.

The framework will make use of existing large datasets, many generated during Phase I (including geo-spatial, remote sensing and climate data), and will combine the use of participatory research (to understand farmers’ constraints and objectives, and identify future scenarios as in FP 4.2), and empirical research (on-station and on-farm trials on component technologies), and modelling tools (to understand

the performance of current farming systems and explore future scenarios) as articulated in FP 4.3 (Giller et al., 2011).

Depending on the constraints and priorities identified in each context, this CoA will consider interventions (1) making more efficient use of inputs (including labor, time, energy, fuel, etc), (2) closing yield gaps, (3) diversifying diets and improving nutrition (e.g., wheat-legume relay cropping, integration of livestock production in wheat production systems), (4) promoting social inclusiveness, with particular emphasis on women and youth (e.g., labor-saving technologies), and (5) improving system’s resilience to climate change and other stresses (e.g., early planting, increased water-use efficiency through CA).

Support to improved targeting of interventions will work at two-levels: landscape-level (i.e., recommendation domains) and farm-level (i.e., farm types). At the landscape-level, the robust geospatial framework from the Global Yield Gap Atlas (van Bussel et al., 2015; van Wart et al., 2013) and associated database will be used. At farm-level, participatory and multivariate approaches will be used for categorizing farming communities in functional or structural types (Kebede, 2009; Tittonell et al., 2010), using survey data collected during Phase I.



Integrated knowledge for development and performance feedback to research

**Knowledge and product flows between CoAs**

- a** - 4.3 to 4.1 Integration of agronomy performance into systems analysis
- b** - 4.1 to 4.3 Prioritization for further field scale research in CRPs agro-ecologies
- c** - Inform participatory research design and prioritized technologies to be integrated according to agro-ecologies and farm types
- d** - Feedback loop and improvement of framework
- e** - Agronomy/technical know-how to participatory research actors
- f** - Feedback on in-situ performance of technologies and their integration for further improvement by agronomists
- g** - Meta-level targeting information to systems analysis
- h** - Feedback loop on meta-level foresight and targeting
- i** - Methodological support to SI scaling.
- j** - Provides prototyped decision support tools/Systems
- k** - Feedback to participatory approaches and DST/DSS
- l** - Provide adoption figures + process indicators to CoA 1.4
- m** - Supply of promising germplasm for targeted environments
- n** - Feedback on GxExM, with emphasis on closing yield gaps
- o** - Business model intelligence to leverage public-private partnerships
- p** - Innovation capacity research and development
- q** - 4.2 to 4.3 integration from research from practice and back (feedback)

**Figure FP 4-2. FP4 CoAs and knowledge/product flows and feedback loops between FPs/CoAs.** FP4.1 and 4.3 provide targeting information on and cropping systems opportunities, respectively, and operate at different analytical scales (region, landscape, farm, and field), while integrating research from FP1.1 and 3.1. FP4.2 operates as the central node by which farmer decision-making and instructional incentives can be assessed, providing feedback loops to FP1.4. This results in the identification of scalable research products and technologies that are extended through research results that inform scaling processes in FP4.4.

The analysis of tradeoffs and synergies will be multi-scale (Baudron et al., 2015a) and multi-criteria (e.g. López-Ridaura et al., 2002), and will make use of a suit of approaches including bio-economic models, systems dynamics, agent-based models, informative scenarios analysis and multi-criteria assessments (Boulangier and Bréchet, 2005; Kelly et al., 2013). Country-level recommendation domains for combinations of wheat SI interventions and for different objectives (increased productivity/efficiency, improved diets/nutrition, social inclusiveness, and improved resilience to climate change and other stresses (South Asia, North, East, and Southern Africa).

#### **FP 4.2 Integration of technological and institutional options in rural livelihood systems**

An enabling institutional context is a necessary condition for agricultural change (Hounkonnou et al., 2012). This CoA aims to understand the incentives and decision-making processes at the farm and institutional landscape scale that drive the integration of SI technologies in diverse rural livelihood systems. FP 4.2 develops and implements participatory methodologies to identify, test and evaluate SI technologies and institutional arrangements – socio-technical options – together with farmers and other stakeholders in targeted geographies. Thus, this CoA will arrive at ‘scalable products’ – SI technologies, decision-support tools and new institutional arrangements – for diverse sets of farmers, agricultural sector stakeholders, and development actors, as well as new methodologies for the integrated assessment of SI approaches when scaling is explicitly considered.

FP 4.2’s focus builds on previous research, which revealed that plot-level assessments of SI technologies, while intrinsically important, are not enough to foster agro-technological change. Institutional constraints at different scales (farm-level and beyond) often shape the applicability of SI technologies in different farming and farm-household systems (Andersson and D’Souza, 2014; Schut et al., 2015); they constitute prerequisite conditions for smallholder farmers’ integration of new technologies into their livelihood systems (Giller et al., 2015; Sumberg, 2005). Cognizant of the need to complement participatory on-farm testing of SI technologies with a focus on the wider farm environment, a wider set of agricultural system stakeholders has been included in agricultural research. However, the numerous multi-stakeholder fora – including innovation platforms – that have been set up by AR4D projects at the local level, have often been deployed mainly as a technology dissemination mechanism, with little regard for end-users and their circumstances. Actionable research is therefore needed into the efficacy and efficiency of different multi-stakeholder participation modalities in the identification, experimentation with, and evaluation of socio-technical options (that is, technologies and/or new institutional arrangements).

This CoA integrates insights generated by ex-ante adoption and impact studies (FP 1.4), multi-scale farming systems research (FP 4.1) and experimental research into cropping system opportunities (FP 4.3), in multi-stakeholder participatory research on the integration of socio-technical options for sustainable intensification in WHEAT-based farming systems. Such feedback also informs research into Flagships 1 and 3, while generating information demands for farming systems research (FP 4.1). It focuses on the incentives/drivers of such integration, by developing research aimed at:

1. Understanding agricultural system configurations (institutional landscapes) and, particularly, the role of multi-stakeholder interaction mechanisms – notably Innovation Platforms – within these, in generating socio-technical options for sustainable intensification.
2. Understanding the decision-making processes and priority setting of different farmer types (as outlined in FP 4.1) and other agricultural system stakeholders regarding the integration of such socio-technical options, in the context of diverse rural livelihood systems and farming strategies.
3. Understanding the impact of different socio-technical options from a multi-scale perspective, that is, from a farm and (institutional and environmental) landscape perspective.

Thus, FP4.2 will provide a framework and identify scalable products – combinations of SI technologies, decision-support tools and (complementary) new institutional arrangements – by partner organizations – beyond the CRP’s on-farm research sites, through different scaling modalities as studied and developed in FP4.4.

In conjunction with the CRP Roots, Tuber and Bananas (notably RTB FP 5.4), and building on agricultural systems research within phase I WHEAT and MAIZE, and the systems-focused CRP Dryland systems, FP4.2 will develop analytical frameworks, methodologies and tools to address the research foci.

### **FP 4.3 Multi-criteria evaluation and participatory adaptation of cropping systems**

This CoA provides proof of concepts, know-how, and knowledge of potential wheat cropping systems interventions that reduce yield gaps focused on resource poor farmers in the targeted agro-ecologies. CoA 4.3 benefits from extensive Phase I research, and also from integration of Dryland Systems CRP. An underlying SI hypothesis is that productivity can be increased while reducing environmental externalities and paying dividends to smallholders (Pretty and Bharucha, 2014). Wheat is a key staple food crop that is increasingly subject to stresses under climate change. Research aimed at buffering the millions of smallholder wheat farmers (see table 2, section 1.1) from the anticipated negative effects of climate change on wheat productivity is a critical concern, and will benefit from strong integration with CCAFS. Additional priority research goals include the development of actionable methods to (a) reduce management yield gaps using low cost tools and approaches (offer complementarity with research at BISA platforms in South Asia), (b) limit greenhouse gas emissions in systems where wheat is rotated with rice (offering complementarities with RICE in South Asia) or farmed intensively (Latin America) and (c) raise farm incomes by efficiently utilizing inputs and labor. The scale of the environmental ramifications of wheat systems are apparent, especially in South Asia, where intensively cultivated rice-wheat zones are experiencing rapid and drastic groundwater decline and rapidly increasing pumping costs (linkage to research at BISA platforms).

These issues underscore the need to develop water use efficient cropping systems. Farm productivity in Latin America, South Asia, and Africa is limited by the availability of farm power, increasingly high labor costs and scarcity, especially as rural out-migration increases (Mottaleb and Mohanty, 2014 ) and resulting feminization of agriculture in densely populated South Asia, where youth increasingly search options outside of agriculture (Justice and Biggs, 2013). FP 4.3 builds on the extensive knowledge generated in systems agronomy, including integrated soil fertility management (ISFM), conservation and precision agriculture, appropriate mechanization, weed management, soil ecology and G x E x M analysis.

Enhance efficiency, resilience, and sustainable functioning: Cropping systems are increasingly subjected to climatic stresses (extreme heat, drought, waterlogging etc., alone or in combination), as well as to socioeconomic problems (availability of labor, inputs, their quality and cost). To avert risk and foster investment in SI, farmers need assurance that cropping systems will consistently produce high, stable and profitable yields under different abreactions. Standardized minimum-datasets that provide indicators and metrics for these variables from long-term trials and networks of participatory research will be developed. Wheat SI research will address the limiting factors and multi-facet system optimization for increased system functionality related to agricultural production, environmental services and livelihoods. The 2017-2021 phase will develop cross-regional minimum-datasets and research pilots to assess both on-farm as well as off-farm consequences of management practices in wheat systems, with emphasis on indicators for assessments of soil and water quality and metrics for energetic and environmental footprint of alternative cropping systems and their contributions to SI goals.

#### **FP 4.4 Improve enabling environment for scaling up/out (including capacity development)**

WHEAT Phase I was largely concerned with scaling up of the sustainable intensification technologies and practices through innovation platforms, farmer organizations, public-private partnerships with private sector agro-dealers and traders and partnership with public sector extension. The approach in Phase II will be to evaluate and learn from the processes of scaling-up introduced over the first phase and to design and develop new models of scaling such as higher level platforms for policy dialogue (e.g. jointly with PIM, other CRPs, linked to Country Coordination action plans), the introduction of ICT methods and the use of mass media and private sector service provider business models. Strategic interventions through FP 4.4 will draw on the multi scale farming system framework of 4.1 and crop management technologies developed under COA4.3, drawing on methodological and decision support to scaling from FP 4.2. This CoA will deliver the following outputs:

1. *SME business model development for provision of goods and services:* a) developing business models of small and medium scale local enterprises including agro-dealers, traders, mechanization service providers, agro-processors and formulate upgrading strategies to develop the demand for their goods and services; b) supporting multiple stakeholder processes in strengthening seed, post-harvest, small scale mechanization and/or other input supply chains; c) developing linkages between private sector stakeholders and with financial service providers.
2. *Partnerships and collaboration in support of smallholder intensification:* a) (co-)developing public-private partnerships with corporate level seed companies, agro-dealers and mechanization businesses to facilitate the uptake of sustainable intensification based technologies (including forward and backward value chain linkages and interventions); b) developing linkages between farmers, farmer organizations and input and output market actors; c) developing linkages with financial institutions for the provision of value chain finance; f) conducting negotiations and developing agreements with seed companies, agro-chemical companies and major importers and manufacturers of mechanization to import and/or produce and market agricultural machineries; and g) developing partnership agreements with public sector extension services to foster the scaling-up and out of SI based technologies and practices.
3. *Developing the capacity to innovate among multiple stakeholders* (strongly linked to cross-cutting CoA Capacity Development)
4. *Learning for feedback and scaling up and out:* The learning aspects of the M&E system is critical for adoption and adaptation to occur. The system will be designed to generate knowledge and facilitate learning. Together with ICARDA and CIMMYT MEL Teams, the BMZ-funded Senior Advisor will be part of a Community of Practice of GIZ scaling-out colleagues in 8 CRPs and will support organizational learning and research about scaling out pathways, models and approaches across WHEAT.

#### **2.4.7 Partnerships**

##### **Partners and target geographies**

Phase I of WHEAT allowed the initiation or strengthening of strategic partnerships with advanced research institutions and national agricultural research partners who are expected to carry on WHEAT's work following the 2021 CRP investment.

**Table FP4-3. FP4 beneficiaries.**

CoA	Products	Direct beneficiaries	Scaling mechanism	Indirect beneficiaries	Ultimate beneficiaries and expected impact by 2021
4.1 Multi-scale farming system framework to guide R4D interventions	Information, knowledge, and methodologies	FP1, FP3.7  Development organizations	Through FP4.4  Feedback loop to FP4	Farmers  Small business/enterprises	<b>South Asia*</b> <b>SSA Africa**</b> <b>Latin America and Caribbean***</b>
4.2 Participatory approaches to adapt and integrate technological components	- Feedback on in-situ integration of technologies  - Improved technical know-how of stakeholders	NARES, and other last mile providers to better target of technical interventions		Farmers in targeted regions  Farmers, rural service providers, private sector, in targeted regions, ICT companies,	
4.3 Development and field testing of crop management technologies	- Improved crop management practices aiming at increasing yields and resources use efficiency (CSA)	Other CRPs (CCAFS, WHEAT, GRiSP, RTB, DCL, WLE), FP1			

\*Asia: Bangladesh (Barisal, Rajshahi, Rangpur, Khulna Divisions), Nepal (Central and Western Regions), India (Bihar, Haryana, Orissa, Punjab, Uttar Pradesh, Karnataka, Madhya Pradesh, Rajasthan), Pakistan (Punjab), Iran (Kurdistan, Loristan, Kermanshah, Esat Azerbaijan), Afghanistan (Kabul, Nangarhar), Central Asia (Uzbekistan, Kazakhstan), and China **North Africa:** Morocco \*\***Sub-Saharan Africa:** Ethiopia (Highlands), Kenya (Laikipia), Rwanda (Northern Region), Burundi, Tanzania (Northern Region and Southern Region), Zambia, and Zimbabwe. \*\*\***Latin America:** Mexico and Ecuador

#### 2.4.8 Sustainable intensification and climate change

FP4 with its focus on systems approaches to developing productive, environmentally sound, and socially equitable SI-based best practices provides a natural home for climate smart agriculture (CSA). Working closely with FP1 and CCAFS, the evidence produced by this flagship will be used to model future climate effects on production, together with synergies and trade-offs, to identify target adaptation domains with potential mitigation co-benefits that will inform how CSA is integrated into strategies and plans at the regional, national and local levels. More specifically, FP4 will work closely with CCAFS around : a) participatory evaluation of WHEAT technologies and practices in climate smart villages (CSVs) and other sites where appropriate, b) improved resource use efficiency, particularly nitrogen and water, and their impact on lowering GHG emissions (Sapkota et al., 2015, 2014) , c) evaluation of the C sequestration potential of SI interventions including crop diversification (Dendooven et al., 2014; Powlson et al., 2016, 2014), and d) creation of multi-criteria datasets and standardized methods and metrics to quantify CSA over a range of scales. The GYGA spatial framework, combined with CCAFS Climate ‘Analogue’ tools (Harvey et al., 2012), will provide a means to explicitly evaluate climate smart options in both current and future climates.

This work will leverage WHEAT and CCAFS climate projections, farm typologies, and farming system models to support the evaluation of technologies in terms of enhanced resilience to climate variability and extremes (drought, floods, and high temperatures), mitigation of GHG emissions and associated costs at the landscape and regional scale, with support from FP 4.1. Building on research determining stress-prone wheat mega-environments, this work will be targeted through CSVs and other CCAFS research.

#### 2.4.9 Gender

Research conducted in Phase I highlighted the importance of understanding and influencing the socio-agro-ecological landscapes within which wheat based farming systems and sub-systems are embedded (Beuchelt and Badstue 2013; Farnworth *et al.* 2015; Baudron *et al.* 2015). The ability of women, youth and marginalized groups to participate effectively in, and benefit from, innovation processes can be hampered by increasing male outmigration as a primary response to climate change and other changes, a relative lack of leveragable productive resources for youth or women at household and community levels and other factors.

In Phase II, FP4 will build on learning to date to integrate gender analysis into its agricultural innovation systems approaches. All applied R4D interventions will proactively engage women, men, and youth of both sexes in technology development, evaluation, and validation, and systematically disaggregate their feedback by sex and age. Social characteristics will be integrated as key variables into the development of farmer typologies and related modeling. Important research questions include:

- How do gender and age (and other relevant) differences in farmers' access to and control over productive resources influence technology choices?
- What types of institutional arrangements and business models can enhance the ability of poor women farmers, youth and marginalized groups to access and benefit from more efficient and labor saving technologies?
- What are potential trade-offs of sustainable intensification technologies from a gender and social inclusion perspective? And what approaches can help mitigate these?
- How do social and gender norms constrain/enhance individuals' ability to engage in agricultural innovation processes? And what are effective measures to address barriers to social inclusion in technology development and dissemination?

#### 2.4.10 Capacity development

FP 4 leverages opportunities for scaling and capacity development through linkages to the cross-cutting CoA, to support national partners, mainly through (1) collaborative research and linkages to advanced global research institutions, (2) graduate students funded by WHEAT, (3) specific training courses, and use of ICT/distance learning tools to engage remotely located trainees and (4) sharing of science infrastructures. In line with External Evaluation Recommendations 3 and 5 ([link](#)), objectives for FP4 are:

- Enhance understanding of the application of SI oriented research methodologies (particularly use of multi-criteria assessments), management practices, technologies and machinery for both irrigated and rainfed wheat production systems.
- Strengthen ability to synthesize and apply available knowledge related to research methodologies, management practices, technologies and machinery.

- Increase knowledge of long-term trial planning and management.
- Strengthen participants' ability to generate scientifically-sound hypotheses, determine data collection strategies (including for soil and crop management), interpret data and summarize into scientifically sound conclusions and recommendations.
- Foster and heighten appreciation of benefits of team work and interdisciplinary research.
- Build skills and capacities necessary to manage innovation and extension networks.

#### 2.4.11 Intellectual asset and open access management

See Annexes 3.9 and 3.10.

#### 2.4.12 FP management

FP4 management will be constituted of co-leaders from the two leading centers at FP and CoA level (Richard Thomas/ICARDA and Bruno Gerard/CIMMYT for overall FP4 management. In our experience, it is very difficult to get firm commitment and understanding of CRP complexity from non CGIAR partners. The co-lead centers will ensure proper complementarity /synergies between meager W1/2 resources allocated to FP4 and the large W3/bilateral portfolio being mapped under this FP.

Guidance for FP science quality and relevance will be provided by a group of scientists recognized in the field for their tremendous expertise and experience (**mentoring committee**). The committee will be constituted of Ken Cassman (ULN), representatives from select NARS, in whose countries WHEAT has major investments (e.g. South Asia, Africa, LAC, high level representatives from 1 or international NGOs). FP4 management and mentoring committee will meet once year to plan and review. Additional virtual meetings will be organized on a need base.

**Table FP4-3. FP and CoA leaders.**

FP/CoA Structure	FP4 coordinators and CoA leaders	
	CIMMYT	ICARDA
FP 4.1 Multi-scale farming systems framework to better integrate and enhance adoption of wheat SI options	Frederic Baudron	Quang Bao LeLe
FP 4.2 Integration of technological and institutional options in rural livelihood systems	Jens Andersson	Shinan Kassam
FP 4.3 Multi-criteria evaluation and participatory adaptation of cropping systems	ML Jat	Yashpal Singh Saharawat
FP 4.4 Improve enabling environment for scaling up/out (including capacity development)	David Kahan	Vinay Nagia

#### 2.4.13 Budget summary (see separate template)

## Section 3: Annexes

### 3.1 Participating Partners Budgets

As per Consortium guidance, see separate template in online submission tool.

### 3.2 Partnership strategy

WHEAT's global partners' network is essential for addressing cross-border challenges, co-developing and disseminating International Public Goods and thus maintain the WHEAT comparative advantages. The **WHEAT Partnership Strategy** is based upon these **assumptions**:

1. WHEAT can achieve outcomes and impact only through partnerships outside and within the CGIAR, of which the going onto 50 years International Wheat Improvement Network (<http://wheatatlas.org/nurseries/references>) is the prime example.
2. Different partnerships and partners are needed in the different phases along the non-linear continuum from discovery of new knowledge to achievement of systemic change (e.g. discovery to scaling out). Table 32-1 visualizes this by way of examples.
3. The further WHEAT moves along this continuum, the less it can/should lead and influence (Circle of Influence principle).
4. As products, solutions and approaches developed under WHEAT move towards scaling-out/-up, partners-of-partners (e.g. boundary partners) become the key drivers of change.

**Table 32-1. Different types of partnerships along the continuum from discovery of new knowledge to achievement of systemic change.**

	Discovery	Validation	Scaling-out
<b>Strategic**</b>			
Regional / Global	International Wheat Yield Partnership	International Wheat Improvement Network Precision phenotyping platforms network	GIZ: Build Scaling Out networks SARD-SC/Wheat in 11 SSA countries (AfDB)
	G-20 Wheat Initiative: Int'l research coordination		
National	CIMMYT-ICAR: Research coordination & collaboration (5-yr plans)		NGO collaboration on mechanization business development (e.g. CSISA-MI: iDE)
		MasAgro Take It To The Farmer: Innovation Systems Approach	
<b>Program-/Project-based</b>			
Regional / Global	Genomic Selection: The next frontier for rapid gains GENNOVATE (11-CRPs, 80 case studies)	Cereal Systems Initiative in South Asia (CSISA): <i>Complex agri impact challenges*</i>	
	Durable Rust Resistance in Wheat Initiative: Global germplasm improvement program		
National		MasAgro: <i>Complex agri impact challenges*</i>	
	S. Korea, Japan, BMZ-CIM: post-doc expert secondment	Pakistan Agricultural Innovation Program: <i>Discrete agri impact challenges*</i>	
Sub-national		Innovation hub partners (e.g. NOGs, CSOs, private sector partners)	
*As defined in "Good Practice in AR4D Partnership", ISPC Guidance Paper, Sept 2015 (draft). **ILRI's Partnership Strategy (2011) distinguishes between institutional (e.g. with FARA; at Center Mgmt level), strategic and project-driven partnerships.			

This strategy aims to

1. Make clear to our existing and future partners how we want to go about partnership and why it is so important to WHEAT, based on their feedback;
2. Support program and project leads, as well as WHEAT-MC, to better plan ahead, set up, manage and close well-functioning partnerships at the strategic and operational level; be they lead, co-lead or participating partner (ILRI Partnership Strategy refers to contractor, equal partner and service provider categories);
3. Develop new kinds of partnerships, for specific purposes and in specific contexts: Work with new kinds of partners (e.g. ORNL, USA), participate in new types of partnership (e.g. International Wheat Yield Consortium, aligned with WHEAT; GIZ scaling out multi-CRP p'ship), including improved alignment of independent research efforts (for definition and categorization of different actions and instruments, see <http://www.faccejpi.com/Document-library/Strategic-Research-Agenda#> and <http://www.faccejpi.com/>).

The strategy will build on learning from the ILAC-led 'Analysis of the portfolio of activities and networks of WHEAT' study (draft report, March 2015). This network analysis has been done for all other CRPs, providing opportunities for inter-CRP learning. How will this strategy be **implemented?** By

1. Giving partnership as such more attention:
  - a. Integrating methods and tools along the partnership life cycle into the WHEAT project management cycle;
2. Improving upon screening partners:
  - a. In many cases, WHEAT cannot choose its partners (e.g. there is only one; donors stipulate partners). Therefore, a better SWOT analysis at the outset is needed, as well as explicit mutual expectations management (e.g. agree on 'how to partner')
3. Staying close to partners and fostering partnership management practices (sustaining, partnering capacity) in three critical areas:
  - a. Approaches, methods and tools, such as stakeholder and network analysis, mutual self-assessments and targeted capacity development activities
  - b. Relationship management: Roles and Competencies
  - c. Building and maintaining Partnership Knowledge Base
4. Exchange of experiences and know-how with other CRPs in the context of country coordination.

**Table 32-2. Strategic partnerships: Illustrative examples (ongoing, into Phase II).**

<b>MSP: Complex agri impact challenges: Cereal Systems in South Asia (CSISA) WHEAT FP4</b>	
Convenor of the Partnership and their role	CIMMYT leads CSISA's work in India and Nepal, is a partner in CSISA Bangladesh and leads CSISA's wheat breeding objectives. IRRI leads CSISA' work in Bangladesh. Est. 2009, as a follow-up to the Rice Wheat Consortium, now in Phase III.
Specific focus and objective	<ul style="list-style-type: none"> <li>• promote durable change at scale in South Asia's cereal-based cropping systems with 8M farmers by 2020, by:</li> <li>• Promoting widespread adoption of resource-conserving practices, technologies and services that increase yields with lower water, labor and input costs.</li> <li>• Supporting mainstreaming innovations in national-, state- and district-level government programs to improve long-term impacts achieved through</li> </ul>

	<p>investments in the agricultural sector.</p> <ul style="list-style-type: none"> <li>• Generating and disseminating new knowledge on cropping system management practices that can withstand the impacts of climate change in South Asia.</li> <li>• Improving the policy environment to facilitate the adoption of sustainable intensification technologies.</li> <li>• Building strategic partnerships that can sustain and enhance the scale of benefits accrued through improving cereal system productivity.</li> </ul> <p>Results Framework, see p.68, Annual Report 2015: <a href="http://csisa.org/wp-content/uploads/sites/2/2014/06/CSISA-II-annual-report-DEC-2015.compressed.pdf">http://csisa.org/wp-content/uploads/sites/2/2014/06/CSISA-II-annual-report-DEC-2015.compressed.pdf</a></p>
Science Agenda	<p>Scaling-out: Catalyzing widespread dissemination of production and post-harvest technologies to increase cereal productivity, resource use efficiency and income. . CSISA supports women farmers by improving their access and exposure to modern and improved technological innovations, knowledge and entrepreneurial skills;</p> <p>Process-based research on crop and resource management practices for future cereal-based systems;</p> <p>High-yielding, heat- and water-stress-tolerant rice, wheat varieties for current and future cereal and mixed crop-livestock systems;</p> <p>Improved policies and institutions for inclusive agricultural growth</p>
Geographical focus / location	<p>Operate in 12 rural ‘innovation hubs’ in Bangladesh, India and Nepal, CSISA works to increase the adoption of various resource-conserving and climate-resilient technologies, and improve farmers’ access to market information and enterprise development; see also <a href="http://csisa.org/csisa-locations/">http://csisa.org/csisa-locations/</a></p>
Role of the CRP/FP in the partnership	<p>Bilaterally funded multi-stakeholder partnership contributing to WHEAT FP4.1 and 4.3 (as well as to MAIZE, other CRPs). W1&amp;2-funded competitive grants under FP4.1 have collaborated with CSISA researchers. Same for W1&amp;2-funded strategic gender research and FP3.1 germplasm improvement (not in Phase III).</p>
Key CGIAR partner(s) and their (its) role(s)	<p>CIMMYT</p> <p>IFPRI is a partner in CSISA Bangladesh, India and Nepal, and leads CSISA’s policy objective.</p> <p>ILRI is a partner in CSISA Bangladesh, India and Nepal, and leads CSISA’s livestock activities.</p> <p>IRRI leads CSISA’s work in Bangladesh, is a partner in CSISA India and leads CSISA’s rice breeding objective.</p> <p>WorldFish is a partner in CSISA Bangladesh and leads CSISA’s aquaculture activities.</p> <p>iDE: Co-implements CSISA-Mechanization and Irrigation (CSISA-MI). iDE is an international NGO that creates income and livelihood opportunities for poor rural households.</p>
Key ‘external’ partner(s) and their (its) role(s)	<p>CSISA’s key national collaborators: Bangladesh Agricultural Research Institute, Indian Council of Agricultural Research, Nepal Agricultural Research Council.</p> <p>For more information about partners, see: Page 60, <a href="http://csisa.org/wp-content/uploads/sites/2/2014/06/CSISA-BD-Annual-Report-2014.pdf">http://csisa.org/wp-content/uploads/sites/2/2014/06/CSISA-BD-Annual-Report-2014.pdf</a> ; 1,472 partners in India, of which 1,372 private sector SMEs, see p.73, <a href="http://csisa.org/wp-content/uploads/sites/2/2014/06/CSISA-Annual-Report-November-2014.pdf">http://csisa.org/wp-content/uploads/sites/2/2014/06/CSISA-Annual-Report-November-2014.pdf</a>;</p>
Contribution to ToC and impact pathways	<p>From validation, with feedback to discovery research outside CSISA, to dissemination and outcome generation; project researchers collaborate with technology delivery and adoption stakeholders</p>

<b>Multi NARS partnership: Global Precision Phenotyping Platforms Network WHEAT FP3</b>	
Convenor of the Partnership and their role	Lead Center CIMMYT for WHEAT; project initiator based on December 2012 CRP partners conference
Specific focus and objective	<ul style="list-style-type: none"> <li>• set up a 2nd generation global network that maximizes genetic gain per year in farm fields, focusing on developing countries with substantial numbers of smallholder farms;</li> <li>• expand precision and prediction value of phenotyping data for new germplasm that annually emerge from the WHEAT and partner breeding pipelines;</li> <li>• To ultimately maximize genetic gain per year by getting more, and more diverse improved varieties, faster onto farmers' fields, by fostering germplasm exchange and line testing for specific traits directly <u>among NARS partners</u>.</li> <li>• Foster international germplasm exchange (physical and data).</li> <li>• Where appropriate, develop multi-crop platforms via inter-AFS-CRP collaboration</li> </ul>
Science Agenda	Precision phenotyping methods development and dissemination in up to 15 platform locations, focusing on different traits. Higher quality phenotyping data (yield, abiotic and biotic stresses) are paramount to fully utilize the potential of new molecular selection technologies.
Geographical focus / location	Started 2015: Uruguay (multi-disease), Sudan (heat), Tunisia (septoria)
Role of the CRP/FP in the partnership	Co-fund establishment of platform, capacity development, knowledge exchange across platforms, together with each NARS partner (co-funding in-kind and/or financial). Funds project management and coordination under FP3.2. W1&2-funded only.
Key CGIAR partner(s) and their (its) role(s)	CIMMYT, ICARDA
Key 'external' partner(s) and their (its) role(s)	INIA Uruguay IRESA Tunisia ARC Sudan
Contribution to ToC and impact pathways	Support discovery research under FP2 (e.g. on heat and drought, yield), integral part of validation research under FP3, leading to elite line development and global dissemination to over 600 IWIN collaborators.

Just as important is **committing resources** to developing and maintaining partnerships:

**Table 32-3. WHEAT uses a mix of (co)-funding approaches and modalities to accommodate different partnership purposes and partner co-funding ability.**

	Type of p'ship / example	Decision-maker	Funding timeframe	Partner co-funding	Funding source	
					W1&2	bilateral
WHEAT competitive grants	Research; WHEAT = contractor (to non-CGIAR R&D partner sub-grantees)	WHEAT-MC	1-3 yrs; 1 yr contracts	Sometimes; in-kind (salaries, infrastructure use)	Y (WHEAT partner budget)	
WHEAT commissioned grants	See above	WHEAT-MC; FP Leads	1-3 yrs; 1-yr contracts	Sometimes; in-kind	Y (see above)	
Global or regional consortium	Equal partners CRP NARS, other / Precision Phenotyping Platform Network	Consortium mgmt. body, Sci advisory body guides	Multi-year	Yes, in-kind & financial	Y	Could be
National, regional or global coordination of R4D	Membership (Wheat Initiative), ad hoc, permanent forum, committee (country coordination; African SROs, e.g. ASARECA)	Members, by consensus	Varies, for coord. only	NA	X	
Bilateral program or project	Research, development; national implementation partner sub-grantees / CSISA Also: CIMMYT, ICARDA sub-grantees	Program or Project Mgr, steering committee, donor  Non-CRP Project Mgr	1-3 yrs depends on bilateral contract	Sometimes		Y
NEW: Joint CRP project	CRPs = equal partners	CRP-MCs	1-3 yrs	NA	Y	
Non-CGIAR aligned program or project	CIMMYT, ICARDA under WHEAT = contractee / IWYP	Non-CRP program mgr & steering committee	depends			Y
NEW: WHEAT & non-CGIAR aligned program: Joint project	WHEAT = equal partner / FACCE-JPI	WHEAT-MC / non-CRP-MC	depends	Could be	Y	Y

What **kind of partners** does WHEAT work with? Overall, WHEAT combines more than 250 partners that together have a tremendous track record. Instead of providing a generic categorization of partners, we provide some examples of collaboration:

1. WHEAT's International Wheat Improvement Network is the most important source of new genetic variation for wheat yield increases, adaptation to climate change, resistance to pests and diseases and the basis for the rapid response to Ug99 rust races.
2. WHEAT accesses, develops and transfers scientific innovations to NARS partners as an IPG, through germplasm and data exchange, joint research and capacity development. It uses its convening power to involve ARIs and the private sector in research within pre-competitive domains, e.g. for hybrid research, genomic selection, Big Data, mechanization, and nutrition research.
3. WHEAT is co-leading an 11-CRP research study on gender norms and women and men's decision-making within households related to farm planning and management. The study develops synergies between the scarce gender research capacities in ARIs and NARS to empirically analyze gender roles and social norms in wheat growing environments. It also examines the way these factors affect production and productivity of wheat. The study will develop strategies to address gender-based constraints in wheat farm systems and the wider environment.
4. WHEAT partners are an important source for the capacity building of students, scientists, technicians and professionals from NARS with 5 to 10 students finishing their degree training every year. In 2014, over 500 applied training courses and field days reached out to 20,000 farmers and research and development collaborators.
5. The deployment of CGIAR wheat staff in regional offices allows close collaboration, understanding of farmer needs, opportunities for engaging local partners in collaborative research and scaling-out, which has led to the successful development of sustainable intensification approaches in Asia, Africa and Latin America, as well as south-south collaboration on mechanization.
6. WHEAT shapes the international R&D agenda to address cross-border challenges and foster collaboration among NARS based on delivery of IPG. It engages with sub-regional and regional agricultural research organizations (e.g. ASARECA, APAARI, CACAARI, PROCISUR), launches with partners new international consortia (e.g. International Wheat Yield Partnership, Durable Rust Resistant Wheat) and participates in the G20 endorsed Wheat Initiative.

#### Engagement with the **private sector**

Wheat-related research remains overwhelmingly in the public sector, though in recent years private sector engagement has increased in developed countries. WHEAT engages with this sector by:

5. Performing joint and commissioned research, such as on wheat hybrids, marker development, conservation agriculture and fertilizer regimes (e.g. Syngenta, Limagrain, Bayer Crop Science).
6. Co-developing solutions along the value chain, such as business models for appropriate-scale mechanization solutions (in Bangladesh, Mexico, Ethiopia).
7. Working with seed companies to disseminate improved varieties for adoption by farmers.

8. Through further capacity development and knowledge-sharing capacity (e.g. Borlaug Foundation for Training, with private sector contributions; sponsorship of conferences and awards, such as the Jeanie Borlaug Laube Women in Triticum (WIT) Early Career Award, HeDWIC/Bayer Crop Science).
9. With all wheat agri-food system actors, through hubs (e.g. CSISA, AIP/Pakistan, MasAgro)

What are WHEAT partners looking for? Surveys underline key elements of Centers' and their R&D partners' comparative advantage

1. In the first CGIAR Stakeholder Perceptions Survey, research partners rated WHEAT highest among all CRPs on global expertise, high-caliber staff, high-quality research innovation, relevance of research and facilitating access to research, helping others to innovate and develop sector specific knowledge.
2. The Partner Priorities Survey emphasized that the close proximity and in-depth understanding of CGIAR researchers is a strong comparative advantage. WHEAT staff are based in Afghanistan, Bangladesh, China, Egypt, Ethiopia, India, Iran, Kazakhstan, Kenya, Lebanon, Mexico, Morocco, Nepal, Pakistan, Rwanda, Syria, Tunisia, Turkey and Uzbekistan.
3. A major donor-funded CIMMYT Breeding Program Review noted the success of the CGIAR's International Wheat Improvement Network and considered capacity development another key strength: *"CIMMYT has excellent relationships with the international research community as well as the national research partners. Training is a key element of these relationships and CIMMYT has a very good track record ... CIMMYT plays a critical role in supporting NARs through sharing best practices, training, providing technology services, and collaborating on projects."*

Strategic Partnership Activities: **Major WHEAT partner consultation events between 2012 and 2016**

- 2012, Africa: Wheat for Africa (W4A) Conference, resulting in W4A Declaration: <http://blog.cimmyt.org/w4a-day-four-a-momentous-day-for-wheat-in-africa/>; <https://cimmyt.app.box.com/s/d68k14rejo0kkop45q8t>.
- Since 2012-13, G-20 Wheat Initiative: Thirteen CIMMYT scientists are members of nine Expert Working Groups, contributing to improved global coordination of national wheat research: <http://www.wheatinitiative.org/activities/expert-working-groups>.
- 2013, ICAR (India): 5-year planning meeting and participation at annual ICAR-DRWB meetings. The Director of ICAR-DRWB (Karnal) is a member of the WHEAT-Management Committee.
- 2013-14: WHEAT Partner Priorities Survey, with 92 responses from 34 countries regarding priorities for IAR4D versus national research; <http://wheat.org/partnerships-wheat-partner-priority-survey/>.
- 2014, PROCISUR/IICA (Latin America Southern Cone): Identification of R&D priorities from member countries' perspective at Borlaug 100 Summit. <http://wheat.org/dr-victor-m-villalobos/>. WHEAT participated in the CGIAR-IICA consultation on Sustainable Agriculture Intensification in LAC.
- 2014-ongoing: ASARECA multi-CRP coordination meetings (Nairobi 7/2014, Burundi 12/2014)
- Yearly, Central Asia: CACAARI annual review and planning meetings (managed by the CGIAR Coordination Unit, Tashkent): <http://www.cacaari.org/en.php>.

- 2014, Global WHEAT Partners Meeting: Partners' input into alignment of sub-DOs to WHEAT FPs and identification of research priorities per FP: <http://wheat.org/documents-for-december-2014-meetings/>.
- 2015, International Wheat Conference: Brief global wheat research community on WHEAT Phase II and invite proposals for partnership, ask: What should WHEAT no longer do? <http://www.iwc2015sydney.com/program.php>
- 2015 (Nov): International Wheat Innovation Workshop, with the major European wheat research programs: <https://colloque.inra.fr/iwiw>.
- 2015 (Dec): MAIZE, WHEAT Sustainable Intensification write-shop with CRPs HT, DS.

#### **2016 Partner Feedback on WHEAT Full Proposal via online consultation**

In February 2016, WHEAT surveyed all 50+ non-CGIAR partner participants of the *Global Partners Meeting on Phase II* (December 2014) and opened up the online consultation via its webpage and a press release. WHEAT received a total of 25 responses from a wide range of countries (India, South Africa, Ethiopia, Tunisia, Australia, Kazakhstan, Europe, Japan, etc.) and type of partner institution (NARS, ARIs, universities, etc.).

Overall, the Full Proposal found wide acceptance, and a number of helpful suggestions were received:

- Partners found the document relevant and applicable;
- Those who had already participated in pre-proposal development stated that their concerns and comments had been addressed;
- Overall, satisfaction with the Full Proposal was high (68% very, 32% satisfied);
- 100% of partners endorsed the Full Proposal.

- 2016 Selected R&D partners participate in Full Proposal development.
- (Feb): Online partner feedback to Full Proposal (25 respondents). <http://wheat.org/download/wheat-full-proposal-partner-feedback/>
- (Mar): CACAARI, International Conference on Eurasian Food Security and Nutrition Network and Eurasian Soil Partnership, Bishkek the [International Conference on Eurasian Food Security and Nutrition Network and Eurasian Soil Partnership](#)
- (Apr): Participation GCARD3 Conference, Johannesburg, South Africa.
- (July-Sept): Workshops with YPARD, IDS on youth strategy, based on a framing paper.

### 3.3 Capacity development strategy

#### Introduction

CIMMYT and ICARDA have a long history of capacity development (CD) activities; to strengthen their collaborating institutions in less developed countries. During the 1960s and 1970s, such activities focused on building a basic cadre of agricultural researchers in most developing countries through support of degree studies and long-term on-the-job training courses. During the 1980s and 1990s, the scope of capacity development activities diversified both in terms of disciplines and training modalities. Many developing countries established degree study programs at their own universities. From the early 2000s onwards, almost all capacity development efforts of both centers were concentrated within research projects. Though project-based funding assured the relevance of training interventions for specific research projects, it prevented a more strategic approach. The downside was a fragmentation of efforts and short-term duration of interventions without monitoring and follow-up. Projects generally end before their outputs reach ultimate beneficiaries and do not include evaluation of training impact, which is usually largest after the project completion. In WHEAT Phase-I, several approaches were taken to strengthen the capacities of intermediary and ultimate beneficiaries, including: a) international/regional/national training courses on areas identified by the stakeholders; b) farmer field days and demonstrations of improved technologies; c) technical training, and training of trainers; d) advanced degree training (via co-supervision of postgraduate students); and e) ad-hoc, on-the-job training of visiting scientists. A 2014 study on the impact of training in China is illustrative of the kind of impacts that long-term capacity development activities in partnership with a NARS can deliver (provide hyperlink).

These and other lessons learned from approaches employed during the first phase of WHEAT are reflected in the comprehensive capacity development strategy for WHEAT Phase II, which aims to engage at the three levels: Individual (competence development; maintain highly recognized international training courses), organizational development and via inter-CRP collaboration and at the societal level (see Table 33-2).

Performance gaps and underlying problems of National Agricultural Research and Extension Systems (NARES) are different in every country and region. There is no “silver bullet” solution applicable across the countries and regions. While it is not in the scope for WHEAT (on its own) to address the full range of the capacity development needs of the collaborating NARS, this CRP aims to adopt a comprehensive perspective, in supporting enhanced capacities of relevant NARS actors in particular regions to establish capacity development strategies, WHEAT support will focus on methods and tools to develop a CD strategy, bring relevant actors to the table, capacity/needs assessment and other methods.

The new cross-cutting CoA led by a BMZ-co-funded position will serve as a platform for inter-Flagship Project coordination and focusing of training/capacity building of R&D partners in SSA, Asia and LAC, with the aim to significantly enhance the local capacities. Note that research on capacity development, with a focus on innovation systems, will be led by FP4.4.

#### Long-term objectives

1. Build a new generation of wheat scientists among our NARS partners and within CIMMYT and ICARDA, together with a committed group of national public and private partners. Gender-sensitive approaches throughout capacity development cycles are a critical component.

- a. Links to subIDO *Enhanced individual capacity in partner research organizations through training and exchange*. WHEAT considers CGIAR Centers to be in scope. Aiming for *Enhanced institutional capacity* at IDO-level (e.g. multi-country, several NARS partners per country) is only realistic, if CRPs collaborate in a particular country (e.g. Country Coordination).
- 2. Integrate capacity development strategy and activities into improved scaling out approaches and partnerships for greater impact, fully complementary to the FP4.4 objective of enabling improved farmer decision-making and farm management through tailored capacity development at community and landscape levels, which can be scaled out by development partners.
  - a. Links to subIDO: Increased capacity for innovation in partner development organizations and in poor and vulnerable communities. Such a development outcome is realistic for a few of WHEAT intervention areas. Inter-CRP collaboration on systems research on innovation pathways and adoption dynamics should reinforce this.

**Strategic actions and progress indicators** (see table 33-2 below for more detail)

Strategic interventions led or coordinated by FP4.4 include:

1. Identifying and employing the best capacity building approaches to enhance the knowledge/skills of partners engaged in various CoAs;
2. Systematically assessing the capacity building needs of key partners, and designing appropriate intervention strategies;
3. Designing innovative capacity building content development and knowledge-sharing mechanisms following best practices in learning and instructional design theories;
4. Developing a process of fellowships and mentorships for future research leaders through better linkages between CG centers, ARIs and advanced NARIs;
5. Developing and adopting gender-sensitive approaches in capacity building to enhance the achievement of gender-related goals and overall outcomes;
6. Effectively transferring knowledge on validated new tools/technologies, including molecular markers/genomics-based breeding, remote sensing for crop management, managing large datasets, quality control in seed production, seed and farm business management skills, sustainable intensification of wheat-based systems, processing and value-addition; g) strengthening institutions to influence policy design and reform, through facilitation of and engagement in multi-stakeholder dialogues, thereby enhancing the capacity of decision makers to use research outputs; and
7. Formalizing M&E of capacity development to solicit feedback, quantify the effectiveness of training, and effectively capture the lessons learned. are shown in the table below (see per FP sections for a description of the role of capacity development in each FP's impact pathway and theory of change).

**Budget and resource allocation:**

**Table 33-1. Budget components relate to strategy implementation and do not include per FP budgets (from whatever source of funding) for cap dev activities.**

	<b>Strategic, bottom-up activity</b>	<b>Required budget p.a. \$US000's</b>	<b>Funding source</b>
	Develop Capacity Development strategy, guide and mainstream implementation	1 FTE (250k)	BMZ-CIM (bilateral), W1&2 – CoA budget
A	NARS comprehensive Capacity Development Needs Assessments (1-3 p.a.)	200k	W1&2 matched to NARS funding
B	Maintain and expand international training programs	150-250k	W1&2 for coordinator; participants via project and other funding
C	Design and implement a WHEAT Learning Platform: Focus on demand-driven knowledge-sharing and learning activities with the NARS partners of the Precision Phenotyping Platforms Network.	250k, increasing to 750k	W1&2 matched by NARS funding (in-kind, financial)
D	Develop approaches to simultaneously increase the 'capacity to innovate' in all components of an innovation system	Tbd	FP4.4 budget
E	Build, maintain and share an overview of Capacity Development activities in all projects	20% of 1 FTE (50k)	W1&2
F	Assist R4D implementation partners (non-CGIAR, CGIAR), with methods and tools	Tbd based on a multi-year action plan; best estimate 300k	Initially W1&2
G	Integrate Cap Dev progress indicators into the WHEAT M&E& L Framework	Completed by end 2017; follow-up cost for routine implementation tbd	Part of Lead and Participating Center MEL unit budget
	<b>2018 (not feasible with 2017 W1&amp;2 budget)</b>	<b>US\$ 1M</b>	

**Table 33-2. WHEAT CD strategic and bottom-up actions.**

Key activities / Progress indicator	Levels of engagement I = Individual, O = Organizational, Soc1 = Societal: develop Cooperation systems, Soc2 = Societal: Develop enabling frameworks				
Strategic actions	I	O	Soc1	Soc2	CGIAR staff CD
<p>(A) Support (a) NARS partner(s) in a particular country in realizing a comprehensive capacity development assessment, which may point to the need for change at the institutional level. Participatory assessments, including action plans and Open Issues list, documented and communicated (e.g. piloted with IRESA-Tunisia, see draft report here hyperlink TNA Tunisia 10-04), see also <a href="https://library.cgiar.org/bitstream/handle/10947/4080/CapDevIndicators_18%20Nov2015.pdf?sequence=1">https://library.cgiar.org/bitstream/handle/10947/4080/CapDevIndicators_18%20Nov2015.pdf?sequence=1</a> outputs 1 and 2, p.5 <i>NARES partners repeatedly plan for Capacity Development in their annual budgets (this would be a novelty in most public sector NARS; not proposed as indicator by Cap Dev CoP)</i></p>	Y	Y	Y		
<p>(B) Maintain and expand international training programs that cut across all FP's scientific domains and foster a network of alumni, who promote international agricultural research for development (IAR4D). <i>Post-training and 1-year later self-assessments of learning goals achievement and benefits derived from applying learning on the job completed by participants. See Cap Dev Indicators Nov 2015 paper (link above): Number, quality and targeting of short-term training Registered alumni and alumni use of web-based services dedicated to them.</i></p>	Y				Y
<p>(C) Building on B, with a select group of partners, design and implement a WHEAT Learning Platform, as a model for effective and sustainable information management (e.g. Wheat Atlas), knowledge sharing and learning tools, make use of new learning formats and channels and provides a major inroads for inter-CRP collaboration. Depending on potential users', funders and partners input, may evolve into several related platforms, e.g. (national; between relevant actors of a national agricultural sector; regional: between actors of different national agricultural sectors and at global wheat research community level).  As a first lower-cost step, focus on demand-driven knowledge-sharing and learning activities with the NARS partners of the Precision Phenotyping Platforms Network. Also, establish repeatable approach to sharing training and learning materials currently used by different WHEAT partners (possibly in collaboration with the G-20 Wheat Initiative). <i>Project milestone achievement, target audience participation rates and self-assessments. Learning Platform: Access, usage, use intensity and user satisfaction indicators.</i></p>	Y	Y			
<p>(D) A joint undertaking with FP4.4, develop approaches to simultaneously increase the 'capacity to</p>		Y	Y		Y

innovate' in all components of an innovation system, at the individual, organization and enabling environment levels, so that local stakeholders' capacity to negotiate their agricultural futures is improved. <i>Approach to monitor progress towards outcomes to be developed together with other CRPs, making use of suggested indicators Cap Dev Indicators Nov 2015 paper (link above), p.14</i>					
Build One Global CGIAR Wheat Program by 2018 ICARDA & CIMMYT joint CD planning, coordination and implementation for own staff and activities aimed at R&D partners and end users is a routine activity.	Y	Y			Y
<b>Bottom-up activities and progress indicators:</b> Their focus is to build the competence of CGIAR and non-CGIAR project leaders and scientist-'trainers' planning and practicing capacity development.					
(E) Build, maintain and share an overview of Capacity Development activities in all projects <i>WHEAT budget assigned, part of a job description, database accessible and used.</i>	Y	Y	Y	Y	
(F) Assist R4D implementation partners (non-CGIAR, CGIAR), with methods and tools to identify performance gaps, learning needs, provide options for how to train/learning formats, collective and self-assessments of learning impact, as well as planning for capacity development in departmental and project budgets. <i>Individual and collective self-assessment, participant surveys of learning goals achievement and benefits derived from applying learning on the job; participant feedback of performance of project leaders and scientists engaged in training different target groups and change over time.</i>	Y				Y
(G) For both strategic and bottom-up: Integrate Cap Dev progress indicators into the WHEAT M&E& L Framework. See Cap Dev Indicators Nov 2015 paper (link above), p.11. The aforementioned study of the impact of CIMMYT training on Chinese scientists relied on five major indicators of research capacity (e.g. ability to obtain the research funding, five dimensions of academic performance). The results show that the CIMMYT training programs have improved the trainee's ability to obtain research funding and their academic performance. (hyperlink).	Y	Y	Y	Y	
<b>Key university partners:</b> Washington SU, KSU, Texas A&M. Minnesota, Cornell, Davis, Aarhus, Bologna, Nottingham, Wageningen, IAV-HassanII-Morocco, Carthage, Jordan, Cukurova Turkey. <b>ARI partners:</b> INRA-France, Agriculture Canada, Uni. Cordoba-Spain, CSIRO, GRDC-Australia, USDA-USA <b>Non-profit partners:</b> CGIAR-ICARDA; IITA; Borlaug Training Foundation; Crop Life International; FAO <b>Private sector partners:</b> SOSEM-Tunisia, INGC-Tunisia, BASF-Germany, Syngenta					

### 3.4 Gender strategy

#### **Knowledge on gender in wheat based agri-food systems gained in Phase I and informing Phase II**

Until 2011, the integration of gender and social equity in CRP WHEAT'S socio-economic research was not an institutional priority. It was based on individual interpretations and interests and tended to be donor-driven. Since then structured, strategic work to create an effective learning research institution able to support, assimilate and mainstream researcher-driven learning on gender in wheat and maize systems has been an important focus. Work to date includes Gender Audits in WHEAT and MAIZE (2013), a Gender Capacity and Awareness Building Program to strengthen scientist research skills in gender (Wong *et al.* 2015); Research Management Framework; developing gender in IDO and Flagship Projects (2014-2015); developing gender-responsive Key Performance Indicators; Gender budget tracking (DAC); and a Gender Policy (draft 2015). This work has contributed towards a dramatic upsurge in bilateral partnerships and funding, from 4 projects in 2012 to 20 in 2014 and 18 in 2015. CRP WHEAT leadership demonstrates strong support through ensuring gender is addressed in meetings, TOC workshops, reviews etc.

Challenges to integration between Flagships remain. It can be difficult for upstream scientists to understand how their work on germplasm suited to large environments can address what appear to be trait preferences by small niche groups, including women or particular indigenous communities. Taking gender to the types of scale WHEAT operates on is a further challenge. The increasingly high profile of gender in WHEAT's work can create expectations among scientists and partners for support in gender research and analysis that cannot currently be met within existing staff capacity. A community of practice is under development and it is expected this will help expand analytic skills and knowledge.

The revised Gender Strategy for WHEAT (approved 2014) guides gender research planning and implementation. Given the paucity of gender data in wheat-based systems in particular (Jafry, 2013), WHEAT is prioritizing building a strong evidence base on gender relations in these systems. The aim is to contribute towards equality of opportunity and outcomes from wheat R4D between resource-poor women and men farmers. The research strategy for gender in WHEAT is broadly:

- To initiate research in a geographical area with a scoping study to document the current state of knowledge and experiences to date, including both research and development related to wheat, as well as overall policy frameworks and the organizational landscape.
- Subsequently, to complement this with cases studies on gender norms and agency in wheat producing areas.

During Phase I, WHEAT undertook a scoping study to assess the status of integration of gender and social equity in wheat R4D in South Asia, a priority region for the CRP (Jafry, 2013). The scoping study confirmed the paucity of evidence regarding gender and social inclusion in wheat-based livelihoods. Initial capacity strengthening for sex-disaggregation in data collection was initiated in Phase I and will be consolidated in Phase II.

WHEAT Phase II research priorities (see section 1.4) are further informed by WHEAT research on gender and rural livelihood diversification (Rahut *et al.* 2014); women's participation in farming activities in Pakistan (Ali *et al.* 2014, 2015); the need to address gender trade-offs of new agricultural technologies (Beuchelt & Badstue 2013); and the potential of gender-responsive service provision and information diffusion in South Asia (Mittal & Mehar, 2014). The literature review covering WHEAT research and similar research suggests that wheat growing areas are facing significant climate-change related stress, and other forms of stress. However, sharply unequal gender relations render women particularly vulnerable with weaker coping strategies, particularly when men out-migrate. At the same time, the

rehearsal of socially acceptable gendered behaviors in public forums may belie considerably more complex intra-household decision-making processes. Women are actually far more involved in almost all tasks in many (though not all) wheat-based farming systems than social norms suggest; intersectionalities with caste and age make the picture more complex still. There is limited evidence, requiring further study, that when wheat lines express strongly marketable traits such as rust-resistance these may be grown entirely for sale as seed by men (Nelson, 2013). Women may not be able to access women-preferred traits if they are also offered in these lines unless downstream work on intra-household decision-making is conducted (*etc.*). Gender-responsive and gender-transformative research is needed to understand and negotiate carefully between public accepted social norms and more complex realities. Examples of WHEAT research in Phase I are described below. Phase I focused on setting up small and large research projects and collating data; research has produced emerging findings and is ongoing in most cases. Phase II will begin analyses of data as well as conduct further research.

**GENNOVATE:** CRP WHEAT is a leading actor in GENNOVTE (<https://gender.cgiar.org/collaborative-research/gennovate/>), a cross-CRP comparative research initiative examining how gender norms and agency influence the ability of men, women and youth to learn about, try out, adopt and adapt new agricultural technologies. In WHEAT 48 case studies were developed in 8 countries. Initial findings are taking shape: In Uzbekistan male outmigration contributes to increased involvement of women in value addition and farm management. This is beginning to influence changes in gender norms related to 'what a woman can do'. In Morocco, mechanization of agricultural activities in wheat production is ranked amongst the top innovations for women reducing female drudgery in weeding, sieving, winnowing and cleaning seeds. However, despite increasing female involvement in both Morocco and Uzbekistan in farm management women prefer to consider these roles as temporary. This may be a strategy for managing 'dissonance' between societal norms and what is actually happening.

**Promoting ICT-based delivery of climate-smart agricultural practices to women and men in Bihar and Haryana, India:** Research on the mobile phone delivery of information on weather, modern seed varieties, and climate-smart agricultural practices to 900 men and women farmers indicated reduced information asymmetry among farmers in general, and between women and men farmers specifically. The listening rate (i.e. the proportion of the full duration of the message listened to) of women farmers was equivalent to that of men farmers. Women farmers reported agro-advisory messaging has improved their knowledge about climate-smart technologies as well as their participation in intra-household decision-making because they are now better informed and recognized as such by male partners.

**Gender Dimensions of the Ability to Adopt Climate-Smart Agricultural Practices in Bihar and Haryana, India:** Comparative research on differences between men and women farmers in climate-smart villages, regarding their ability to select and adopt climate-smart agricultural practices (CSAPs) showed social institutions, including gender, caste and tribal status, as well as the economic position of the household are significant factors determining the ability of households to adopt CSAPs. Although adoption of CSAPs in Bihar is low due to poverty and small landholdings, female-headed households are more likely to adopt CSAPs than male-headed households.

**Wheat Trait preferences:** Only a limited number of studies consider gender differences in wheat trait preferences. For example, an Ethiopian study (Nelson, 2013) shows that both women and men value high-yield attributes, tillering and also baking quality, grain marketability, and plant dry matter for animal fodder, fuel, and roofing. Women prefer 'tried and tested' older varieties for preparing traditional dishes, home-made fermented beverages, and as straw for roofing material. Men are primarily concerned with marketability and high yield. New, widely grown rust-resistant varieties have, in the study area, never been cooked or used for other purposes. They are grown only for seed due to high market demand (Nelson, 2013, see also Ortiz-Ferrara *et al.* 2000). This has strong implications for

work to develop integrate traits: marketability in male-dominated markets may prevent women from accessing and benefiting from secondary traits they favor. Downstream work may need to focus on securing equity in benefit flows, securing women a niche in markets, *etc.*

### **Persisting unequal gender roles and relations in many core wheat regions**

Many WHEAT core target regions, particularly rural areas, from North Africa, across the Middle East and into South and East Asia, frequently exhibit rigid cultural and social norms (Abdelali-Martini 2011; Jafry 2013; Offenhauer 2005). Despite planned and unplanned change in all these regions, including civil rights and women's movements, tenacious and unequal gender roles and relations, and consequentially differential abilities to benefit from technologies often persist (Kabeer *et al.* 2011; Echavez, 2012; Behera *et al.*, 2015). Research on laser land levelling (LLL) in Haryana, India, show that female headed households (FHH) have almost no access to information, and women farmers depend on male relatives or children to approach a male LLL owner or service provider to draw up a contract (Aryal *et al.* 2015). Studies elsewhere report that men more likely to prepare land and plant, whilst harvesting and transport/ head-loading is shared between men and women. Weeding and post-harvest processing is either shared or mainly done by women (Ashrafi 2009; Klawitter *et al.* 2009; Munoz *et al.* 2013; Tavva *et al.* 2013).

Interpretative caution is important: Women and men frequently deliberately model gender roles in public spaces in accordance with local societal norms. However, *actual* roles and responsibilities, and intra-household decision-making processes, can be considerably more complex. Projects developed on the basis of 'public displays' run the risk of obscuring actual behaviors and processes and can further marginalize women by excluding consideration of their needs and priorities. Gender-blind projects may result in further supporting the capabilities of men thereby deepening inequalities (Galiè, 2014). Indeed, 'conceptual lock in' persists in many research and extension systems whereby men are considered farmers and women helpers (Ashrafi 2009; Aryal *et al.* 2014; Farnworth & Colverson, 2015), despite strong participation by women in reality (Nelson, 2013; Galiè *et al.* 2013, 2014).

In Pakistan households with active female participation were able to grow high value crops, required less hired labor and had a higher income compared to households with no women's participation (Ali *et al.* 2014, 2015). Findings from Afghanistan indicate that women's involvement in wheat production depends on factors including economic standing, marital status, labor resources, land ownership, the degree of stigma related to men's and women's involvement in certain activities, and how strongly individuals and households adhere to these (Ashrafi 2009; Munoz *et al.* 2013).

Studies in the IGP on gendered vulnerabilities to climate changes suggest that inequalities in existing social structures shape gendered patterns of vulnerability (Sugden *et al.* 2014). Women typically have weaker social support networks, weaker access to assets including land and credit with which to potentially bridge a difficult season, less access to advice on adaptation and mitigation technologies, and lower participation in intra-household decision-making around which coping, adaptation and mitigation strategies to adopt (Sugden *et al.* 2014; Sheremenko & Magnum, 2015; Mehar *et al.* 2016). Male outmigration is a primary response to livelihood stress; this can magnify the vulnerabilities of women left behind (Sugden *et al.* 2014, see also Rahut *et al.* 2014).

### **Two-pronged approach to implement the WHEAT Gender Strategy**

As described in section 1.4, the Gender Strategy is implemented through

- Strategic gender research
- Mainstreaming gender research into ongoing and future programs and projects, whilst incorporating gender research into institutional frameworks. How is this achieved?

### **Incorporating the gender research dimension in institutional frameworks**

Under the WHEAT Research Management Framework (RMF) funded projects prepare a detailed work plan. Activities planned are assigned to the person responsible in the Research Management System (RMS). This person must provide progress updates at the task and summary task levels. Reports are then aggregated up to the project level and up to the Cluster of Activity, Flagship Project, and CRP levels. Physical progress reported to the RMS is integrated to financial management. This allows financial and physical issues in implemented to be notified and projects to be recalibrated as necessary. Key Performance Indicators (KPIs) are registered at the RMS level. Gender is mainstreamed into all relevant CRP WHEAT research development, implementation and evaluation processes:

- Gender-responsive R4D project design; Gender budget tracking (DAC).
- Gender Competency Framework: to strengthen scientist research skills in gender.
- Gender-responsive and sex-disaggregated research implementation in targeting, data collection and analysis, participatory technology testing / evaluation, demonstrations and training.
- Monitoring and evaluation through tracking gender-responsive Key Performance Indicators.
- Accountability for gender-responsive outcomes.

Strong attention will be paid to managing iterative research processes. As results and lessons learnt with respect to gender are generated they will be fed back into FP and CRP learning processes, thus contributing to further development, and calibration of, the programmatic and institutional frameworks. In turn this will inform the next generation of research projects and FP implementation.

### **Tracking and evaluating progress**

Under the WHEAT Research Management Framework (RMF) funded projects prepare a detailed work plan. Activities planned are assigned to a specific individual in the Research Management System (RMS). This person provides progress updates at task and summary task levels. Reports are then aggregated up to project level and thence to Cluster of Activity, Flagship Project, and CRP levels. Physical progress reported to the RMS is integrated with financial management reporting. This allows financial and physical issues arising during implementation to be assessed with projects recalibrated as necessary. Key Performance Indicators (KPIs) are registered at RMS level.

Sex-disaggregated KPIs include the number of (i) Wheat lines with characteristics valued by women farmers, (ii) Technologies evaluated with explicit relevance for women farmers, (iii) Trials conducted with women farmers, (iv) Demonstrations conducted with women farmers, (v) Technologies demonstrated with explicit relevance for women farmers, (vi) Surveys with sex-disaggregated data. Adoption studies and impact assessments (especially under CoA 1.2) investigate uptake of CRP WHEAT technologies.

When funding has been secured for projects sex-disaggregated data on beneficiaries to be reached can be provided.

### 3.5 Youth strategy

#### **Introduction**

90% of the world's young people live in Africa, Asia and Latin America and the Caribbean. Up to 70% of youth in SSA and South Asia live in rural areas (Bennell 2010), and 47% of rural youth in Africa work in agriculture (Kokanova 2013).

The combined challenges of continued population growth, declining agricultural productivity growth and environmental depletion put pressure on agricultural research and development to work on all fronts to further enhance agricultural productivity and food security. Youth, or young women and men, represent a tremendous human resource and development potential, but have often been neglected in agricultural research and development. In recognition of the need to leverage the potential of youth for agricultural development and food security, CRP WHEAT phase II will include special attention on exploring avenues for harnessing the capacities, opportunities and empowerment of young women and men as agents of change in wheat agri-food systems. In the course of phase II, WHEAT will increasingly combine bottom-up and top-down approaches. Part of the strategy is also to determine the comparative advantage of WHEAT in doing youth-related research linked to agricultural systems research.

#### **The rationale for a focus on youth in WHEAT**

The agricultural sector's declining ability to attract youth causes concern in the face of continued population growth, rising food demands and natural resources challenges (Sumberg et al. 2012). According to Kokanova (2013), youth working in agriculture represent the poorest group of working rural youth compared to rural youth engaged in other sectors, often earning significantly less than the common poverty threshold of \$1.25 per day. Across the globe, more and more young people do not see the farming sector as offering attractive livelihood options (Leavy and Hossain 2014). Increasingly, traditional small-scale farming, which in many parts continues to involve high levels of drudgery and hardship, is no longer enough to make ends meet and raise a family.

Young people today are generally better educated than their parents. However, with higher levels of education typically come greater expectations – both of young people themselves but also parents' expectations for their children. But many rural contexts do not offer options that match youth aspirations (Leavy and Hossain 2014; Chinsinga and Chasukwa 2012).

Farming is a viable choice only for those who can access (enough) land and inputs. However, land fragmentation linked to rising populations as well as gerontocratic and very often patriarchal social systems is a key constraint to the development of small-scale agriculture (White 2012; for Ethiopia, see also Bezu and Holden 2014). Still, as Leavy and Hossain (2014) note, agriculture, and related fields, could acquire status among young people to the extent that it was modern and cash-based rather than subsistence oriented.

In 2013, global youth unemployment reached 12.6%, with young people almost three times more likely than adults to be unemployed (Drylands Systems Youth Strategy, table 1) and the situation is particularly critical in developing regions where 90% of the global youth population lives. Moreover, high levels of unemployment and disillusion can lead to social and political instability with the 'Arab spring' in 2010-11 as a recent example, as also noted by ILO in its Policy Brief on investments in rural youth (ILO 2012). The world needs farmers, as well as professionals and entrepreneurs engaged in dynamic, inclusive agri-food systems, to ensure the food and nutrition security of future generations. However, while hopes for developing the agricultural sector are often pinned to the alleged energy and innovativeness of youth

and their willingness to take risks (e.g. IFAD 2013; Adedugbe 2013), interventions focusing on youth should appeal and make sense to young women and men from their own perspectives (White 2012).

### Defining youth as a social category

The concept of ‘youth’ as a distinguishable demographic group is socially defined and varies across different contexts<sup>2</sup>. ‘Youth’ is often viewed as a stage in life of transition from childhood to adulthood, associated with physiological and psychological changes and increasing social and economic autonomy (World Bank 2006; Bennell 2007; White 2012). In many contexts the concept of ‘youth’ does not exist as such or is delimited by entirely different parameters for entry into adulthood, e.g. age-sets, initiation or rites of passage, the onset of menstruation or childbearing, marriage, death of a parent, working for pay (Keesing 1981, Potash 1981 in Quisumbing et al. 2014). However, defining ‘youth’ as being in transition to adulthood, conceals the fact that they are living in the here and now with their own needs, rights and interests (White 2012; Sumberg in CGIAR Consortium Office 2015).

Formal, legal definitions of youth typically apply age-based criteria linked to rights or special protective measures and policies, e.g., the right to vote or the uptake of hazardous work, and in many countries the age of 18 marks the boundary to adulthood in the legal sense. The UN system usually defines youth as persons between the ages of 15 to 24, and children as persons up to the age of 14 years.<sup>3</sup>

Though in principle the term ‘youth’ covers both genders, in practice it often refers primarily to young males, thus rendering invisible the gender-based constraints and opportunities young rural women face (Farnworth and Sillah 2013; Levine et al. 2008; Bertini 2011). Overall, the social heterogeneity of youth and their embeddedness in different social relations and institutions needs to be understood and taken into account in research and development interventions. In WHEAT research on youth will be guided by relevant social definitions of this demographic group, taking into account their heterogeneity.

### WHEAT youth strategy

By including youth-related and –focused research, we address IDO B.1: Equity and inclusion achieved. Informed by the commitment to promote equality of opportunity and outcomes, the objectives as well as the expected impact and outcomes of the CRP WHEAT youth strategy are listed in the table below:

<b>Objectives</b>	<ul style="list-style-type: none"> <li>• To increase inclusion of youth in multi-stakeholder research partnerships.</li> <li>• To harness the opportunities and innovation capacities of resource-poor young women and men in wheat-based agri-food systems.</li> </ul>
<b>Impact</b>	<ul style="list-style-type: none"> <li>• Improved livelihoods due to improved opportunities for young women and men to engage in wheat-based agri-food systems.</li> </ul>
<b>Outcomes</b>	<ul style="list-style-type: none"> <li>• WHEAT scientists and research teams increase research focus on youth’s local opportunity structures and their linkages to sustainable agri-food system development.</li> <li>• Increased livelihood opportunities for young women and men, directly or indirectly linked to wheat based agri-food systems.</li> </ul>

<sup>2</sup> This is reflected in national policies; for example, Ethiopia's national youth policy (2004) defines youth as those aged between 15-29., while the National Youth Policy of Nepal (2010) defines youth as “women, men and third gender” persons aged 16-40 years old (<http://www.youthpolicy.org/>).

<sup>3</sup> However, even within the UN system diverging age brackets exist, e.g. the Youth Fund of UN Habitat includes in the youth category people with in the age of 15-32 years, the Convention on Rights of the Child applies to persons up to the age of 18 years,

## Overall approach to youth in CRP WHEAT

WHEAT's overall approach to youth focuses on understanding and harnessing rural opportunity structures. Limited research has been conducted specifically on the roles of young women and men in agriculture (Farnworth and Sillah 2013; Proctor and Lucchesi 2012; Paroda et al. 2014) and related value chains, and statistics are rarely disaggregated by age (FAO 2014, p. xvii). Integrating a perspective on youth in the WHEAT phase-II agenda therefore has to begin with strengthening the evidence base and the establishment of a research agenda. Borrowing from Sumberg et al. (2012), key research questions include:

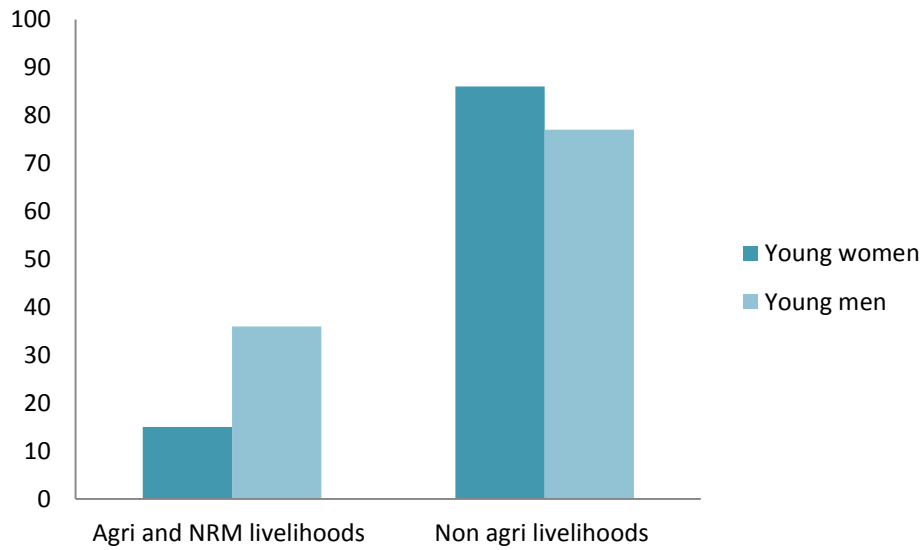
- How are opportunities for engagement with wheat farming and wheat agri-food system development more broadly structured for young women and men in different places?
- What are the implications of this structuring for consequent patterns of young women and men's engagement with wheat farming and wheat agri-food systems, as well as for livelihood, poverty, social justice and sustainability outcomes?
- How might particular policy options affect or modify these outcomes?
- What are the politics around these policy options and associated processes?

## Emerging findings from GENNOVATE

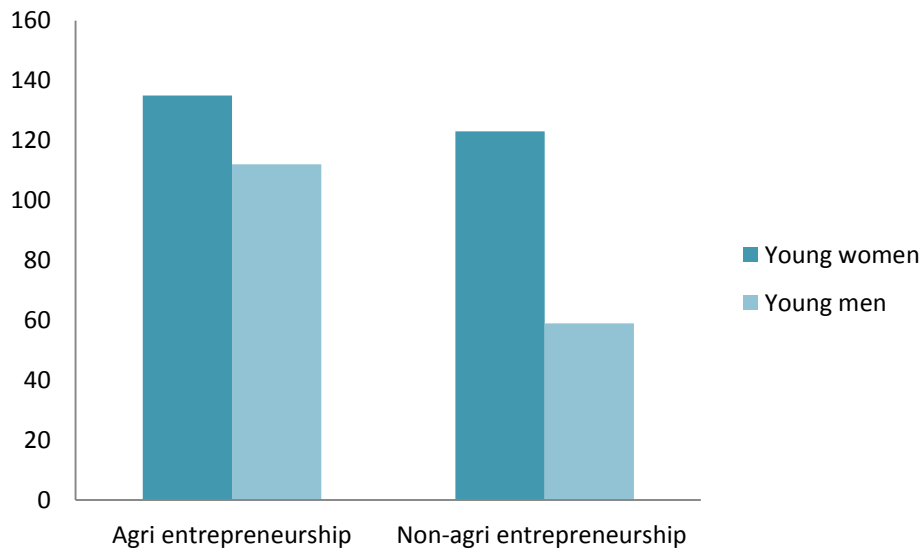
Current examples under CRP WHEAT of research with specific attention to the perspectives of rural youth include the cross-CRP comparative research initiative, GENNOVATE, informed by an agency – opportunity structure conceptual framework, and in which WHEAT plays a lead role ([http://gender.cgiar.org/wp-content/uploads/2015/12/GENNOVATE-Flyer\\_WEB.pdf](http://gender.cgiar.org/wp-content/uploads/2015/12/GENNOVATE-Flyer_WEB.pdf)).<sup>1</sup> As part of this initiative WHEAT is capturing the views of young women and men regarding social *norms* and *practices* in relation to their aspirations, livelihoods, capacities for innovation, physical mobility, access to economic opportunities and family formation.

Initial findings from 18 communities in Ethiopia, Bangladesh, India and Nepal indicate that the aspirations of young men and women are mostly found outside agriculture or NRM activities (see Fig.3.5-1 below). For many of these young respondents owning a business, holding a degree, or migrating is fundamental for moving out of poverty. As many relate farming activities with economic stagnation and backwardness, they hope for other opportunities.

Still, at the same time, both young women and men express interest in agriculture-*related* business activities, figure 3.5-2. Yet, limited access to knowledge and resources are common constraints for youth respondents across these countries. Young people speak critically about their local opportunity structures and wish for more inclusion and openness. As a young Nepalese man points out: “To be a working man I must transform traditional farming system to advance system. I must bring a total transformation in agriculture. But when I passed JTA course in 2068 B.S. (2011 AD) and came back home, I couldn't do anything because I don't get favorable environment. Our elders will not listen to us [and] we do not have irrigation. No irrigation, then nothing can be done in agriculture.”



**Figure 3.5-1. Aspirations of rural youth (frequency), 2015 data from 36 FGs (18 men, 18 women) in 18 communities in Ethiopia, Bangladesh, India and Nepal.**



**Figure 3.5-2. Entrepreneurship by gender (frequency), agri and non-agri, 2015 data from 36 FGs (18 men, 18 women) in 18 communities in Ethiopia, Bangladesh, India and Nepal.**

## **Integrating youth in WHEAT phase-II R4D agenda**

In phase II, WHEAT will take a two-pronged approach: i) develop and implement a strategic framework for the systematic integration of youth-related issues in wheat agri-food systems research; ii) develop and apply key principles and practices for inclusion of youth-related concerns in research.

### **i) Strategic framework**

In order to take stock, and achieve a rigorous input to the process of strengthening the systematic integration of youth into the WHEAT research agenda, in 2016 WHEAT is partnering with IDS to develop a strategic framework for its engagement with young people and youth-related issues.

The framework will include a detailed exploration of the distinction between, on the one hand, structural issues and interventions (i.e. that affect or have the potential to affect multiple social groups), and on the other hand, what might be considered “youth-specific” issues and interventions. Structural issues within the agricultural sector include those affecting productivity, and access to land, credit, technology and markets. A working hypothesis is that much current policy and development programming that purports to address the youth and agriculture problem is “youth-specific” and therefore fails to address – or even acknowledge – the core structural issues.

The development of the strategic framework will draw on findings from GENNOVATE, and on relevant research literatures, including: literature on the structural transformation of agriculture in the developing world; literature on youth transition, youth employment and young people’s imagined futures; and literature on the “new entrant problem” in developed country agriculture and the use of social protection programs to facilitate the inter-generational transfer of key assets like land. The strategic framework will guide the subsequent steps to integrate youth-related issues in the WHEAT research agenda.

### **ii) Integrating a youth-lens in WHEAT research practice and procedures**

Where relevant, youth will be targeted purposefully in WHEAT research projects and increased emphasis put on gathering feedback on the research process from young men and women. In addition to sex-disaggregation, people level data collection and analysis will also be disaggregated systematically by age and other relevant socio-economic variables. Where possible and relevant, mixed methods will be applied, combining qualitative and quantitative data collection and analysis and engaging youth as research partners. To take into account the social heterogeneity of youth, representation of diverse groups will be ensured to the extent possible.

For projects with a youth focus or component, this dimension will be incorporated in the monitoring and evaluation frameworks. Similarly, adoption studies and impact assessments as well as foresight and targeting and value chain analyses will seek to incorporate consideration of youth issues.

As integration of youth in WHEAT research practice and procedures progresses, it is expected that increased awareness and capacity will lead to an increase of research projects paying special attention to youth. In a first stage of phase II, WHEAT will pursue a bottom-up approach: i.e., identify opportunities for youth-centered research that can be included into ongoing projects. Later on in phase II, WHEAT will increasingly apply top-down approaches, designing new projects from the beginning with youth components or planning youth-focused projects.

WHEAT will focus its youth informed and –focused research on the FP1, FP3 and FP4. Potential researchable issues include:

FP	Possible research questions
1	<ul style="list-style-type: none"> <li>• What are the structural opportunities and constraints for young men and women to engage in wheat agri-food systems?</li> <li>• What are the implications of this structuring for consequent patterns of young men and women’s engagement with wheat agri-food systems and how might particular institutional arrangements, policy options, programs, technological support or capacity building and training affect or modify these outcomes?</li> <li>• Are young men and women’s voices being heard and what are the best ways to enhance their contribution in policy dialogues?</li> </ul>
3	<ul style="list-style-type: none"> <li>• How can youth’s priorities be addressed in product development strategies?</li> <li>• How can youth be included as co-designers of agricultural innovations?</li> </ul>
4	<ul style="list-style-type: none"> <li>• What types of institutional arrangements and business models can enhance the ability of youth to access and benefit from more efficient and labor saving technologies?</li> <li>• How inclusive are service providers (public, private, NGOs) with consideration to youth in particular? How can their inclusiveness be enhanced?</li> </ul>

### 3.6 Results based management

Describe the strategy for monitoring, evaluation, learning (including feedback loops), and impact assessment; table of IDO indicators to be used, and explanation how they are going to be collected. Explain how results-based management is incorporated into CRP management structures. Max 6 pages text.

Final 2nd Call Full Proposal Guidance: CRPs “are expected to propose a RBM framework which is described as a management strategy focusing on performance and achievement of outputs, outcomes and impact. This framework should describe how CGIAR’s approach to RBM is conceptualized and will be operationalized for the CRPs to demonstrate commitment to accountability and adaptive management”. In a footnote, it is expected that guidance on operationalization of the RBM framework by the CRPs and Platforms will be developed by MEL CoP and made available through the online tool.

*"I should have made nothing if I had not made mistakes." (Winston Churchill)*

#### **Results-Based Management System**

##### **Purpose**

For Phase II, WHEAT will be implementing a results-based management (RBM) framework. This framework will act as a strategic management system that integrates strategy, results, people, resources, processes and measurements.<sup>4</sup> It will also consist of a set of tools for strategic planning, monitoring and evaluating performance, reporting, improvement and learning.<sup>5</sup> RBM will support greater accountability, transparency, informed decision making, learning from experience and better management of opportunities and risks.

This framework will be implemented based on a set of globally recognized RBM principles (see section 1.3).

##### **Steps in Managing for Results**

Given that RBM is a management strategy, the framework will be part of the overall ongoing CRP cycle of planning, budget allocation, risk management, and performance reporting and evaluation, including value for money.

Key steps that will be used throughout this cycle include:<sup>6</sup> defining and revising based on lessons the impact pathways at CRP level and theories of change at the Flagship level; budget allocation based on performance; planning for monitoring and evaluation; establishing responsibilities and accountabilities; monitoring and analyzing performance and risks information; using performance and risks information; and reporting performance results.

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<sup>4</sup> “Results-Based Management Lexicon.” Government of Canada, Treasury Board of Canada, Secretariat. Web. 02 Feb. 2016. <http://www.tbs-sct.gc.ca/hgw-cgf/oversight-surveillance/ae-ve/cee/pubs/lex-eng.asp>

<sup>5</sup> “An Introduction to Results Management.” Asian Development Bank. Web. 02 Feb. 2016. <http://www.adb.org/sites/default/files/institutional-document/32577/files/introduction-results-management.pdf>

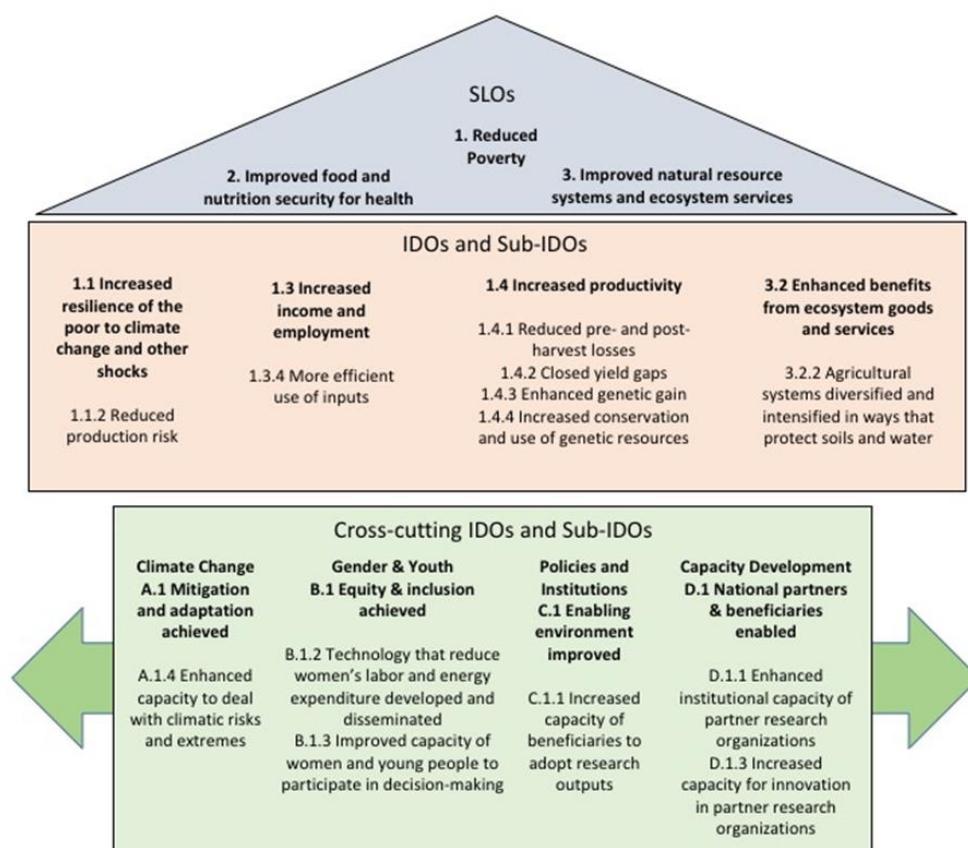
<sup>6</sup> Ibid.

## Implementation within CRP

### CRP Impact Pathway and Flagship Theories of Change

The CRP impact pathway and Flagship Programs' theories of change as presented in the proposal above were developed during workshops with Flagship teams. A participatory approach was used to capture all views, experiences and known evidence into these theories of change. They serve as the CRP's hypotheses of the way by which change is expected to occur from output to outcome and impact. They are meant to be dynamic document and adapted as evidence is further collected. Assumptions explaining the causality underlying the relationships between the outcomes and impacts were also identified. Key assumptions will be tested to validate the theories of change. Furthermore, critical risks were included and will be monitored to support effective management of the CRP.

In terms of high-level outcomes, the CRP will be contributing to the following CGIAR Strategy and Results Framework elements:



### Interoperable Tools to Support RBM Implementation

The CRP's RBM framework will be supported by a user-friendly Information Communication Technology (ICT) online platform that will cover the whole program and project management cycles, including pre- and planning, monitoring, reporting, adaptive management (i.e., support decision making and program/project improvements) and learning as part of the operationalization of the CRP's MELIA plan.

Given that projects will align to Flagship Projects' theories of change (ToCs), the platform will be structure on the basis of these ToCs. The CRP will ensure that the platform will comply with CGIAR policies (e.g., Open Access and Data Management Policy); is interoperable with other systems, including those of the other lead center; and can produce reports necessary for the CRP. To the extent possible, interoperability with other CRPs' systems will also be sought to support reporting at the portfolio level.

To ensure effective implementation of this ICT online platform, capacity building at various levels will be needed.

### 3.6.1 Monitoring, Evaluation, Learning and Impact Assessment (MELIA)

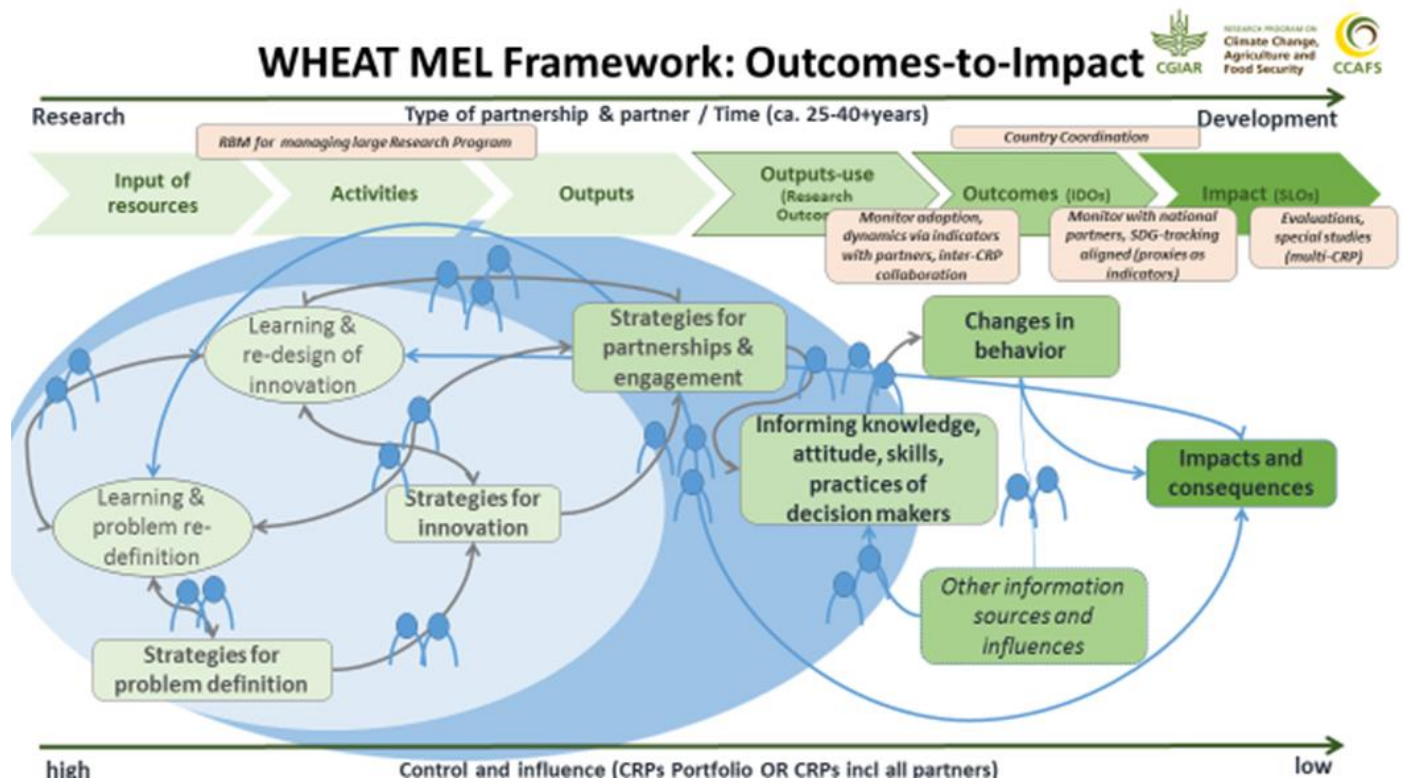


Figure 36-1. WHEAT MEL Framework along research-to-development continuum and Circle of Influence. (courtesy of CCAFS, T. Schuetz et al.)

#### Purpose

In order to effectively implement the RBM framework, strengthening monitoring, evaluation, learning and impact assessment (MELIA) will be necessary at both project and program levels. A robust and strategic plan is proposed and will support CRP cycle of planning, budget allocation and reporting steps. Operationalization of the plan will take place following submission of the proposal under the guidance of the CGIAR MEL Communication of Practice (CoP). To the extent possible, the MEL CoP will strive to establish minimal standardization and consistency across the CRPs to contribute to coherent reporting at the portfolio level.

In addition to the above RBM principles, the MELIA strategy will focus on adding value and creating opportunities for adaptive management and learning. The CRP will use a modular approach for the

implementation of the strategy, which will include a suite of tools, guidelines and best practices. Furthermore, plans will be put in place to systematically review the strategy and make necessary adjustments, where required, to better assist staff and management in delivering and improving the performance of the CRP. It is expected that the strategy and its modules will improve over time as more information is gathered and experience is gained in implementing such a framework.

## **MELIA Strategy Modules**

### Monitoring

A monitoring plan consisting of a continuous process of collection and analysis of data is proposed on: the performance of the CRP at the output, outcome and impact levels; the key assumptions of the theories of change; and the critical risks.

The definition of indicators to assess these above elements will be conducted by using a two-pronged approach. First, the CRP will seek indicators already in existence that are credible, well-recognized, accessible, and being monitored by other better positioned organizations (e.g., FAO, WB) and/or in national statistics. Second, in cases where there are no suitable indicators, the CRP will develop new indicators with a cost-effective monitoring system in close collaboration with the Flagship teams. Furthermore, the CRP will support and seek to use, where possible, standardized indicators established by the MEL CoP and other communities of practice.

A set of proposed indicators for intermediate development outcomes to which the CRP will be contributing is proposed in the table 5 (section 2.2). These proposed indicators and others at lower levels will be developed and confirmed during the operational phase of the RBM framework after proposal submission.

In addition to the targets identified for SLOs, the CRP will identify targets to indicators, to the extent possible and where appropriate, drawing from existing baselines, studies, and thematic and regional context expertise. The methodology used to identify the targets and to measure progress, as well as key assumptions, will be detailed to ensure transparency.

To complete the monitoring plan, data collection sources and methodologies, responsibilities and timelines will be identified for each of the indicators. A variety of methodologies are expected to be used dependent on the indicators, including document reviews, surveys, case studies, meta-analyses, meta-syntheses, impact assessments, adoption studies and contribution analysis.

### Evaluation

Under the CGIAR Policy for Independent External Evaluation, several types of evaluations have been identified to support the system, including IEA commissioned External Evaluation, CRP-Commissioned External Evaluations (CCEEs), and Impact Assessments.

The IEA conducts a cycle of **Independent External Evaluations** of CRPs to provide accountability, support to decision making, and lessons for improving quality and effectiveness of research programs. It is expected that IEA will use CRP monitoring and evaluation information as its primary source of evidence, including CCEEs, impact assessments, and annual monitoring reports.

The CRP will operationalize a rolling evaluation plan to build credible evaluative evidence to support decision-making and lessons for improved and more cost-effective programming. This rolling plan will include CCEEs, impact assessments and other studies identified by CRP management.

The **CCEEs** will most likely be at the Flagship level but could also include other programming elements to evaluation. The conduct of these CCEEs will be spread over the cycle to minimize the burden on management and researchers. The CCEEs will cover at least half of the budgeted activities of a Flagship in a cycle in line with the CGIAR Independent Evaluation Arrangement's Guidance for CRP-Commissioned External Evaluations (January 2015). A maximum budget of \$300,000 per year will be identified in the CRP budget for the conduct of these CCEEs. Joint CCEEs will be sought to leverage the resources of multiple CRPs and to assess performance within a geographic focus (likely in line with the site integration plans) or thematic area (e.g., seed systems, nutrition, and gender). They will be conducted in line with the CGIAR Evaluation Standards.

These CCEEs will consist of a systematic and objective assessment of the program based on evaluation criteria related to relevance, efficiency, quality of science, effectiveness, impact and sustainability. They are considered the building blocks to the external evaluations conducted by the IEA.

The CRP proposed rolling plan for CCEEs is attached to this section. The CRP management will annually review this plan to ensure it meets its needs for accountability and learning purposes. Planned impact assessments can be found in the FP1 section of the proposal.

### Impact Assessment

Globally, impacts are defined as the positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended. Within the CGIAR, impacts are described as the consequences of the CRPs on the state of selected development variables concerning the SLOs, which are themselves related to Sustainable Development Goals. There is increasing recognition that interventions that contribute to complex, indirect causal chains, with multiple partnerships, and with data limitations require a broad range of methods to evaluate effectively, especially at the impact level.

Therefore, the CRP will adopt a mixed methods approach to evaluate its performance, including ex-ante and ex-post **impact assessments**. Specific needs of the CPR for the conduct of impact assessments will be identified as part of the monitoring plan as well as by the programming needs for prioritization of research and improved performance.

Impact assessments aim to understand impact (attributable change) and how that impact has been brought about. In order to do so in a way that yields unambiguous results, it is helpful to analyze interventions with a theory-based evaluation (TBE) methodology (Ton, 2012). The basis of this approach is the use of theories of change and the determination of critical nodes where the development process may need to be validated. These critical nodes are the focal points of impact assessment. Depending on the nature of the critical node, (i) whether it is a state or a process, (ii) whether data related to the critical node can be gathered easily or not, and (iii) whether the data is quantitative or qualitative, will determine the type of method that can be employed for the impact assessment, hence the mixed methods. The rigorous application of impact logic for conducting meaningful ex-ante impact assessment allows for determining the key issues that need to be monitored in order to do ex-post impact

assessment. For each step in the intervention logic framework there are a number of questions that need to be answered:

- What are the key assumptions and do they need to be tested?
- What outside factors that are not under control of the programme play a key role? How do they form a counterfactual to the intervention logic?
- To what extent are idiosyncratic circumstances at play? Is there scope for generalisations?

### Reporting

The annual reporting process will be the key method for the CRP to describe its progress and results achieved as established in the Flagship theories of change. Reporting of results will be conducted at the output and outcomes levels, and when possible, at the impact level. A review of data collected on indicators, assumptions and risks will serve as guides for reporting on results. As part of this process, the CRP will also document any lessons and changes to the implementation of the program, including to the theories of change and monitoring plan.

### Learning

In line with the RBM principles, the CRP will be operationalizing a variety of measures to support learning from the information collected from monitoring and evaluation. The CRP will integrate these measures as part of its planning and reporting cycle with clear roles and responsibilities. The measures include:

- Annually reviewing and revising the ToCs based on evidence collected, and to the extent possible, conducting contribution analysis to reflect and strengthen the CRP performance story;
- Annually conducting reflection sessions on performance and risk information collected;
- Adjusting and prioritizing the implementation of the Program in line with the evidence collected;
- Implementing and adjusting mitigation measures to manage risks;
- Documenting lessons learned and best practices (e.g., meta-synthesis of lessons from evaluations);
- Conducting evaluation workshops to reflect on and adjust to the evaluation findings and lessons;
- Knowledge management and information sharing; and
- Following up on learning decisions, including actions plans in response to evaluation recommendations.

### **3.6.2 Budget Allocation to MELIA**

Resources required to implement a robust and credible MELIA strategy have been included accordingly in the CRP's budget.

For the MEL elements of the strategy, a budget of 2% of CRP budget should be allocated. This allocation would cover:

- development and implementation of a stronger monitoring and reporting interoperable platform
- management of data collection measures in various geographies to implement the monitoring plan effectively
- annual conduct of a CCEE, which is estimated at USD 300,000 of consulting fees per evaluation
- MEL specialists to provide MEL expertise to CRP and project leads, build capacity across the lead centers and partners, and coordinate the implementation of the MEL modules

As for impact assessments, detailed information of the budget and coverage can be found under the FP1 section of the proposal.

Proposed Rolling Evaluation Plan for CCEEs

<b>CRP PHASE II - Rolling Evaluation Plan</b>											
CRP	Review / Evaluation/	Dates		Evaluation Focus	Main Evaluation Topic/Issue	Geographic Focus		Description	Budget	Participating Centers	Evaluation Manager
		Start	End			Focus Country	Non-Focus				
WHEAT	CCEE	2017		FP2 - Novel tools and diversity	relevance, efficiency, quality of science, effectiveness, impact and sustainability	TBD	TBD	Joint evaluation with MAIZE	Max - 300K	CIMMYT, ICARDA, IITA	M. Guertin
WHEAT	CCEE	2018		FP1 - Inclusive and profitable wheat opportunities		TBD	TBD	Joint evaluation with MAIZE	Max - 300K	CIMMYT, ICARDA, IITA	M. Guertin
WHEAT	CCEE	2019		FP4 -Sustainable Intensification		TBD	TBD	Joint evaluation with MAIZE	Max - 300K	CIMMYT, ICARDA, IITA	M. Guertin
WHEAT	CCEE	2020		FP3 - Better varieties reach farmers faster		TBD	TBD		Max - 300K	CIMMYT, ICARDA	M. Guertin
WHEAT	Thematic CCEE	TBD		Thematic - TBD	TBD	TBD	Based on Management Committee needs	Max - 300K	CIMMYT, ICARDA	M. Guertin	
<p>Note: Planned impact assessments can be found in the FP1 section of the</p> <p>Note: Joint CCEEs will be sought to leverage the resources of multiple CRPs and to assess performance within a geographic focus (likely in line with the site integration plans) or thematic area (e.g., seed systems, nutrition, and gender). They will be conducted in line with the CGIAR Evaluation Standards.</p>											

### 3.7 Linkages with other CRPs and Country Coordination

The tables below provide more detailed information about inter-CRP collaboration, including on Country Coordination (e.g. site coordination), provided in section 1.7 and Tables 7 and 8a. WHEAT distinguishes between CRP-with-CRP and multi-CRP collaborations. Table 37-3 describes which Country Coordination countries are “priority” for WHEAT, intended scope of engagement and opportunities for inter-CRP collaboration. WHEAT also proposes additional countries for ‘bottom-up’ Country Coordination with interested CRPs. Table 37-4 provides more detail on researchable issues and inter-CRP collaboration opportunities, whilst Table 37-5 lists WHEAT planned contributions to ongoing national consultation processes.

**Table 37-1a. Inter-CRP collaboration CRP-with-CRP.**

<b>WHEAT Collaborates with (CRP)</b>	<b>Ongoing (from Phase I) or New</b>	<b>Our CRP provides (mention relevant FP of your own CRP)</b>	<b>Our CRP receives (mention relevant FP of your own CRP)</b>	<b>Added value</b>	<b>Geo focus or scope</b>	<b>Collaboration Mode (our CRP is ...)</b>	<b>Budgeted in core and/or uplift? &amp; estimated USD</b>
<i>State CRP(s) you are collaborating with</i>	<i>State Ongoing Ongoing (expanded) New</i>	<i>Use one line per major ‘provides’</i>	<i>Use one line per major ‘receives’</i>		<i>State: Global OR Regional (e.g. which region) OR one, a few country/ies)</i>	<i>State: Joint (e.g. 50/50) OR Junior OR Lead partner Identify funding source(s): W1&amp;2, W3/Bil Optional: Classify as Light, Medium, OR Heavy</i>	<i>State whether you budgeted in Core and or Uplift budget; Show estimated budget p.a. / how many years e.g. max 6 yrs 2017-22</i>
CCAFS See also <b>Table 37-2</b>	Ongoing	N modeling & measurement	Models, aggregation	Multi-crop climate change scenarios	Global	Junior partner, funded by CCAFS FP3 W1&2	Yes, in CCAFS core
	Ongoing	Climate smart varieties and practices	Innovation / adoption hubs	Climate-Smart Villages S. Asia: Scaling out CSA	CCAFS priority regions	Joint partners: Combine CCAFS FP3 & WHEAT Bilateral	Yes, in both CRPs core
	New	HeDWIC: Analog site definition, data collection, germplasm improvement	Climate modeling	Climate-proof wheat in 25 years from now:	Global	Joint partners, jointly fundraise	Yes, in both CRPs uplift
	New	Analog site definition, data analysis	Climate modeling	Identify climate vulnerable ecologies based on long-term IWIN data	Global	Joint partners, W1&2	Yes, in both CRPs uplift
PIM	Ongoing, expanded	Global databases, models, tools, CoP (FP1 Foresight)	Define needs, co-invest in modeling, provide data (FP3.....)	Better, more useful foresight also at portfolio level	Global	Joint partners, together with other CRPs, W1&2	Yes, both CRPs in core; expanded in uplift
	Ongoing, expanded	Impact assessment case studies	Ex ante , ex post IA approaches, tools	Improved IA methodologies, methods;	Global	Joint partners, inter-CRP	Yes, WHEAT uplift W1&2

				inter-CRP aggregation		dimension	
	New	Value chain analysis, improvement cases FP3.7, FP4.3, 4.4	Value chain approaches, methods, tools	Improved value chain research, inter-CRP collaboration on value chain analysis & change	Priority PIM, WHEAT target regions S. Asia, SSA, C Asia?, N Africa?	Joint partners, inter-CRP dimension	Yes, WHEAT uplift W1&2
	New (changed)	Collaborative Platform for Gender Research (PIM FP6)	shared results, shared effort to develop tools	tools, methods, shared learning across CRPs, geographies, systems	S Asia, SSA	Joint partners with other CRPs; link to bilateral projects	Yes, WHEAT uplift W1&2
	New	Measuring and reducing post-harvest losses	Tbd whether value add; currently planned to be incorporated into value chain analysis				No
A4NH	Ongoing	biofortified varieties for improved nutrition; farmer testing and adaption in S. Asia, Mexico	Overall program design (Harvest+), funding, validation, scaling out	Improved nutrition in H+ target regions based on appropriate mix of biofortified crops including wheat	S Asia	Junior partner, funded by A4NH bilateral	Yes, A4NH bilateral core
	New	wheat quality R&D for nutrition and health (fiber, starch)	Value chains, consumer validation, scaling out	Improved nutrition and health in A4NH target regions with high per capita wheat consumption	Global; suitable target countries	Tbd	Yes, WHEAT W1&2 uplift
WLE	New	Intervention sites, innovation hubs with NRM scope; water use efficiency research under FP3, FP4.3	Trade-off modeling; water, land mgmt options at landscape scale, scaling-out	Improved ex ante targeting and prioritizing, inter-CRP collaboration in specific geographies at landscape level	S Asia, C Asia, SSA	Joint partners, W1&2, link to bilateral projects under both CRPs	Yes, WHEAT W1&2 uplift
Ex-DS	New	Incorporate Dryland Systems components including seed systems innovation & scale-out: 3 action sites (FP4)		Expand systems research under FP4, integrate into existing intervention areas	C Asia, Morocco, Ethiopia	NA	Yes, WHEAT core and uplift W1&2, bilateral

**Table 37-1b. Multi-CRP collaboration.**

Collaborate with (CRPs)	Ongoing (from Phase I) or New	Our CRP provides/gives (mention relevant FP of your own CRP)	Our CRP receives (mention relevant FP of your own CRP)	Added value	Geo focus or scope	Collaboration Mode (light, medium, heavy)	Budgeted (core or uplift) and estimated USD
All CRPs	new	Country coordination plans & implementation See <b>Tables 37-3</b> and <b>37-4</b> below			See 37-3, 37-4	Tbd	Yes, WHEAT uplift
JIRCAS and 3 other CRPs (Livestock, CCAFS, DCL)	Ongoing (expanded) BNI Consortium	Member, joint R&D with JIRCAS, cross-crop/systems learning with other CRP projects (FP2)	Learn from other crop/BNI projects, fundamental research	New source of nitrogen use efficiency, reduce N2O in many farming systems, across crops / rotations	Global	Joint partners: CRPs W1&2 & Bilateral plus JIRCAS bilateral	Yes, WHEAT uplift
	Ongoing	w/ JIRCAS: Germplasm, introgressions (FP2)	w/JIRCAS: wheat trait discovery R&D (FP2)	Find BNI wheat varieties that can go on farmers fields	Global	Joint partners, WHEAT W1&2, JIRCAS bilateral	Yes, WHEAT core
All AFS-CRPs	Ongoing, expanded	Capacity for inter-CRP collaboration, WHEAT MEL approaches, methods	Grow WHEAT M&E capacity, expertise	Inter-CRP M&E Framework, Platform; Metrics for faster, more precise, genetic gain, more structured pipelines	Global	Joint partners in CoP	Yes, WHEAT core and uplift
	New	<b>See Genetic Gains Platform</b>		high-throughput data standards, processing & open access (GOBII - BMGF/CGIAR)	Global		
	New	<b>See Genetic Gains Platform</b>		Unlock and make accessible genetic diversity of CGIAR crops in genebank collections	Global		
	New	Breeding, agronomy, farm mgmt, mechanization solutions developed under WHEAT, FP3-4	Other CRPs solutions for other crops and farming systems	Combine, adapt breeding, agronomy, farm mgmt, mechanization for multi-crop farming systems	tbd	tbd	Yes, WHEAT uplift W1&2
	New	Innovation framework and adoption dynamics; analysis R&D targeting	Innovation framework and adoption dynamics analysis, systems R&D	Share, build knowledge across CRPs for specific	Tbd	Tbd	Yes, WHEAT uplift

		(FP4); Set up and share Integrated Systems Analysis and Modeling Group (ICARDA-led)	targeting approaches, methods	intervention areas			
	New See also Country Coord.	Partner on dual-purpose crops R4D (targeting, breeding & farm mgmt, value chains Partner with resources on dual-purpose crops R4D (targeting, breeding & farm mgmt, value chains		Joint R4D on dual purpose crops for value addition and improved livelihoods	2-3 agroeco zones tbd	Joint partners, CRPs W1&2 and co-fundraise for bilateral	Yes, WHEAT uplift W1&2 and bilateral
	New See also Country Coord.	Partner with other CRPs their NARS partners, to identify and develop companion crops, livestock, agroforestry: Insert into ongoing, new systems projects		Insert companion crops into another AFS-CRPs scope, activities in specific geographies	S. Asia, Mexico, SSA, N. Africa?	Joint partners, CRPs large bilateral projects / funding	Yes, WHEAT uplift bilateral
	New	Share, co-develop precision phenotyping methods, tools development, up to 15 sites focusing on different traits, data collection & processing	Share knowledge, use platforms/sites (e.g. Sudan for sorghum/heat)	Share WHEAT, other CRPs' precision phenotyping platforms, sites with other AFS-CRPs, crops; reinforce international germplasm exchange	Global	Tbd	Yes, WHEAT uplift W1&2
<b>PIM, AFS-CRPs</b>		See <b>Table 37-1a</b> above					
<b>PIM, A4NH</b>		See <b>Table 37-1a</b> above					

## WHEAT-CCAFS collaboration

WHEAT with CCAFS collaboration will take place around research activities relating to (i) climate sensitive breeding strategies and (ii) participatory evaluation of technologies and practices developed under FP4 in Climate Smart Villages. Collaboration between the two CRPs will address the following key questions:

1. How can genotypic responses to climate be better understood through use of current and future crop and climate databases and modeling tools? (led by CIMMYT)
2. What are the predictable aspects of climate that need to be taken into account when breeding for future climates? (Led by CCAFS)
3. How can previous research and breeding efforts accelerate rapid adaptation of cropping systems in climate vulnerable hotspots (led by CIMMYT)
4. What WHEAT FP4 practices and technologies work where, for whom and to what extent?

Promising climate-resilient material, including those identified during CCAFS Phase I from analysis of historical IWIN data, will be evaluated more intensely in climate vulnerable sites in Asia and Africa. Wherever appropriate, this research will take place in CCAFS climate smart villages where outputs together with other FP4-driven management practices will be evaluated under a climate lens. In addition to FP4 targets, the climate lens will make use of WHEAT and CCAFS data and tools (e.g. climate projections, farm typologies and farming system models) to support the evaluation of technologies in terms of enhanced resilience to climate variability and extremes (particularly drought and high temperature), mitigation of GHG emissions and associated costs. Through CCAFS Climate Smart Villages, WHEAT will also gain access to important climate-related actors in both the public and private sectors for scaling up and out.

In the climate change debates, fertilisers have come under much criticism given their role in GHG emissions, to the point where some civil society stakeholders at UNFCCC events will question whether fertilisers are necessary in Africa. That said, it is hard to envisage how future productivity and food security goals can be achieved in Africa without greater use of synthetic fertiliser. Working with all the relevant AFS-CRPs, CCAFS will examine the role of fertilisers, particularly nitrogen, in achieving the CSA targets (food security, adaptation and mitigation). This will include meta-analysis of the scientific literature and drawing on field and farmer experiments globally. One of the aims will be to define the appropriate targets, indicators and MRV system that will be needed to drive optimal nitrogen use. Nutrient retention, nutrient leakage, nutrient output and nutrient efficiency targets will be considered globally and for particular contexts. Key partners will be WHEAT among other AFS-CRPs, as well as Wageningen and YARA.

**Table 37-2. Continued and new CCAFS-WHEAT collaborations are shown in the table below. Some budget figures remain to be determined.**

Degree of collaboration (envisaged)			Topic CRP-FP level (researchable issue)	Budget	Target geographies	What each CRP brings to table		
Light (info exchange, joint publications)	Medium (share, analyze data, sites.)	Heavy (jointly plan, fund, implement projects)				Systems Research, sustainable intensification, agronomy (W FP4)	Germplasm improvement (W FP2-3)	Cross-cutting
<b>Climate-smart breeding strategies</b>								
		W: FP3.1 C: FP 1.4	Generating climate-smart wheat breeding targets for South Asia using dynamic crop simulation modeling.	50:50 \$200k each CRP	South Asia		WHEAT: Crop trials; stakeholder engagement with national breeding programs	CCAFS : Modeling methodology, analysis.
		W: FP4.2 C: FP 3.1	Improving nitrous oxide estimates globally with major focus on strategies to optimize nitrogen use in wheat (and maize).	W1&2 \$300k + Bilateral 90k (based on Phase I CCAFS budget)	Global application but field work in Mexico and India	WHEAT: crop trials on nitrogen use efficiency. CCAFS: Improved crop models to estimate N2O from fertilizer use in wheat ; trade-off analysis to identify priority mitigation actions.		CCAFS : Modeling methodology, analysis
		W: FP3.1 C: FP1.4	Explore adaptation and GxM of IWIN materials to identify climate vulnerable ecologies in terms of physical and socio-economic vulnerability ; identify heat-adapted germplasm	W1&2: 1M p.a. <u>Uplift</u> CCAFS: W1&2 tbd	Global (priority regions CCAFS)	Evaluate GxExM interactions to determine best agronomic packages	W : WIN cooperator phenotypic data 5 decades	CCAFS : Modeling methodology, analysis
		W: FP2.4 C: FP1.4	Climate-proof (Heat and Drought) Wheat Yield Consortium to identify tolerant/resistant genes needed in climate-vulnerable ecologies in 25 years from now	W : 2M p.a. W1&2W ; bilateral : tbd, <u>Uplift</u> CCAFS : tbd	Global (priority WHEAT and CCAFS regions)	n/a	Crop design, forward genetics, phenomics, trait-gene research, genetic resource exploration, pre-breeding, bioinformatics	CCAFS : Modeling methodology, analysis, model integration at different scales

Participatory evaluation of community supported agriculture practices and portfolios in Climate Smart Villages							
	W: FP 4.3 C: FP1.2		Continue with Phase I collaboration Develop, adapt, and target portfolios of CSA practices for sustainable intensification of smallholder, vulnerable farming systems. Practices being evaluated include: Improved nutrient and water management (laser land-leveler, nutrient expert, green seeker, micro-irrigation), climate-resilient germplasm, expert validation and scaling-up/out.	W : Bilateral project funding (e.g. CSISA ; ACIAR) and W1 and 2 ca. 1M p.a. CCAFS : W1 and 2 (F1) as in Phase I	S. Asia	CCAFS : CSV innovation platforms W : Validated LLL technology, Nutrient Expert farmer decision-making support	
Upstream R&D on N-cycle and climate change							
	W: FP2.3		Biological nitrification inhibition in major CGIAR crops to reduce N2O emissions and to improve NUE in agricultural systems.	Collaboration between 4 CRPs and JIRCAS W : 0.5M p.a.			CCAFS: measurements and modeling GHG emissions.

WHEAT Perspectives and Progress on Country Coordination

**Table 37-3. Overview of WHEAT participation in Country Coordination and further countries proposed by WHEAT.**

Countries				WHEAT scope of engagement					inter-CRP			
Region	Countries (top 5 = green; other 15 = yellow; WHEAT only =white)	WHEAT priority	focal point	germplasm improvem.	seed systems	sustainable intensification	systems	Value chain	Key objectives	Coordination mechanism (proposed)	Initial joint activities (ideas)	Co-Invest (estimated amount, type)
S Asia	Bangladesh	Y	T.P. Tiwari, T. Krupnik	Y	Y	Y	N	Y	Greater resilience to climate change; higher income thru diversification, risk mgmt	Formalize current informal inter-Center/ NARS set-up	Socioeconomic (HH surveys, other); Joint R4D; Adapt R4D results; Share sites, support services	scoping studies (300k), coordination & knowledge-sharing (250k), increased capacity for joint R4D (tbd), PP leaf blight (300K)
	India	Y	E. Duveiller	Y	Y	Y	Y	Y	tba		Socioeconomic; Joint R4D; Adapt R4D results; Share sites, support services	scoping studies (300k), coordination & knowledge-sharing (250k), provide research platforms
	Nepal	Y	Arun Joshi	Y	Y	Y	tbd	Y	Stabilize yields under climate change; higher income thru diversification, risk mgmt; Improved nutrition of poorest	use CSISA mechanisms?		
	Pakistan	Y	M. Imtiaz	Y	Y	Y	Y	Y	Sustainable scaling-out of improved practices, seed	Agriculture Innov. Prog. (AIP, USAID) project	International Partners in Agriculture Inn. Prog.	Bilateral: Expand AIP scope; scoping studies to target

										mechanisms	CIMMYT, IRRI, ILRI, IFPRI, ICARDA, AVRDC, U. Davis-Cal.	interventions (300k); pool cap dev funding & activities (tbd)
Central Asia	Iran	Y	<i>added by WHEAT/J Kamali</i>	Y	Y	Y	Y	tbd	Intensify production systems to reduce wheat imports	use DCLAS/ ICARDA action sites for rainfed areas	Adapt R4D results; Share sites, support services	Bilateral Iranian funds
	Uzbekistan	Y	Ram Sharma	Y	Y	Y	Y	tbd	Reduce rural poverty		Winter wheat breeding linked to Turkey/ CIMMYT/ ICARDA program	
	Kazakhstan	Y	M. Karabayev	Y	Y	Y	Y	Y				Bilateral
SE Asia	Vietnam			<b>N</b>								
N Africa	Morocco	Y	M. Baum	Y	Y	Y	Y	tbd	N African food security; higher incomes thru diversification, risk mgmt	develop new	DCLAS/ICARD A	

Horn of Africa	Ethiopia	Y	B. Abeyo	Y	Y	Y	Y	Y	Reduce import bill thru systems approach; better connect with scaling out actors	Formalize current informal inter-Center/ NARS set-up	Socioeconomic; Joint R4D; Adapt R4D results; Share sites, support services	scoping studies (300k), coordination & knowledge-sharing (250k), increased capacity for joint R4D (tbd); precision phenotyping shared site 500K
East Africa	Kenya	Y	S. Bhavani	Y	Y	tbd	tbd	tbd				
	Malawi			N								
	Rwanda	Y	F. Baudron	Y	Y	Y	N	Y				Bilateral; scoping
	Tanzania	Y		Y		Y	tbd	Y	Reduce import bill, higher farmer incomes	tbd		
	Uganda			N								
W Africa	Burkina Faso			N								
	Cameroon			N								
	DRC			N								
	Ghana			N								
	Mali	Y		Y	Y - tbd	Y	tbd	tbd				
	Niger			N								
	Nigeria			Y	Y - tbd	Y	Y - tbd		Reduce import bill, foster value chains			
S Africa	Mozambique			N								
	Zambia	Y	S. Mugo	Y		Y						
Central & Latin America	Nicaragua			N						tbd		
	Mexico	Y	B. Govaerts	Y	Y	Y	Y	Y				bilateral (MASAGRO)

**Table 37-4. Key opportunities per country from a WHEAT perspective.**

Countries			WHEAT scope of engagement					inter-CRP			
Region	Country priority (bold)	Tier I or II (+ or ++) & focal point	germplasm improvement	seed systems	sustainable intensification	systems	Value chain	Key objectives	Coord. mechanism	Joint activities	Invest (amount, type) needed
S Asia	<b>Bangladesh</b>	(++) T.P. Tiwari	Y - yield, salinity, disease resistance, CC-traits, Phenotyping for leaf blight, wheat blast, dual purpose crops	Y - faster access; replacement rates; strategize biofortified varieties (Zn, Fe)	Y - CA-based crop management; water and nutrient efficiency, yield potential, dual purpose crops	N	Y - inputs, mechanization, farmer decision support, biofortified crops	Greater resilience to CC; stable income thru diversification, risk management, biotic (e.g. blast, BpLB) and abiotic (e.g. saline, heat, drought) tolerant	Formalize current informal inter-Center/ NARS set-up through the Bangladesh CGIAR Advisory Committee (CAC)	Socioeconomic (HH surveys, other); Joint R4D and Adapt R4D results; Share sites, support services	Scoping studies (300k), coord. & knowledge-sharing (150k), increased capacity for joint R4D (tbd), consultation meeting to develop strategies for new disease (tbd), Precision phenotyping of BpLB and wheat blast and fast track seed multiplication of tolerant varieties (450K)
	<b>India</b>	E. Duveiller	Y - shorter duration, heat-tolerant, WUE (Indo Gangetic Plains, Bihar, Madhya Pradesh, Haryana); dual purpose varieties adapted to early sowing (fodder + grain), Zn/Fe grain content	Y - faster access; replacement rates; strategize biofortified varieties (Zn, Fe);	Y - CA-based crop management; water & land use efficiency, irrigation systems rotation, dual purpose crops	Y - water, land management landscape scale; post-harvest?	Y - inputs, seeds, mechanization, farmer decision support			Socioeconomic; Joint R4D; Adapt R4D results; Share sites, support services	scoping studies (300k), coordination & knowledge-sharing (250k), provide research platforms

	Nepal	Arun Joshi	Y-10M ha rice-wheat system; CC-traits, Crowd-sourcing to evaluate new varieties	Y - faster access; replacement rates; strategize biofortified varieties (Zn, Fe);	Y - CA-based crop management: Laser Land Levelling & Nutrient Expert	tbd	Y- biofortified crops, improved nutrition	Stabilize yields under CC; higher income thru diversification , risk mgmt; Improved nutrition	use CSISA mechanisms?		
	Pakistan	<i>added by WHEAT / M. Imtiaz</i>	Y - yield, rust resistance, Zn/Fe grain content, feed quality	Y - faster access; replacement rates; strategize biofortified varieties (Zn, Fe);	Y - zero till rice, wheat, companion crops rotation, laser leveling,	Y - seed systems innovation; multi-crop sowing machines	Y - durum value chain	Sustainable scaling-out of improved practices, seed	AIP-Pak, USAID) project mechanism	International Partners in Agriculture Inn. Prog. CIMMYT, IRRI, ILRI, IFPRI, ICARDA, AVRDC, Uni Davis-Cal.	Bilateral: Expand AIP scope; scoping studies to target interventions (300k); pool cap dev funding & activities (tbd)
Centr al Asia	Iran	<i>added by WHEAT / J Kamali</i>	Y - yield, early maturity (heat and drought escape), reverse yield decline (by 30% over recent yrs; irrigation, rainfed); rust resistance, quality	faster access through pre-release multiplication	CA in irrigated, rainfed environments (cold!!, warm, temperate); raised bed; suppl. Irrigation; diversification in rainfed areas	Impact of changing climate, water crisis on wheat, maize prod.	tbd	Intensify wheat based production systems to reduce wheat imports	use DCL/ ICARDA action sites for rainfed areas	Adapt R4D results; Share sites, support services	Bilateral Iranian funds
	Uzbekist an	<i>added by WHEAT / Ram Sharma</i>	Y - yield, cold tolerance, yellow rust, heat tolerance, salinity short duration	faster access through pre-release multiplication ;	Y- crop rotation innovation, short duration wheat, WUE, NUE, raised beds,	Y - Accelerate adoption of varieties thru crop rotation with maximum profitability, seed systems, innovation platform, CA	tbd	Reduce rural poverty		Winter wheat breeding closely linked with Turkey/CIMMYT/ ICARDA program in Turkey	
	Kazakhst an	<i>added by CIMMYT/ M. Karabayev</i>	Y Yield -high latitude wheat; disease resistance, quality,	Y - see Systems	Y - expand CA, crop diversification	Y - Accelerate adoption of varieties thru crop rotation with maximum profitability, seed systems, innovation	Intensify wheat based production systems to maintain Kazakhstan as grain provider for C-Asia (regional food security).			Bilateral	

						platform, CA					
SE Asia	Vietnam	(++)	No								
N Africa	Morocco	added by WHEAT / M. Baum	Y - heat tolerance, pests/diseases	Y - see Systems	Y - WUE, crop rotation for diversification, soil health,	Y - seed systems innovation	tbd	N African food security; higher incomes thru diversification , risk mgmt	develop new	DCL/ICARDA	
Horn of Africa	Ethiopia	(++) B. Abeyo	Y - rusts, heat, WUE, regional germplasm exchange; Phenotyping Platform for stem rust (DW) and septoria (BW).	Y - improved farmer access, maintain, improve replacement rates	Y - mechanization	Y - seed systems innovation	Y - durum value chain; Ethiopia historically DW producer but currently major importer.	Reduce import bill thru systems approach; better connect with scaling out actors	Formalize current informal inter-Center/ NARS set-up	Socioeconomic; Joint R4D; Adapt R4D results; Share sites, support services	scoping studies (300k), coordination & knowledge-sharing (250k), increased capacity for joint R4D (tbd); PP 500K
East Africa	Kenya	S. Bhavani	Y - rusts, heat, WUE, regional germplasm exchange; global PP for stem rust (Bread wheat)	seed out scaling with Kenya Seed Co.	tbd	tbd	tbd				
	Malawi		N								
	Rwanda	F. Baudron	Y - Identify varieties that meets quality characteristic demanded by formal market)	Y - improved farmer access	Y - mechanization, crop rotation for diversification, soil health (erosion)	N	Y - Analyze wheat value chain and decide on feasibility to develop viable wheat industry (farm to fork).				Bilateral; scoping
	Tanzania	(++)	scale out improved seed access (SARD-SC/wheat)	scale out improved seed access (SARD-SC/wheat)	tbd	Y - on the ground scoping study to investigate potential	Reduce import bill, higher farmer incomes				

W Africa	Uganda		N								
	Burkina Faso		N								
	Cameroon		N								
	DRC		N								
	Ghana		N								
	Mali		scale out improved seed access (SARD-SC/wheat)	tbd	scale out improved practices (SARD-SC/wheat)	tbd	tbd				
	Niger		N								
	Nigeria	(++)	scale out improved seed access (SARD-SC/wheat)	Y - tbd	scale out improved practices (SARD-SC/wheat)	Y - tbd		Reduce import bill, foster value chains			
S Africa	Mozambique		N								
	Zambia		Y - high potential increased production, productivity		Y - high potential increased production, productivity						
LAC	Nicaragua	(++)	N								
	Mexico	added by WHEAT	Y	Y - fast track seed multiplication established;	scale out technologies / N-use efficiency (green seeker); long term trials wheat maize legume rotation; fodder during winter for cattle	Analyze wheat value chain / evaluate feasibility to increase wheat production to reduce import					bilateral (MASAGRO)

**Table 37-5. WHEAT planned contributions to national Country Coordination processes.**

Target country (++, + countries relevant to WHEAT)	Define steps taken so far (March 2016) to establish national level engagement with other CRPs towards site integration	Define plan and schedule through which WHEAT will provide relevant elements for development of CGIAR site integration in this country
<b>Bangladesh</b>	<p>Seven CGIAR centers representing over 7 CRPs have established a CGIAR Advisory Committee several years ago. This committee will serve as a platform for site integration efforts in Bangladesh, to both better integrate with NARES and also to build in new strategic objectives for the next phase of the CRPs, including renewed focus on food and nutrition security, gender and youth. Through this venue all CGIAR centers plus AVRDC and IFDC meet with our NARS and Ministry officials twice a year. All details for this integration as well as 4 CAC minutes are posted on the web, which provides further details of the CAC and avenues for site integration efforts: <a href="http://gcard3.cgiar.org/national-consultations/bangladesh/">http://gcard3.cgiar.org/national-consultations/bangladesh/</a></p>	<ul style="list-style-type: none"> <li>• Leverage existing bi-annual coordination mechanism</li> <li>• Determine how to fund greater capacity for WHEAT participation</li> <li>• Focus on shared socio-economic approaches (e.g. HH surveys), water and nutrient use efficiency, yield gap studies, farming systems analysis in wheat based systems, business models for mechanisation, other services</li> <li>• Focus on better agronomy, biotic (e.g. wheat blast), and abiotic (e.g. terminal heat, saline, drought) stress tolerant and fast track seed multiplication.</li> <li>• Joint fundraising for joint new projects (CRPs, national partners) to fill gaps in current portfolio</li> </ul>
<b>Ethiopia</b>	<p>Coordination committee representing 11 CGIAR Centers based in Ethiopia, plus 3 others (Africa Rice, IITA and IRRI), 10 CRP focal points meets quarterly, coincides with existing Heads of Institutes meetings. Smaller group of six (3 Centers and 3 CRPs) to manage country coordination process, with support from ILRI Communications and Knowledge Management team.</p> <p>Key activities to date:</p> <ul style="list-style-type: none"> <li>• Creating a database of our major partners/collaborators</li> <li>• Mapping CGIAR Center and CRP work in Ethiopia (November 2015). Continuing to refine.</li> <li>• Engaging in partners' (ATA, RED&amp;FS) national consultations on alignment to GTP II (November 2015 – January 2016).</li> <li>• Creating a wiki for the coordinating committee</li> </ul> <p>CRPs and Centers should continue to align with Government's Growth and</p>	<ul style="list-style-type: none"> <li>• Use existing coordination mechanisms</li> <li>• Determine how to fund greater capacity for WHEAT participation</li> <li>• Contribute to sharing information about research projects, to avoid double work. Many donors and implementing agencies that do not coordinate.</li> <li>• Push for joint actions with regard to socioeconomic approaches, seed system innovation across crops, sharing of research sites</li> </ul>

	Transformation Plan II (GTP II, late 2015), Sustainable Land Management (SLM), other large, ongoing programs. Improve alignment via a new joint CGIAR-national agriculture research system collaboration and communication mechanism, with a permanent secretariat for joint planning, sharing of findings, and monitoring and evaluation. Problem areas: Shared understanding of what site integration means, adequate funding for participating in coordination	
<b>India</b>	1 <sup>st</sup> meeting CGIAR-NARS 23 <sup>rd</sup> March	See Tables 37-3, 37-4
<b>Kenya</b>	1 <sup>st</sup> meeting CGIAR-NARS 10-11 <sup>th</sup> March 2016	See Tables 37-3, 37-4
<b>Mali</b>	Ad hoc committee with 7 Centers, 1 <sup>st</sup> consultation meeting with NARS came up with a draft framework of the site integration: Includes CGIAR Mali current status, principles, gaps and opportunities for site integration, resourcing, communication within and outside the CG, mechanisms to monitor progress and assess activities and impact. Working groups on five main issues of site integration; Full report on the national consultation by March 25 <sup>th</sup> , 2016. The Site Integration plan will be submitted on or before April 29 <sup>th</sup> , 2016	<ul style="list-style-type: none"> <li>• The key connector/contributor under WHEAT is SARD-SC/Wheat project, in which Mali participates (ICARDA-led) – successor project under TAAT?</li> <li>• Make sure SARD-SC/WHEAT has capacity to engage in country coordination processes</li> </ul>
<b>Nepal</b>	site integration steering committee formed, includes Centers, CCAFS. Stakeholder consultation meeting on 11 January 2016, next one January 2017. Areas for collaboration identified: How to better align CG work with national policy issues, demand for continued capacity building of local agricultural scientists, the development of stronger national databases, promoting local genetic resources and the need for research on both climatic and non-climatic stress on agriculture. Ideas for new research avenues were also raised. For more info, see <a href="https://library.cgiar.org/handle/10947/4148">https://library.cgiar.org/handle/10947/4148</a> Key reference point: Agriculture Development Strategy (ADS 2015-2035) approved by Government of Nepal on 14th August, 2015.	<ul style="list-style-type: none"> <li>• Continue to co-lead process with existing coordination mechanism</li> <li>• Push for joint activities to stabilize yields under climate change; higher income thru diversification, risk mgmt; improved nutrition for the poorest</li> </ul>
<b>Nigeria</b>		<ul style="list-style-type: none"> <li>• The key connector/contributor under WHEAT is SARD-SC/Wheat project, in which Mali participates (ICARDA-led) – successor project under TAAT?</li> <li>• Make sure SARD-SC/WHEAT has capacity to engage in country coordination processes</li> </ul>

<b>Rwanda</b>	<p>Coordinating committee of six people representing 4 centres, 4 site integration meetings, one with three main donors (USAID, EU, and DFID); working on mapping all on-going Centers’/CRPs projects. Builds on existing R4D Forum by CRP-Humid Tropics.</p> <p>CGIAR site integration workshop in Kigali on 29<sup>th</sup> March, 2016, to bring together an estimated 75 representative of donors, government agencies, other development organizations, civil societies, and financial institutions. Aim to finalize site integration plan by end of April, 2016.</p>	<ul style="list-style-type: none"> <li>• Verify, provide focal point for WHEAT</li> <li>• Determine how to fund for greater capacity for WHEAT participation</li> </ul>
<b>Tanzania</b>	<p>Coordination Committee comprises: Ministry of Agriculture , Livestock and Fisheries, Private Sector (1) , 7 CGIAR Centres based in Tanzania plus 4 others (Africa Rice, ICRISAT, CIMMYT, Bioversity International ) + 9 CRP focal points.</p> <p>National stakeholders’ consultation workshop held in December 2015: Principles of success and major opportunities for integration between and amongst CG centers, CRPs and national partners identified. Ensure CGIAR alignment with the national agricultural priorities (Tanzanian Agricultural Sector Development Program (ASDP) Phase II.</p> <p>For changes, new programs used AFRICA RISING (USAID) as model; good example of collaboration and integration, common set of research sites and staff from various centres are participating in the implementation the project. CGIAR-FARA-African Development Bank’s Africa-wide initiative on FEEDING AFRICA: Tanzania, is one of the focus countries for TAAT.</p> <p>Plans for organizing a CG- NARS national awareness workshop to popularize to the new government, our best-bet technologies for scaling-up and out using the internally-sourced resources</p>	<ul style="list-style-type: none"> <li>• Contribute to AFRICA RISING-type multi-crop program development</li> <li>• Focus on establishing critical mass regarding wheat R4D and capacity on both sides to collaborate: Demand six times greater than supply (production), low yields, very little interaction with NARS</li> </ul>

<b>Zambia</b>	<p>Steering committee (CIMMYT, ILRI, WorldFish, HarvestPlus, CIAT, IITA, Bioversity, ICRAF, ICRISAT and CIP). Site integration consultation workshop 9-10 February Participants identified key activities that would be required to bring about site integration and which areas they would like to proceed in partnership with the CGIAR and CRPs. The Zambian National Agriculture Investment Plan (NAIP) provided basis for discussion. Key issues to tackle for site integration:</p> <ol style="list-style-type: none"> <li>a) Resource mobilization to drive the site integration process</li> <li>b) Development of coordination structures to provide strategic direction for site integration</li> <li>c) Capacity development of national partners and research infrastructure</li> <li>d) Collaboration mechanisms</li> <li>e) Alignment of CGIAR research activities to national priorities</li> <li>f) Identification of research priorities, effective delivery and scaling-out</li> <li>g) Impactful development initiatives to ensure improved production, food and nutrition security for smallholder farmers in Zambia.</li> </ol>	<ul style="list-style-type: none"> <li>• Continue to co-lead</li> <li>• Determine how to fund greater capacity for WHEAT participation</li> <li>• Push for joint activities in water use management (irrigation), soil management, rotation</li> </ul>
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## 3.8 Staffing of management team and flagship projects

### Annex 3.8 Staffing of management team and flagship projects

**Name:** Hans-Joachim BRAUN

**Role in WHEAT:** Director CRP WHEAT, FP3 co-leader

#### **Expertise**

- Leads and manages 40 internationally recruited scientists
- Board member, Wheat Initiative and board member, International Wheat Yield Partnership
- Main author or co-author on more than 120 scientific articles, including more than 50 peer-reviewed articles and book chapters
- Contributed to the development and release of 44 winter wheat varieties grown on nearly 1.5 million hectares in Central and West Asia
- Recipient of Friendship Award of China for contribution to disease resistance wheat lines in Gansu province

#### **Employment including current position**

- 2015—to date: Director, CRP WHEAT, CIMMYT
- 2004—to date: Director, Global Wheat Program, CIMMYT
- 1985—2005: Head, International Winter Wheat Improvement Program, CIMMYT / ICARDA
- 1983: Post Doc, CIMMYT

#### **Education**

- 1983, Ph.D., University of Hohenheim, Germany
- 1980, M.S., University of Stuttgart-Hohenheim, Germany

#### **Selected Recent Peer-reviewed publications**

Please see <http://wheat.org/download/wheat-publications/>  
(comprehensive publications list for all WHEAT Flagship and Cluster of Activities leads)

## FP1 Inclusive and profitable wheat opportunities

**Name:** Olaf ERENSTEIN

**Role in WHEAT:** WHEAT MC-member, FP1 leader (time commitment 50%)

### **Expertise**

- Program director of a team of 30+ internationally recruited scientists located in sub-Saharan Africa, Latin America and Asia. The team's research-for-development (R4D) aims to help prioritize, target, understand and enhance wheat and maize interventions for greatest impact and social inclusiveness.
- Since 2013 involved in the CRP's Management Committee.
- Research has focused on R&D implications based on agricultural system and innovation analysis in developing countries, particularly in cereal based systems (wheat, maize, rice).

### **Employment including current position**

- 2013 – to date: Director Socio-economics Program, CIMMYT, Mexico (initially Ethiopia)
- 2009-2012: Senior Ag-economist, CIMMYT, Ethiopia
- 2004-2009: Agro-economist, CIMMYT, India
- 2000-2004: Production economist, Africa Rice Centre (WARDA/ADRAO), Côte d'Ivoire/Mali

### **Education**

- 1999, Ph.D. Agricultural Economics, Wageningen University, the Netherlands
- 1990, M.Sc. Agricultural Economics & M.Sc. Tropical Crop Science, Wageningen Ag. University, the Netherlands

**Name:** Yigezu YIGEZU

**Role in WHEAT:** FP1 co-leader and CoA 1.2 co-leader

**Expertise**

- Agricultural economics with focus on international development and policy analysis.
- Production economics, bio-economic modeling of production systems, natural resource and environmental economics, policy analysis, and technology adoption, out-scaling and impact assessment.
- Econometrics, mathematical programming, stochastic dynamic programming, computable general equilibrium (CGE) and input-output (IO) modeling.

**Employment including current position**

- 2012—to date: Senior Scientist; Social, Economic and Policy Research Program, ICARDA, Amman Jordan
- 2011-2012: Scientist, Social, Economic and Policy Research Program, ICARDA, Aleppo, Syria
- 2010-2011: Postdoctoral scientist, Social, Economic and Policy Research Program, ICARDA, Aleppo, Syria
- 1999-2001: Senior research assistant, Livestock policy analysis program, ILRI, Addis Ababa, Ethiopia

**Education**

- 2009, Ph.D., Department of Agricultural Economics, Purdue University, USA
- 2005, M.Sc., Department of Agricultural Economics, Purdue University, USA

## CoA 1.1

**Name:** Gideon KRUSEMAN

**Role in WHEAT:** CoA 1.1 leader (time commitment 50%)

### **Expertise**

- As ex-ante and foresight specialist, leading this research with a multi-disciplinary team of scientists located in sub-Saharan Africa, Latin America and Asia, since August 2015.
- Expert in quantitative economic and bio-economic modeling of complex systems at farm household, community, value chain, national and global levels, using econometric, simulation and mathematical programming techniques.
- Expert in quantitative and qualitative ex-ante policy analysis.
- Expert in ex-post impact assessment, monitoring and evaluation.
- Published numerous research papers on a wide variety of topics in international journals of repute, besides (co)authoring several books/edited volumes/technical manuals and book chapters.
- As a Faculty Member at Wageningen University and senior researcher fellow at LEI, guided several Ph.D. and M.Sc. students, and served as external panel member on PhD committee.

### **Employment including current position**

- 2016-to date: Focal point Big Data at CIMMYT
- 2015-to date: Ex-ante and foresight specialist at CIMMYT
- 2015-2016: Consultant Big Data
- 2006-2015: Lead on environmental economic modelling, at LEI Wageningen, ex-ante and ex-post impact evaluation of programs, projects and policies in Netherlands, EU, Tunisia, Egypt and Bangladesh
- 2004-2006: Senior Research fellow at the Institute of Environmental studies in Amsterdam involved in environmental modelling, research on the poverty environment nexus, environmental policy
- 2003-2004: Consultant for IFPRI for East African highlands project; consultant for ICCO concerning monitoring and evaluation
- 1992-2003: Worked in different capacities in Wageningen University and DLO research institutes on research related to food security and sustainable land use and research on climate change
- 1989-1992: Associate expert for the Andean outreach project of CIAT's bean program covering Peru, Ecuador and Bolivia.

### **Education**

- 2000, Ph.D. in Development economics, Wageningen University, Netherlands

**Name:** Aymen FRIJA

**Role in WHEAT:** CoA 1.1 leader at ICARDA

### **Expertise**

- Fellow of the Global Futures project (of PIM) at ICARDA between 2014-2016 (mainly conducting wheat foresight for MENA region).
- Economic modelling, analysis of farm efficiency and productivity, Natural resources management (governance and new institutional economics), conservation agriculture economics.
- National coordinator of the APEWC-MENA (“Agricultural Productivity with an Emphasis on Water Constraints in the Middle East and North Africa (MENA)”) project of ICARDA (2013-2015).
- Currently involved in the preparation of FPs 1 and 5 of PIM II, FP1 of wheat CRP II, FP5 of livestock CRP II, and FP1 of DCL CRP II.

### **Employment including current position**

- 2014-to date: Scientist, Agricultural Economist at ICARDA
- 2011-2013: Assistant Professor of Agricultural Economics, at Carthage University, Tunisia
- 2009-2011: Postdoctoral researcher at Ghent University, Belgium,
- 2004-2005: Research Assistant, INRAT, Tunisia

### **Education**

- 2009, Ph.D., Agricultural Sciences, Ghent University, Belgium
- 2006, Master Degree in agricultural economics, SupAgro, Montpellier, France
- 2004, Master Degree in agricultural economics and development INAT, Tunisia
- 2001, Engineer Degree in agricultural economics, ESAM, Tunisia

## CoA 1.2

**Name:** Aziz KARIMOV

**Role in WHEAT:** CoA 1.2 co-leader; CoA 1.4 co-leader (time commitment 50%)

### **Expertise**

- Market/Value chain economics
- Adoption-impact assessment
- Productivity and efficiency analysis

### **Employment including current position**

- 2015-to date: Agricultural Economist, CIMMYT -Turkey
- 2014-2015: Agricultural Economist, International Livestock Research Institute (ILRI) - Vietnam
- 2011-2013: Research Fellow, UNU-World Institute for Development Economics Research (UNU-WIDER), Finland
- 2007-2011: Junior Researcher, Center for Development Research (ZEF), Germany

### **Education**

- 2012, Ph.D., Agricultural Economics, University of Bonn, Germany
- 2004, MA, Economics, Northeastern University, Boston, USA

YIGEZU: CoA 1.2 co-leader, see FP1

## CoA 1.3

**Name:** Dina NAJJAR

**Role in WHEAT:** CoA 1.3 co-leader

### **Expertise:**

- Principal investigator for activities related to examining the interplay between gender norms and wheat innovations (hardware and software) in Morocco and Uzbekistan, gender wage gap and working conditions in wheat-based systems of Morocco and Egypt, women's economic empowerment in wheat based systems of Nigeria, Sudan and Ethiopia.
- Interdisciplinary training in anthropology, natural resources management and agriculture; with a concentration on relations between gender norms and wheat-related agricultural innovations.

### **Employment including current position**

- 2014-to date: Associate Social and Gender Research Scientist, International Center for Agricultural Research in the Dry Areas (ICARDA), Jordan
- 2014-to date: Special Graduate Faculty, The School of Environmental Design and Rural Development, University of Guelph, Canada

### **Education**

- 2013, Ph.D. in Anthropology, University of Western Ontario, Canada
- 2008, Masters in Natural Resource Management, University of Manitoba, Canada
- 2004, Ecosystem Restoration Post-graduate Certificate, Niagara College, Canada
- 2003, Bachelor of Science in Agriculture and a Diploma of Ingenieur Agricole, American University of, Beirut, Lebanon

**Name:** Lone Bech BADSTUE

**Role in WHEAT:** CoA 3.1. co-leader

### **Expertise**

- Rural Development Sociologist with special focus on gender and social heterogeneity, crop genetic resources improvement and seed systems, knowledge processes, local livelihoods and farmer decision making processes.
- Badstue has over 15 years of experience working with international development issues. She has broad experience working with different types of social actors and multi-disciplinary teams on issues related to rural development processes, including social relations and gender, seed systems and crop genetic resources, technology diffusion, natural resource management and collective action, as well as mainstreaming of gender in institutional procedures and project portfolios. She has long-term experience in several countries of Latin America and in Tunisia and Kenya, and short-term assignments in a number of countries in Sub-Saharan Africa and Asia.
- Badstue is currently Strategic Leader for Gender research at CIMMYT, and chairs the Executive Committee of GENNOVATE, a collaborative research initiative on Gender Norms, Agency and Innovation in Agriculture and Natural Resource Management involving 11 CRPs.

### **Employment including current position**

- 2011—to date: Strategic Leader for Gender Research, CIMMYT, Mexico
- 2010 –2011: Gender and Advocacy Specialist, Helen Keller International (HKI), Kenya
- 2007–2010: Socio-Economic and Gender Specialist, African Water Facility (AWF), African Development Bank
- 2000–2006: Associate Scientist, CIMMYT, Mexico

### **Education**

- 2006, Ph.D. Rural Development Sociology, Wageningen University, The Netherlands
- 2000, MA Social Anthropology, University of Copenhagen, Denmark

## CoA 1.4

**Name:** Girma Tesfahun KASSIE

**Role in WHEAT:** CoA 1.4 leader

### **Expertise**

- Girma Tesfahun Kassie is an agricultural economist (PhD) working for the international center for agricultural research in the dry areas (ICARDA) as a senior scientist based in Addis Ababa, Ethiopia.
- Girma has close to 20 years of research and teaching experience in many fields of applied economics particularly in the fields of agricultural production economics, agricultural marketing and value chain analysis, discrete choice analysis, agricultural risk analysis, and monitoring, evaluation and impact assessment of agricultural programs and technologies.
- He has 23 peer reviewed journal publications.

### **Employment including current position**

- 2014—to date: Senior Scientist, agricultural marketing, ICARDA
- 2009—2013: Associate Scientist, socioeconomics, CIMMYT, Zimbabwe
- 2004—2008: Research Fellow, biosciences, ILRI
- 1995—2004: Program Leader, socioeconomic research, Amhara Regional Agricultural Research Institute

### **Education**

- 2008, Ph.D., World Food Economics, University of Kiel, Germany
- 2002, M.Sc. Agricultural Economics, Alemaya University of Agriculture

Karimov: CoA 1.4 co-leader, see CoA 1.2

## FP2 Novel diversity and tools for improving genetic gains and breeding efficiency

**Name:** Kevin PIXLEY

**Role in WHEAT:** FP 2 co-leader; Director, Genetic Resources Program, CIMMYT

### Expertise

- As Director of Genetic Resources Program of CIMMYT, provides strategic and administrative leadership to conserve and apply a wide range of genetic and bioinformatics tools.
- As Associate Professor of Agronomy at the University of Wisconsin, leads the oat breeding program with emphasis on cultivar development while developing opportunities for graduate student research projects.
- As Associate Director & Maize Breeder, Maize Program, CIMMYT, develops the research agenda and strategies for CIMMYT Global Maize Program's Projects, provide research and administrative leadership for approximately 10 internationally recruited scientists.
- Maize Crop Leader, HarvestPlus Challenge Program, (June 2003-2012), coordinate and lead efforts of a global network of scientists seeking to enhance nutritional value of maize, lead a maize breeding program to develop maize with enhanced nutritional value for provitamin A and zinc.
- Developed and provided grey leaf spot (GLS), streak virus (MSV) and turicum resistant inbred lines currently used by private and public sector programs in Africa, investigated use of marker-assisted selection for MSV resistance breeding, initiated quality protein maize (QPM) breeding.

### Employment including current position

- 2011-to date: Director, Genetic Resources Program, CIMMYT. Co-leader of CRP WHEAT FP2. Project Leader of MasAgro Biodiversidad.
- 2009-2001: Associate Professor of Agronomy, University of Wisconsin, Madison, WI, USA.
- 1990-2009: Maize Breeder, CIMMYT. Held various positions including Program Director of the Tropical Ecosystems Program, Associate Director of the Maize Program, Team Leader and Regional Representative for CIMMYT in Zimbabwe/Southern Africa, Maize Coordinator for Harvest Plus, and others.

### Education

- 1990, Ph.D. in Plant Breeding, Iowa State University
- 1985, M.Sc. in Crop Physiology, University of Florida
- 1982, B.Sc. in Agronomy, Purdue University

**Name:** Ahmed AMRI

**Role in WHEAT:** FP2 co-leader, CoA 2.2 co-leader

**Expertise**

- Cereal breeding and wheat pre-breeding (30 years)
- Conservation of genetic resources (15 years)
- Curating wheat genetic resources
- In situ conservation of dryland agrobiodiversity (20 years)

**Employment including current position**

- 2008-to date: Head of Genetic Resources Unit at ICARDA
- 2001-2009: Regional Coordinator West Asia and Iran office, ICARDA
- 1999-2006: Agrobiodiversity project regional coordinator, GEF
- 1980-1999: Cereal breeder, INRA-Morocco

**Education**

- 1989, Ph.D. Genetic and breeding, Kansas State University, USA
- 1980, M.Sc. Plant Breeding, IAV Hassan II in Morocco (coursework at University of Minnesota)

## CoA 2.1

**Name:** Kate DREHER

**Role in WHEAT:** CoA 2.1 leader

### **Expertise**

- As a Germplasm Data Coordinator at CIMMYT since 2013, helps to coordinate efforts to implement institutional databases and tools for storing and utilizing maize and wheat phenotypic, genotypic, and genealogical data.
- Serves as a CIMMYT representative to the CGIAR Data Management Task Force and the Wheat Information System Expert Working Group, leads the CGIAR Dataverse Community of Practice.
- At the Carnegie Institution for Science (2007-2013) worked on biological database curation for The Arabidopsis Information Resource (TAIR, [www.arabidopsis.org](http://www.arabidopsis.org)) and the Plant Metabolic Network ([www.plantcyc.org](http://www.plantcyc.org)) and helped release databases focused on plant metabolism in over 15 species.

### **Employment including current position**

- 2013-to date: Germplasm Data Coordinator, CIMMYT, México
- 2007- 2013: Biocurator, Carnegie Institution for Science, USA
- 2007- 2007: Molecular Biology Consultant, CIMMYT, México

### **Education**

- 2007, Ph.D. in Plant Biology, University of California, Davis, USA
- 1999, B.A. in Biology and Economics, Williams College, USA

## CoA 2.2

**Name:** Kanwarpal DHUGGA

**Role in WHEAT:** CoA 2.2 co-leader

### **Expertise**

- Biotechnology Opportunities in Agriculture. Wheat transformation and regeneration.
- Agronomy, biochemistry, chemistry, genetics, molecular biology, and statistics.
- Building and leading international teams of scientists from diverse disciplines focused on crop improvement using an integrated approach

### **Employment including current position**

- 2015 – to date: Lead, Biotechnology Opportunities in Agriculture, CIMMYT, Mexico
- 1996-2014: Research Scientist, Sr. Research Scientist, Research Fellow, DuPont Pioneer, Johnston, USA
- 1991-1995: Basic Life Sciences Research Associated, Dept. Biological Sciences, Stanford University, USA

### **Education**

- 1987, Ph.D. Genetics, the University of California, Riverside, CA, USA
- 1980, M.Sc. Plant Breeding, Punjab Agricultural University, Ludhiana, India

Amri: CoA 2.2 co-leader, see FP2

## CoA 2.3

**Name:** Michel GHANEM

**Role in WHEAT:** CoA 2.2 co-leader

### **Expertise**

- A crop physiologist and agronomist working at ICARDA as crop physiologist where he leads the Crop Physiology Laboratory. His research focuses on deciphering plant traits that contribute to drought and heat adaptation.

### **Employment including current position**

- Head, Crop Physiology Laboratory, ICARDA
- 2010—2012, Research Associate, Spanish National Research Council, Department of Plant Nutrition (CEBAS), Alfocea Lab, Spain
- 2009—2012, Chargé de recherches, Fonds de la Recherche Scientifique (FNRS), Belgium
- Researcher, Catholic University of Louvain, Belgium

### **Education**

- Ph.D., Plant biology, University of Louvain
- Agronomy Engineering

**Name:** Matthew REYNOLDS

**Role in WHEAT:** CoA 2.3 co-leader

### **Expertise**

- Germplasm development and improvement of breeding methodology
- Understanding genetic and physiological bases of crop adaptation
- Strategy development, external fundraising and project management
- Initiated *Wheat Yield Consortium* in 2009 which became *International Wheat Yield Partnership (IWYP)* in 2014- to raise genetic yield potential of wheat to its biological limit
- Lead CIMMYT Wheat Physiology Laboratory and IWYP Research Hub
- Establishing the *Heat and Drought Wheat Improvement Consortium (HeDWIC)*, an international partnership involving hundreds of plant abiotic stress experts; target budget of \$50m+, endorsed by the Wheat Initiative as a research priority for the wheat community.
- Wrote strategic initiatives on yield potential & abiotic stress for earlier phase of CRP WHEAT

### **Employment including current position**

- 1996-to date: Distinguished Scientist (since 2014); Principal Scientist (since 2004), Head of Wheat Physiology, 1996-present, International Maize and Wheat Improvement Center (CIMMYT), Mexico.
- 2014: Expert Consultant, Bayer
- 2005: Associate Expert, Australian Centre for Plant Functional Genomics (ACPGF)
- 1989-95: Scientist & post-doctoral fellow, Wheat Program, CIMMYT, Mexico
- 1984-1989: Research Assistant, Department of Horticulture, Cornell University

### **Education**

- 1989, Ph.D. Horticulture science, Cornell University
- 1984, M.Sc. Crop physiology, Reading University
- 1983, B.A. Botany, Oxford University

## CoA 2.4

**Name:** *Jessica RUTKOSKI*

**Role in WHEAT:** CoA 2.4 leader

### **Expertise**

- Expert in gain from selection theory and implementation of genomic selection in applied breeding programs

### **Employment including current position**

- 2014-to date: Assistant Professor, International Programs, College of Agriculture and Life Sciences, Cornell University
- 2014-to date: Adjunct Assistant Professor, Plant Breeding and Genetics Section of the School of Integrative Plant Sciences
- 2014-to date: Adjunct Associate Scientist, CIMMYT

### **Education**

- 2014, Ph.D, Plant Breeding and Genetics, Cornell University
- 2009, BS, Genetics, University of Wisconsin Madison

## FP3 Better varieties reach farmers faster

**Name:** Hans-Joachim BRAUN

**Role in WHEAT:** Director CRP WHEAT, FP3 co-leader

### Expertise

- Leads and manages 40 internationally recruited scientists
- Board member, Wheat Initiative and board member, International Wheat Yield Partnership
- Main author or co-author on more than 120 scientific articles, including more than 50 peer-reviewed articles and book chapters
- Contributed to the development and release of 44 winter wheat varieties grown on nearly 1.5 million hectares in Central and West Asia
- Recipient of Friendship Award of China for contribution to disease resistance wheat lines in Gansu province

### Employment including current position

- 2015—to date: Director, CRP WHEAT, CIMMYT
- 2004—to date: Director, Global Wheat Program, CIMMYT
- 1985—2005: Head, International Winter Wheat Improvement Program, CIMMYT / ICARDA
- 1983: Post Doc, CIMMYT

### Education

- 1983, Ph.D., University of Hohenheim, Germany
- 1980, M.S., University of Stuttgart-Hohenheim, Germany

**Name:** Michael BAUM

**Role in WHEAT:** FP 3 co-leader

**Expertise**

- Plant breeding and cytogenetics; molecular marker application in plant breeding; doubled haploid breeding in wheat and barley; genetic transformation in cereals and legumes.
- Coordinate the work of up to 40 international scientists (barley, durum and bread wheat, chickpea, lentil, faba bean breeding, cereal and legume pathology, virology, biotechnology, international nurseries, seed health, cereal and legume quality), and more than 50 technical staff in the West Asia and North Africa region with major hubs in Rabat, Morocco, Terbol, Lebanon, Izmir, Turkey, Cairo, Egypt.

**Employment including current position**

- 2010-to date: Director, Biodiversity and Integrated Gene Management Program (BIGM), International Center for Agricultural Research in the Dry Areas (ICARDA), Amman- Rabat, Morocco
- 1992-2010: Biotechnologist, BIGM, ICARDA, Aleppo, Syria
- 1989-1991: Post-doctoral Fellow, CSIRO, Canberra, Australia
- 1985-1988: Ph.D. student, Göttingen, University, Germany,

**Education**

- 1988, Ph.D. in plant breeding and cytogenetics, University of Göttingen, Germany
- 1985, Diploma in Agriculture, University of Göttingen, Germany

## CoA 3.1

Braun: CoA 3.1 co-leader, see FP3

Baum: CoA 3.1 co-leader, see FP3

## CoA 3.2

**Name:** Carolina SAINT PIERRE

**Role in WHEAT:** CoA 3.2 co-leader

### Expertise

- Project Coordination. CRP-WHEAT Coordinator for the Global Network of Precision field-based Wheat Phenotyping Platforms, promoting partnership, communication and data sharing, training activities, and the use of good phenotyping practices for innovative and interdisciplinary research in wheat phenotyping.
- Project Coordination. Wheat Phenotyping Coordinator for Seeds of Discovery, providing overall management of phenotyping activities for the characterization of ~70,000 gene bank wheat accessions under field and glasshouse conditions with partners including scientists from ICARDA, CIMMYT, INIFAP, universities and national institutes.
- Wheat Phenotyping. Lead greenhouse and field experiments to evaluate genetically modified wheats in Mexico, being also responsible for official documentations and interactions with Mexican authorities and auditors.
- Wheat Physiology. Lead studies to understand gene action of canopy temperature in wheat. Conducted researches on wheat stem solidness and its relationship to water-soluble carbohydrates, and experiments on the influence of moisture stress and soil N on protein content, protein quality, and end-use functionality of different wheat varieties.
- Wheat Breeding. Participation in Wheat Breeding Programs at CIMMYT and Oregon State University, contributing in pre-breeding activities and in the development of cultivars with durable resistance to biotic and abiotic stresses, enhanced grain yields, and superior end-use properties.

### Employment including current position

- 2011-to date: Scientist, Wheat Phenotyping Coordinator, Global Wheat Program, CIMMYT-México
- 2008-2011: Associate Scientist, Wheat Physiology, Global Wheat Program, CIMMYT-México
- 2006-2008: Postdoctoral Fellow, Wheat Physiology, Global Wheat Program, CIMMYT-México
- 2002-2006: Graduate Research Assistantship, Oregon State University, OR, USA
- 1998-2002: Graduate Research Assistantship, Universidad Nacional del Sur, CIC, and CONICET, Argentina

### Education

- 2006, Ph.D., Crop and Soil Science Department, Oregon State University, OR, USA
- 2002, M.Sc., Agrarian Sciences, Universidad Nacional del Sur, Bahía Blanca, Argentina

Baum: CoA 3.2 co-leader, see FP3

## CoA 3.3

**Name:** Sridhar BHAVANI

**Role in WHEAT:** CoA 3.3 co-leader

### **Expertise**

- Wheat rust genetics, pathology and breeding: Sridhar Bhavani is CIMMYT wheat scientist working on wheat rust genetics, pathology and breeding based in Kenya and is the international coordinator for stem rust screening activities in East Africa under the DRRW (Durable Rust Resistance in Wheat) project. Sridhar facilitates pre-breeding and breeding components for several global partners with an objective to develop durable stem rust resistant varieties and the result of such massive screening efforts has resulted in the release of more than 80 varieties globally that are resistant to Ug99 globally. Sridhar is also keen in understanding the race-non specificity of stem rust resistance genes that confer durability and so far 13 new loci with adult plant resistance to stem rust Ug99 have been identified for which fine mapping is underway to develop reliable markers that can be used in breeding. He has collaborative projects with Montana State University (BREAD), Cornell University (DRRW), USDA, AAFC, CSIRO, GRDC, BBSRC, ICAR, PBI, Sydney and National Research Institutes. As a part of capacity building Sridhar also organizes an annual training course at KARI, Njoro focusing on standardization and evaluation of germplasm against stem rust U99.

### **Employment including current position**

- 2011-to date: Scientist, CIMMYT
- 2010-2011: Associate Scientist, CIMMYT
- 2008-2010: Post-Doc, CIMMYT

### **Education**

- Ph.D. Molecular genetics and Breeding, University of Sydney
- M.Sc. Molecular Biotechnology, University of Sydney

**Name:** Kumarse NAZARI

**Role in WHEAT:** CoA 3.3 co-leader

**Expertise**

- Leading cereal rust activities at RCRRC and coordinating ICARDA's rust research activities in CWANA
- Regional coordinator of BGRI rust surveillance in CWANA
- Coordinator of International Wheat Rust Trap Nurseries

**Employment including current position**

- Senior cereal rust pathologist, Regional Cereal Rust Research Center (RCRRC), ICARDA, Turkey

**Education**

- Ph.D., University of Sydney

## CoA 3.4

**Name:** Pawan SINGH

**Role in WHEAT:** CoA 3.4 co-leader

### **Expertise**

- Lead SI5 in the CRP WHEAT Phase I
- Scientific oversight to four CRP competitive partnership projects and Precision Phenotyping Platforms in Tunisia (Septoria tritici blotch), Uruguay (Multiple Diseases) and Bolivia (Blast) in CRP WHEAT Phase I
- Development and implementation of high throughput disease screening protocols including phenotypic, molecular and biochemical analysis for wheat disease
- Host-pathogen interactions for fungal head and leaf blight diseases of wheat
- Disease assessment and identification of the causal pathogen, understanding the population biology of the pathogen using pathogenicity, virulence and molecular analysis
- Scientific oversight to four CRP competitive partnership projects and Precision Phenotyping Platforms in Tunisia (Septoria tritici blotch), Uruguay (Multiple Diseases) and Bolivia (Blast) in CRP WHEAT phase I
- Scientific Advisory Board member for the project “Novel Strategies for Managing Blast Diseases of Rice and Wheat” USDA NIFA/AFRI Competitive Grant 2013-68004-20378

### **Employment including current position**

- 2015-to date: Senior Scientist, Head Wheat Pathology, International Maize and Wheat Improvement Center (CIMMYT), Mexico
- 2009-2014: Scientist, Head Wheat Pathology, CIMMYT, Mexico
- 2004-2008: Post-Doctoral Fellow, North Dakota State University, Fargo, USA
- 2001-2004: Professional Research Associate, University of Saskatchewan, Saskatoon, Canada

### **Education**

- 2001: Doctorate of Philosophy, Plant Sciences, Department of Plant Sciences, University of Saskatchewan, Saskatoon, Canada
- 1995: Master of Science, Plant Breeding, Department of Genetics and Plant Breeding, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, India

**Name:** Mustapha EL BOUHSSINI

**Role in WHEAT:** CoA 3.4 co-leader

**Expertise**

- Host plant resistance to insect pests (screening of germplasm, mechanisms of resistance and biotypes characterization)
- Biological control (parasitoids and entomopathogenic fungi)

**Employment including current position**

- 2014—to date: Principal entomologist (Integrated pest management of cereal and legume pests), ICARDA, Rabat, Morocco
- 2005—to date: Adjunct Professor, Entomology Department, Kansas State University, Manhattan, KS, USA
- 1997-2014: Senior Entomologist (IPM of cereal and legume insect pests), ICARDA, Aleppo, Syria

**Education**

- 1992, Ph.D., Entomology, Kansas State University, Manhattan, USA
- 1986, M.S., Entomology, Kansas State University, Manhattan, USA

## CoA 3.5

**Name:** Carlos GUZMAN

**Role in WHEAT:** CoA 3.5 leader

### **Expertise**

- Wheat breeding
- Molecular markers
- Genetic resources
- One of the leaders of the Expert Working Group on Improving Wheat Quality for Processing and Health

### **Employment including current position**

- 2014-to date: Scientist, Head of Wheat Chemistry and Quality Laboratory at CIMMYT, Mexico
- 2012-2013: Post-doctoral Fellow at CIMMYT, Mexico
- 2006-2011: PhD student at University of Cordoba, Spain

### **Education**

- 2007, Ph.D. in Plant Breeding “Polymorphism of waxy proteins and puroindolines in Spanish hulled wheats”. ETSIAM, Genetics Department, University of Córdoba, Spain
- 2011, M.Sc. “Molecular, Cell and Genetics Biotechnology”. ETSIAM, Genetics Department, University of Córdoba, Spain

## CoA 3.6

**Name:** Susanne DREISIGACKER

**Role in WHEAT:** CoA 3.6 co-leader

### Expertise

- Bridging genetic and genomic tools via new approaches into crop improvement.
- Understanding the genetic basis of biotic (rust, septoria, tan spot, fusarium) and abiotic (drought, heat) stress responses.
- Project participation: Genomic & Open-source Breeding Informatics Initiative (GOBII), 2015-2020, Technology development initiative aims to facilitate the routine use of genomic data.
- Project participation: Feed the Future Innovation Lab for Applied Wheat Genomics, 2013-2017, Genomic selection to boost genetic gains in wheat targeted to future warmer climates.
- Project participation: BMZ-large grant, 2013-2015, Increasing the productivity of the wheat crop under conditions of rising temperatures and water scarcity in South Asia.
- Project lead: BMZ-small grant, 2015-2016, Understanding cross pollination ability to improved seed production for future hybrid wheat.

### Employment including current position

- 2013-to date: Head of Wheat Laboratory, Global Wheat Program, CIMMYT, Mexico (Previously Senior Scientist)

### Education

- 2004, Ph.D. Plant breeding and Genetics, University of Hohenheim, Stuttgart, Germany
- 2000, M.S. Agriculture Biology, University of Hohenheim, Stuttgart, Germany

**Name:** Ayed AL-ABDALLAT

**Role in WHEAT:** CoA 3.6 co-leader

**Expertise**

- Plant biotechnology
- Functional genomics
- Abiotic stresses
- Molecular markers
- Bioinformatics

**Employment including current position**

- Senior biotechnologist, ICARDA
- Associate Professor of Plant Molecular Biology, The University of Jordan

**Education**

## CoA 3.7

**Name:** Zewdie BISHAW

**Role in WHEAT:** CoA 3.7 co-leader

### **Expertise**

- Trained as a Seed Technologist with a Ph.D. from Wageningen University, the Netherlands.
- He has broad managerial and technical knowledge with 35 years of experience in the sector, and is currently leading the Seed Unit of ICARDA, where he is responsible for strengthening the national seed systems targeting - both the formal (public and private seed sector) and informal (community/farmer-based) seed sectors.
- Authored and co-authored over 60 scientific and technical publications including training manuals and audio-tutorials with ICARDA and national seed program scientists.

### **Employment including current position**

- 2006—to date: Head, Seed Section and International Nurseries, ICARDA

### **Education**

- 2004, Ph.D., Production ecology and sustainable conservation, Wageningen University, the Netherlands
- 1984, M.Sc., Seed technology, School of Agriculture, Edinburgh University, Scotland
- 1979, B.Sc., Plant sciences, College of Agriculture, Addis Ababa University, Ethiopia

**Name:** Arun JOSHI

**Role in WHEAT:** CoA 3.7 co-leader

**Expertise**

- 30 years of experience in wheat research.
- A DAAD and INSA fellow, he has contributed to development and release of more than three-dozen wheat varieties in south Asia. He has been engaged in fast track dissemination of agronomically superior rust (Ug99) resistant wheat varieties in south Asia and Africa using innovative approach of pre-release multiplication.
- Jeanie Borlaug Laube Women in Triticum Mentor Award 2014 from Borlaug Global Rust Initiative, Cornell, USA.
- His research findings are published in 111 refereed journal articles; 8 books, book chapters, and reviews, and 65 symposia proceedings. He holds one patent. Joshi has trained three dozen Masters and PhD students in his career.

**Employment including current position**

- Principal Scientist, Global Wheat Program, CIMMYT
- Professor, genetics and plant breeding, BHU, India

**Education**

- M.S. and Ph.D., Banaras Hindu University

## FP4 Sustainable intensification of wheat-based farming systems

**Name:** Bruno GERARD

**Role in WHEAT:** FP4 co-leader, WHEAT MC Member

### **Expertise**

- Sustainable Intensification Flagship leader of WHEAT Phase I
- Research leadership in CIMMYT (team of 42 internationally recruited scientists)
- Coordination of multi-center research under CGIAR system-wide initiative (SLP)
- Research interests in geospatial topics, land use, soil fertility and resource management at farm and landscape levels, multi-disciplinary approaches

### **Employment including current position**

- 2011–to date: Director, Sustainable Intensification Program, CIMMYT, Mexico
- 2008-2011: System-wide Livestock (SLP) Program coordinator, International Livestock Research Institute (ILRI), Ethiopia
- 2005-2008: Visiting Scientist seconded from ICRISAT to Université Catholique de Louvain, Belgium
- 2000-2005: Principal Scientist International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Niger

### **Education**

- 2000, Ph.D. from the plant nutrition department at the University of Hohenheim, Germany
- 1990, M.Sc. in Irrigation Engineering, Utah State University, USA

**Name:** Richard THOMAS

**Role in WHEAT:** FP4 co-leader

**Expertise**

- Scientific coordinator, Global Economics of Land Degradation Initiative
- Integrated soil, water and nutrient management in crop-livestock systems
- 2001 CGIAR Excellence in Science Award for Outstanding Partnership
- Author of over 100 refereed journal articles, more than 41 book chapters, co-editor of 4 books and 26 articles

**Employment including current position**

- 2014—to date: Program Director, CRP Drylands System
- Assistant Director, United Nations University Institute for Water, Environment and Health, McMaster University, Canada
- Director, Natural Resources Management Programme, ICARDA
- Program Leader, CIAT

**Education**

- Ph.D, botany and microbiology, University of Wales, UK
- M.Sc., botany and microbiology, University of Wales, UK

## CoA 4.1

**Name:** Frédéric BAUDRON

**Role in WHEAT:** CoA 4.1 co-leader

### **Expertise**

- Areas of expertise: farming systems research, sustainable intensification, impact of agriculture on biodiversity, and participatory innovation development
- Coordination (currently) of a regional project (FACASI - Farm Mechanization and Conservation Agriculture for Sustainable Intensification) project implemented in Ethiopia, Kenya, Tanzania and Zimbabwe.

### **Employment including current position**

- 2011-to date: Systems agronomist, CIMMYT Ethiopia
- 2010-2011: Research fellow, CIRAD France
- 2010-2010: Private consultant
- 2007-2010: Research fellow, CIRAD Zimbabwe

### **Education**

- 2011, Ph.D., from the Graduate School 'Production Ecology and Resource Conservation', Wageningen University, The Netherlands
- 2001, Diploma of Specialized Agronomy (Master of Science) in Animal Science, AgroParisTech (formely 'Institut National Agronomique de Paris Grignon', INAPG), Paris, France

Thomas: CoA 4.1 co-leader, see FP4

## CoA 4.2

**Name:** Jens A. ANDERSSON

**Role in WHEAT:** CoA 4.2 co-leader

### **Expertise**

- Anthropology of development in Africa
- Development and implementation of on-farm research methodologies, focusing on multi-scale analyses, farmer decision-making and technology integration
- Coordination of innovation research and external support to innovation approaches in CRP WHEAT

### **Employment including current position**

- 2012-to date: Innovation scientist, CIMMYT (working globally), The Netherlands
- 2005-2011: Research coordinator, southern Africa, Wageningen University, The Netherlands
- 2004-2006: Postdoc Research Fellow, University of Amsterdam.

### **Education**

- 2002, Ph.D. (cum laude), Social Sciences, Wageningen University
- 1993, M.Sc. (cum laude), Sociology of Rural Development, Wageningen University

**Name:** Somanagouda PATIL

**Role in WHEAT:** CoA 4.2 co-leader

**Expertise**

**Employment including current position**

- Agronomist, ICARDA

**Education**

## CoA 4.3

**Name:** Yashipal SINGH SAHARAWAT

**Role in WHEAT:** FP 4.3 Leader

### Expertise

- Long-term research platforms on sustainable intensification across South Asia
- Conservation Agriculture in wheat based systems
- Precision Agriculture for efficient water and nutrient management in wheat based systems
- Dry land wheat systems agronomy

### Employment including current position

- Agronomist and Country Manager- ICARDA (2014-till date)
- Senior Scientist – Indian Council of Agricultural Research (2012-2014)
- Senior Agronomist- International Rice Research Institute (2009-2012)
- Soil Scientist- International Fertilizer Development Centre, USA (2008-2009)
- Soil Scientist- International Rice Research Institute (2005-2008)

### Education

- PDF- IRRI
- PDF- IFDC USA
- MBA- (Finance and HR)- India
- Ph.D. (Soils)- University of Hohenheim Stuttgart Germany
- M.Sc. (Soils) – CCS Haryana Agricultural University Hisar Haryana
- Post Graduate Diploma in Computer Application (PGDCA)- India

**Name:** ML JAT

**Role in WHEAT:** CoA 4.3 co-leader

**Expertise**

- Systems Research with special focus on Conservation Agriculture, Precision Farming and Climate Smart Agriculture in wheat based systems.
- Leading CCAFS Flagship project on Climate Smart Agriculture in South Asia and coordinating CIMMYT's CCAFS research portfolio in South Asia.

**Employment including current position**

- 2010-to date: Senior Cropping Systems Agronomist, CIMMYT
- 2007-2010: Senior Cropping Systems Agronomist, Indian Council of Agricultural Research, (ICAR), India
- 1998-2007: Agronomist, Indian Council of Agricultural Research, (ICAR), India

**Education**

- 1999, Ph.D., Agronomy, Indian Agricultural Research Institute (IAR), Pusa New Delhi
- 1996, M.Sc., Agronomy, Rajasthan Agricultural University, Bikaner, India

## CoA 4.4

**Name:** David KAHAN

**Role in WHEAT:** CoA 4.4 co-leader

### **Expertise**

- Agribusiness development
- Business modeling
- Innovation Systems
- Agricultural extension
- Farm business management
- Farm economics
- Natural resource management
- Marketing and value chain development

### **Employment including current position**

- 2013–to date: Agribusiness/ Scaling up Specialist, CIMMYT, Addis Ababa, Ethiopia
- 2012–2013: Principal Officer, Agricultural Innovation and Extension, FAO Rome, Italy
- 2010–2012: Senior Officer, Agribusiness and Agro-enterprise Development, FAO, Regional Office for Asia and the Pacific, Bangkok, Thailand
- 2001–2010: Senior Officer, Agribusiness and Agro-enterprise Development, FAO, Rome, Italy
- 1996-2001: Chief Technical Adviser, FAO, Myanmar

### **Education**

- 1982, Ph.D Rural Development, University of Reading, UK
- 1976, M.Sc. Farm Management, University of Reading, UK
- 1976, M.A Agricultural Economics, University of Wisconsin, USA
- 1973, B.Sc. Agricultural Economics, University of Reading, UK

Bishaw: CoA 4.4 co-leader, see CoA 3.7

## Cross-cutting (ex FP5, 5.3) Capacity development for the next generation of researchers and farmers

**Name:** Joachim STAHL

**Role in WHEAT:** Cross-cutting co-leader

### **Expertise**

- Capacity development
- Project management and M&E
- Change management

### **Employment including current position**

- Since 2011: Planner change management and methodological approaches, GIZ, Germany
- 2006-2011: Quality assurance referent, German Development Service (DED), Germany
- 2003-2005: Quality assurance consultant, DED, Tanzania
- 1997-2002: Adult education consultant, DED, Ecuador

### **Education**

- 1990, PhD, Philosophy, Goethe University Frankfurt, Germany
- 1986, MA, Philosophy and Sociology, Goethe University Frankfurt, Germany

**Name:** Amor YAHYAOU

**Role in WHEAT:** Cross-cutting co-leader

### **Expertise**

Main research teaching interests include disease resistance in wheat and barley, genetic diversity in cereal crops, host-parasite interactions, genetic diversity in fungal populations, virulence shifts in plant pathogens, and disease epidemics. Major area of teaching includes plant pathology, epidemiology, integrated pest management, and crop breeding.

- Research and Research-development on field crops cereals in particular
- Training young scientists in applied field research
- Training young scientists in disease diagnosis
- Advise farmers on crop and pest management and farmers' field schools
- Conducting workshops on plant protection, agronomy, breeding, integrated pest and crop management, disease epidemiology, and breeding for disease resistance
- Project development on various research & development areas
- Disease monitoring

### **Employment including current position**

- Senior scientist and training officer, CIMMYT
- 2015-to date: Adjunct Professor Kef College of Agriculture, Univ.of Jendouba, Tunisia
- 2014-to date: Coordinator Tunisia "WHEAT CRP"-Septoria Precision Phenotyping platform
- 2011-to date: Sr. Scientist, Wheat training Officer, Global Wheat Program, CIMMYT
- 2008-2010: Coordinator, ICARDA-CIMMYT Wheat Improvement Program in CWANA
- 2005-2007: Senior Cereal Pathologist (IGM), and IPM Coordinator, ICARDA
- 2002-2004: Manager of Integrated Pest Management (IPM) Project, Senior Cereal Pathologist, Germplasm Program, ICARDA
- 1998-2001: Senior Cereal Pathologist, Germplasm Program at ICARDA
- 1993-1998: Professor, Director of Kef College of Agriculture (University of Tunis II), Regional Coordinator Dry land Research in North West Tunisia
- 1993-1998: Professor Plant Breeding and Pathology, and Director of Kef College of Agriculture Univ. Tunis II, Tunisia
- 1989-1993: Associate Professor in Plant Breeding and Pathology; Director of Kef College of Agriculture, Univ. Tunis II, Tunisia
- 1987-1993: Assistant Professor of Plant Breeding and Pathology; Head of Plant Breeding Department at Kef College of Agriculture University

### **Education**

- 1986, Ph.D., Plant Pathology, Montana State University, USA
- 1981, M.Sc., Plant breeding and genetics, Oregon State University, USA
- 1979, BSc., Agronomy, Oregon State University, USA

**Name:** Charles KLEINERMANN

**Role in WHEAT:** Cross-cutting co-leader

**Expertise**

- Capacity development
- Partnerships development
- Project management

**Employment including current position**

- 2014--to date: Head of Capacity Development Unit, ICARDA, Amman, Jordan
- 2012—2014: Technical Training Officer, ICARDA, Amman, Jordan
- 2009—2012: Deputy Secretary General – European Movement International and Secretary General, MEDEA Institute, Brussels, Belgium

**Education**

- 2003, Diplome d Etude Applique (DEA) in Political Science and International Relations (equivalent to first year Ph.D.) from Agence Universitaire de la Francophonie (AUF), Beirut, Lebanon
- 2001, Diplome d Etude Specialise (DESS) in European Studies from the Catholic University of Louvain-la-Neuve, Belgium

**Selected Recent Peer-reviewed publications**

- Please see <http://wheat.org/download/wheat-publications/> (comprehensive publications list for all WHEAT Flagship and Cluster of Activities leads)

### 3.9 Open Access and Data strategy

#### Planning for and implementing OA/OD: Critical issues and anticipated challenges

Open Access and Open data planning, according to the CGIAR Open Access and Data Management Policy (“CG OADMP”), is driven by the target date of implementing Policy mandates by the end of 2018. By then, full Open Access and Open Data should be a reality (CG OADMP is effective as of October 2, 2013).

Key challenges are:

- Culture change: Since scientists are compelled by the CG OADMP to make their information products immediately, irrevocably, unrestrictedly and freely accessible online, they are going to confront a challenge for changing the way they used to operate in that regard in the past, so that they can adapt to current and future requirements. This challenge is closely related to
- Availability and commitment of resources for implementing Open Access and Open Data: To be compliant with the CG OADMP requires investments and thus budgets. Cost drivers are:
  - The implementation, maintenance and improvement of suitable repositories, which includes hardware infrastructure as well as staff costs for development, maintenance and population. [CG OADMP § 4.1.2]
  - The implementation, maintenance and improvement of interoperability, which includes the cost of properly tagging all the information products with metadata based on controlled vocabularies. [CG OADMP § 4.1.3]
  - Data storage, format conversion and adequate preservation for future use, which includes the costs related to storage volumes, backup storage and disaster recovery plans. [CG OADMP § 4.1.4]
  - Copyright and Open Licenses, which includes the royalties paid for publishing articles under the Gold or Green Open Access ways. [CG OADMP § 4.1.5]
  - Incentives and professional expertise in all areas of Open Access and Data Management. [CG OADMP § 4.1.6]
  - Translations of key documents and other media into pertinent languages. [CG OADMP § 4.1.7]

#### Planning and implementation

To be compliant with the CG OADMP, CRP-Management should consider the following issues during project planning and implementation:

- Allocate staff and material resources for proper implementation, maintenance and improvement of suitable repositories and tools, implementation of interoperability (including metadata tagging), data curation and data quality control, data storage, license management (including royalties for Gold and Green Open Access publishing), counselling on information product management, and translations. [CG OADMP § 4.1.2 to § 4.1.7]
- Properly design and put in place coordination mechanisms among participating centers and/or units for ensuring proper Open Access and Open Data implementation. [CG OADMP § 2]
- Establish and implement procedures and workflows for accomplishing the deadlines for making information products Open Access, according to the CG OADMP. [CG OADMP § 4.2]

## Data Management Plan (DMP – high level)

- Expected information product types  
WHEAT expects to produce the following types of information products: Annual reports, books and monographs, brochures, databases, datasets, fact sheets/flyers, financial management documents, financial statements, guidelines and manuals, grey literature, journal articles, newsletter/bulletins, non-conventional literature, photographs, posters, presentations, proceedings, reports, reprints, research highlights, research plans, research reports, software, special publications, speeches and presentations, technical bulletins, thesis, trip reports, videos/film.
- Formats  
Currently most of the information products are natively created in digital formats, so they can be immediately stored in proper repositories for “into perpetuity” archiving. Nevertheless, WHEAT will perform special efforts in order to transform relevant legacy information products into digital formats, as a way to preserve the institutional knowledge. Moreover, WHEAT will do its best for archiving its information products in commonly used and highly compatible digital file formats, like PDF, CSV, JPG, MP4, etc.
- Storage and preservation of information products  
Currently WHEAT uses the following state-of-the-art digital repositories:
  - CIMMYT Institutional Multimedia Publications Repository
  - CIMMYT Institutional Research Data and Software Repository

These repositories ensure not only preservation and backup but openness of research outputs via FAIR principles as well. Since the partner center does not have such repositories in place, it will be necessary to implement similar ones for preserving FAIR principles CRP-wide as well as center’s independency.

- Licensing  
CIMMYT has already in place different licenses for all its information products publicly available. Those licenses have been approved by its Legal Unit and are shown to the users of the repositories before they can download any information product. Since the partner center has not fully implemented a licensing system, it will be necessary to cover all information products coherently CRP-wide.
- Procedures, workflows and embargo periods  
All procedures, workflows and embargo periods regarding information products must observe the regulations given in the CG OADMP. CRP WHEAT will review current procedures, workflows and embargo periods currently in place in both centers and will adapt them to be compliant with the CG OADMP if necessary.

## Technical considerations

The information products stored in the repositories cited in the DMP can be discovered by search engines, and their contents indexed via standard protocols. Those state-of-the-art repositories provide syntactic and semantic interoperability by means of internationally widely used standards like OAI-PMH, Agrovoc, Dublin Core, etc., and they are hosted in first-class cloud servers so the content is properly backed-up and archived “into perpetuity”. The partner center has not implemented such kinds of interoperable repositories, so this should be one of the priority actions to be taken.

The following table summarizes the repositories currently used in the CRP.

**Table 3.9-1. WHEAT-related information product repositories.**

<b>Name</b>	<b>Repository Technology</b>	<b>URL</b>	<b>FAIR compliant?</b>
CIMMYT Institutional Multimedia Publications Repository	DSpace	<a href="http://repository.cimmyt.org/">http://repository.cimmyt.org/</a>	Yes
CIMMYT Institutional Research Data and Software Repository	Dataverse	<a href="http://data.cimmyt.org/">http://data.cimmyt.org/</a>	Yes
ICARDA Publications & Resources	Non-specific	<a href="http://www.icarda.org/publications-resources">http://www.icarda.org/publications-resources</a>	No

### **Technical Operations**

Given the above considerations, personnel and infrastructures will be allocated for ensuring the proper development of the following routine and on-demand operations:

- Implementation of suitable repositories and tools (on-demand). [CG OADMP § 4.1.2]
- Maintenance and improvement of suitable repositories and tools (routine). [CG OADMP § 4.1.2]
- Implementation of interoperability (on-demand). [CG OADMP § 4.1.3]
- Maintenance and improvement of interoperability (routine). [CG OADMP § 4.1.3]
- Implementation of hardware infrastructure, storage volumes, backup storage, and disaster recovery plans (on-demand). [CG OADMP § 4.1.4]
- Maintenance and improvement of hardware infrastructure, storage volumes, backup storage, and disaster recovery plans (routine). [CG OADMP § 4.1.4]
- Translations of key documents and other media into pertinent languages (on-demand). [CG OADMP § 4.1.7]
- Data curation, metadata tagging, and data quality control (routine). [CG OADMP § 4.1.3 and § 4.1.4]
- Periodic evidence-based review of the implementation of the relevant regulations in force (routine). [CG OADMP § 5]
- Continuous coordination among participating centers to ensure proper Open Access and Open Data implementation (routine). [CG OADMP § 2]
- Training activities covering relevant topics to ensure proper staff knowledge and engagement to accomplishing envisaged Open Access and Open Data objectives (on-demand).

### **Coordination and decision making**

The CIMMYT Knowledge Management, Data Management, Geographic Information Systems and Intellectual Property working group, which holds periodic meetings regarding Open Access and Open Data Management activities, should be extended with relevant equivalent staff from the partner center, as well as with the CRP Program Manager and other relevant staff, in order to jointly define workflows, procedures and governance recommendations that should be followed CRP-wide.

### Narrative for required resources (e.g. human and financial)

On top of existing resources (material and human), the following tables show additional resources forecasted for OA/OD activities for WHEAT (see Uplift budget).

**Table 3.9-2. Additional WHEAT OA/OD budget proposed.**

Amount	Resource	Average estimated yearly extra cost
1	Locally Recruited Staff for data curation, data quality assurance prior to final publication, metadata tagging, data storage, coordination with other centers and units and implementation of procedures and workflows related to information products management.	USD 48,700
0.5	Locally Recruited Staff for license management, data storage, counselling on information product management and coordination with other centers and units, shared by both MAIZE and WHEAT.	USD 17,000
0.5	Locally Recruited Staff for the design, development and implementation of trainings, shared by both MAIZE and WHEAT.	USD 17,000
N/A	Server rental and maintenance, storage volumes, backup storage and server disaster recovery set-up	USD 26,000
N/A	Implementation of suitable publicly accessible repositories (outsourcing).	USD 4,000
N/A	Implementation of a FAIR Integrated Library Management System (outsourcing).	USD 2,500
N/A	Maintenance of repositories and Information Library Management Systems.	USD 6,000
N/A	Improvement of suitable publicly accessible repositories, mainly regarding interoperability and dissemination features and channels/pipelines (outsourcing).	USD 50,000
N/A	Translations of key documents and other media into pertinent languages	USD 20,000
N/A	Training materials and fees (books, fees for attending courses, etc.)	USD 15,000
N/A	Fees for publishing in Open Access (see tables below)	USD 654,895
<b>Total average estimated yearly extra cost</b>		<b>USD 861,095</b>

**Total estimated extra cost for 2017-2022 for CRP WHEAT = USD 5,166,570**

The following tables show estimates for WHEAT publishing fees in Open Access, based on the assumption that all articles published in 2015 have been published as Gold Open Access. A 15% annual increase is added, to compensate increments both in scientific production and publishers' prices.

**Table 3.9-3. WHEAT Open Access publishing costs for CIMMYT and ICARDA.**

Year	Cost (CIMMYT)	Cost CIMMYT and ICARDA (CRP)
2015	USD 212,908	USD 354,847 (60%-40%)
2016	USD 234,199	USD 390,331 (60%-40%)
2017	USD 269,328	USD 448,880 (60%-40%)
2018	USD 309,727	USD 516,212 (60%-40%)
2019	USD 356,186	USD 593,643 (60%-40%)
2020	USD 409,614	USD 682,690 (60%-40%)
2021	USD 471,056	USD 785,093 (60%-40%)
2022	USD 541,714	USD 902,857 (60%-40%)
<b>Total cost estimate 2017-2022</b>	<b>USD 2,357,625</b>	<b>USD 3,929,375 (60%-40%)</b>
<b>Average annual cost estimate 2017-2022</b>	<b>USD 392,937</b>	<b>USD 654,895 (60%-40%)</b>

**Explanatory note for above tables:**

The “total average estimated yearly extra cost” in **Table 3.9-2** is the result of dividing by 6 (2017 to 2022) the “total estimated extra cost for 2017-2022 for WHEAT” ( $5,166,570 / 6 = 861,095$ ).

The numbers shown in **Table 3.9-3** were calculated as follows:

1. The cost for year 2015 is the hypothetical cost of having published all 2015 CIMMYT CRP WHEAT publications in Gold Open Access.
2. The cost for year 2016 is the result of applying a 15% increase to the cost for 2015. The cost for year 2017 is the result of applying a 15% increase to the cost for year 2016 and so on.
3. The “total cost estimate 2017-2022” is the sum of costs from 2017 to 2022:  $269,328 + 309,727 + 356,186 + 409,614 + 471,056 + 541,714 = 2,357,937$ .
4. The “average annual cost estimate” is the result of dividing by 6 (2017 to 2022) the “total cost estimate 2017-2022” ( $2,357,625 / 6 = 392,937$ ).
5. We assume that CIMMYT will contribute 60% and ICARDA 40% of total publications production. For example, since USD 309,727 was estimated for CIMMYT Open Access publications for 2018, this means that ICARDA Open Access publications for 2018 would amount to USD 206,485. The total cost for Open Access publications for the whole CRP for 2018 would be USD 516,212.

### 3.10 Intellectual Asset Management (see section 1.12) max 4p

#### I. Relevance of IA management for CRPs

All WHEAT participants (Lead and the Participant Center(s), as well as other partners, to the extent that those are able to align) will treat research results and products developed under WHEAT following the appropriate implementation of the CGIAR Principles for the Management of Intellectual Assets and the CGIAR Open Access and Data Management Policy as described below.

#### II. Critical issues to address in CRP implementation from IA perspective

Barriers to Full Adoption	Actions implemented to address critical issues	Envisioned improvements
Ensuring CGIAR IA Principles, Center Policies, and Center contracts are in compliance with local legislation, local markets, and local practices.	Preparing agreements to align with CGIAR Principles for the Management of Intellectual Assets and with LEA and RUA requirements when local laws and practices differ. Revising internal Policies to address critical issues, as well as to align them with local legislation standards and when possible, with local markets/practices	Monitoring and training of partners of local laws and revise internal and CGIAR policies in view of local laws, potentially as part of CRP "Policies and Markets". Focusing on local seed laws and regulations that affect dissemination of research outputs.
Lack of incorporation of IA management principles into the project lifecycle.	Including tools in the project management lifecycle to assist with tracking of intellectual assets.	Standardizing such practices in WHEAT projects.
	Preparing freedom to operate analysis for dissemination of CRP outputs.	
	Formulating flow down obligations and standards from internal and CGIAR Policies to Participant Center(s) and other partners, according to their capacities.	Monitoring and training of partners.
Aligning CGIAR IA Principle with private sector partner interests.	Drafting and negotiating agreements with private partners, in light of CGIAR Principles, and if necessary drafting exceptions while ensuring appropriate justification for appropriate dissemination along with the appropriate search and emergency exceptions.	Continue revising internal policies and extending such policies within the CGIAR.

#### III. Challenges for CRP implementation as they related to IA management

1. CGIAR Policy requirements are at odds with private sector interests and stewardship for GMO technologies. This applies for both outputs created through use of private sector technology or outputs created solely by a Center.
2. There are concerns about confidentiality obligations in order to maintain trade secrets and delay disclosure of information to provide ample time for enablement of patentable inventions in view of the CGIAR IA Principles.
3. Ensuring that CRP Wheat has adequate human resources, funding and capacity development to timely implement all actions needed for a proper IA management.
4. Lack of knowledge among NARs of IA practices from Centers.
5. Nonexistence of IP Policies within the various NARs.
6. Collecting, Exporting and Licensing seed in view of the International Treaty on Plant Genetic Resources for Food and Agriculture and the Nagoya Protocol.

#### IV. Project planning and implementation

1. The Lead Center IP & Legal will intervene in the following parts of the project management lifecycle:

Project phase	Intervention from IP & Legal
Planning	Direct and/or participate in drafting of documents for work plan, data management, knowledge management, and dissemination of results. IP & Legal will handle contractual obligations including subgrants to ensure appropriate planning. If appropriate prepare preliminary FTO assessment for dissemination of results.
Implementation, monitoring and evaluation	Draft and Negotiate agreements, including material transfer agreements. As needed, monitor work scope, risk issues and legal issues in moving forward with project. Draft commercial licenses, if necessary, for dissemination of outputs. Assist with any audits, if necessary. If appropriate prepare preliminary FTO assessment for dissemination of results. Assist in implement methods and tools such as legal documents and legal language to be incorporated into documents used in the project lifecycle
End of the project	Administrative closeout, ensure sharing of information and/or materials and closing out contract and tracking finalization of any confidentiality clauses.

2. Accountability for the appropriate implementation of the CGIAR Principles will be handled as follows:
  - a. Participant Centers are also CG Centers and therefore, their policies and procedures should also be consistent to those of the CGIAR; additionally, the Lead Center will ensure this approach by contractual obligation and the right to audit the Participant Center;
  - b. The Lead Center will encourage compliance by non-CGIAR partners, to the extent possible, for example through Subgrant contractual obligations.
  - c. The Lead Center will create appropriate stewardship issues so not to expose third parties to not be in compliance with IA principles. It is the exception, rather than the rule, that any new language will be needed. For example, in germplasm, CIMMYT does not disclose confidential pedigree information. Additionally, in data and information products management, CIMMYT repositories and management plans will be applicable to results generated by partners and up to the extent possible, CIMMYT will lead such management.
3. Implementation is subject to available budget; capacity building for incorporation of CGIAR Policies into project planning & implementation will be developed and provided through guidelines, trainings, etc.

## V. Key dissemination pathways for maximizing global impact.

Type of Intellectual Asset	Dissemination pathway	IP + Legal contributions
Data & Information Products (databases, publications, multimedia, reports, training materials, software, algorithms, maps)	<ul style="list-style-type: none"> <li>- Multi-lingual Open Access repositories</li> <li>- Adapted information dissemination channels to specific target groups e.g. farmers</li> <li>- Licensing</li> </ul>	<ul style="list-style-type: none"> <li>• Development of global licenses for dissemination as 'International Public Goods'</li> <li>• Legal advice on:               <ul style="list-style-type: none"> <li>- access to third party technologies/ data/ software/information;</li> <li>- agreements to publish information products through publishers and/or scientific journals;</li> <li>- freedom to operate opinions; and</li> <li>- development of IA management strategies to achieve a higher impact.</li> </ul> </li> </ul>
Know how (protocols, how to guides, best practices)	<ul style="list-style-type: none"> <li>- OA repositories,</li> <li>- Partnership approaches and capacity development</li> <li>- NARs</li> <li>- Extension specialists</li> <li>- Partners &amp; collaborators</li> </ul>	Legal advice on: <ul style="list-style-type: none"> <li>- development of IA management strategies to achieve a higher impact;</li> <li>- dissemination strategies &amp; global licenses for that purpose;</li> <li>- access to third party know how; and</li> <li>- management of confidential/ proprietary information;</li> </ul>
Germplasm (physical, dissemination)	<ul style="list-style-type: none"> <li>- As International Public Goods/through NARs /</li> <li>- Public and Private Partnerships</li> <li>- Networks</li> <li>- Participatory development</li> </ul>	<ul style="list-style-type: none"> <li>• Preparation of licenses and other kind of applicable agreements to access and give access to germplasm, including SMATA/MTAs;</li> <li>• Legal advice on:               <ul style="list-style-type: none"> <li>- Collection of germplasm and exportation of germplasm;</li> <li>- Transfer of germplasm;</li> <li>- contract negotiation for PPP;</li> <li>- freedom to operate opinions;</li> <li>- dissemination strategies for scaling up and out; and</li> <li>- dissemination of data.</li> </ul> </li> </ul>
Agronomic technologies (SI)	<ul style="list-style-type: none"> <li>- On-farm management/ Participatory research</li> </ul>	Legal advice on: <ul style="list-style-type: none"> <li>- farmer's rights, collection and transfer of germplasm, use of traditional knowledge &amp; Prior Informed Consent;</li> <li>- freedom to operate opinions;</li> <li>- Ethics in research &amp; privacy matters;</li> <li>- contract negotiation for accessing third party technologies and/or for collaborations/ use of patents; and</li> <li>- dissemination of data.</li> </ul>
Agronomic special category: Specialized machinery	<ul style="list-style-type: none"> <li>- Scaling up and out</li> <li>- Networks</li> </ul>	Legal advice on <ul style="list-style-type: none"> <li>- contract negotiation and drafting, including for accessing third party technologies and/or for granting access to third parties, collaborations/ use of patents;</li> <li>- dissemination strategies for scaling up and out; and</li> <li>- dissemination of data.</li> </ul>
New Tools such as newly discovered DNA, RNA, enzymatic and analytical methods and processes for use in biotechnology discovery and/or trait development, including but not limited to transformation tools and methods, promoters, introns, enhancers, DNA and RNA modification tools ect.	<ul style="list-style-type: none"> <li>- Licensing</li> <li>- Partnerships</li> </ul>	Legal advice on <ul style="list-style-type: none"> <li>- contract negotiation and drafting, including access to third party technologies;</li> <li>- freedom to operate opinions;</li> <li>- use of patents; and</li> <li>- dissemination strategies.</li> </ul>
Traits	<ul style="list-style-type: none"> <li>- Licensing</li> <li>- Partnerships</li> </ul>	Legal advice on <ul style="list-style-type: none"> <li>- contract negotiation and drafting, including access to third party technologies;</li> <li>- freedom to operate opinions;</li> <li>- use of patents; and</li> <li>- dissemination strategies.</li> </ul>

## VI. Operations (technical infrastructure, planned activities).

IA/IP Operations category	Policy, procedure, work process Status (provide ref docs if apt)	Policy, procedure, process owner	Est cost core budget	Additional invest, budget needed
Incorporation into Leader Center project cycle	Project Management lifecycle (in draft)	Project Managers + IP & Legal	IP & Legal: 5% FTE of one IP Counsel + 3% FTE of General Counsel	+ 5 % FTE of one IP Counsel + 2% FTE of General Counsel
Incorporation into project cycle for participating centers, non-CGIAR partners	In accordance with CIMMYT Policies and decisions taken in the CRP-MC; Subgrant	CRP Managers + Participating Centers/ non-CGIAR partners		
IA/IP tracking	Project Management lifecycle (in draft)	Project Leader + IP & Legal	IP & Legal: 5% FTE of one IP Counsel	+15 % FTE of one IP Counsel
Negotiation of partner agreements	IP Policy & IP Manual (approved, under revision for update)	Project Leader + IP & Legal	IP & Legal: 15% FTE of each IP Counsel (2)	+10% FTE of each IP Counsel (2)
Convention on Biological Diversity/Farmer's Rights/Nagoya Protocol /International Treaty for Plant Genetic Resources for Food & Agriculture	Germplasm Policy (in draft)	Project Leader + IP & Legal	IP & Legal: 5% FTE of one IP Counsel	+15 % FTE of one IP Counsel
Ethics in Research & Privacy Protection	Ethics in Research Policy (in draft)	Project Leader + IP & Legal	IP & Legal: 5% FTE of one IP Counsel	+15 % FTE of one IP Counsel
Policy development, update of existing	IP Policy; IP Manual; Copyright & Authorship Policy; Germplasm Policy (in draft); Ethics in Research Policy (in draft); Project Management lifecycle;	IP + Legal	IP & Legal: 10% FTE of each IP Counsel (2) + 5% FTE of General Counsel	+ 15% FTE of each IP Counsel (2) + 5% FTE of General Counsel
CGIAR Coordination	CRP management	Project Managers	N/A	N/A

## VII. Coordination and decision making (i.e. Policies, procedures, committee, task force)

Topic that triggers coordination of MC with IP + Legal for decision making	Coordination /decision making procedure	Applicable Policy & Status	Est cost core budget	Additional invest, budget needed
Accessing technology that have or may have restrictions for results dissemination	Legal advice during the project through participation in the MC meetings / application of polices in documents produced	CIMMYT Intellectual Property Policy & Manual (approved, under revision for update)	5% FTE of each IP Counsel (2)	+ 3% FTE of each IP Counsel (2)
Granting limited exclusivity agreements for commercialization, whether as part of a partnership or a dissemination strategy,	Legal advice during the project through participation in the MC meetings / application of polices in documents produced	CIMMYT Intellectual Property Policy & Manual (approved, under revision for update) CGIAR Principles for the Management of IA	5% FTE of each IP Counsel (2)	+ 10% FTE of each IP Counsel (2)
Partnership or strategies that include the possibility of registering IPRs	Legal advice during the project through participation in the MC meetings / application of polices in documents produced	CIMMYT Intellectual Property Policy & Manual (approved, under revision for update) CGIAR Principles for the Management of IA Germplasm Policy (in draft);	5% FTE of each IP Counsel (2)	--

Planning direct/specific research activities, particularly if they involve: Collection and transfer of germplasm; Licensing of Tools and Traits Interaction with Human Subjects/ communities; Scaling up and out; Dissemination of Data through non-standard platforms.	Legal advice during the project through participation in the MC meetings / application of polices in documents produced	Policies applicable to all matters: CIMMYT Intellectual Property Policy & Manual (approved, under revision for update) CGIAR Principles for the Management of IA; For specific topics: Collection of Germplasm: CIMMYT Germplasm Policy (in draft); Interaction with Human Subject/Communities: CIMMYT Ethics in Research Policy (in draft); Dissemination of Data: CIMMYT Research Data & Information Management Policy & cigar Open Access Policy.	10% FTE of each IP Counsel (2)	+ 10% FTE of each IP Counsel (2)
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\* Additional decisions made by the Lead Center-MC will be made in accordance with the CGIAR and Lead Center relevant Policies.

### VIII. Indicative resources (HR & budget statement)

CIMMYT Human Resources that will support CRPs implementation include:

1. CIMMYT General Counsel to focus on general coordination and oversight of legal implications-. (10% FTE devoted to CRPs).
2. CIMMYT IP Counsel with background in legal matters related to germplasm development and deployment. (10% FTE devoted to CRP Wheat, in addition to 25% FTE approximately to be invested in projects that are linked to CRP Wheat and 20% FTE approximately devoted to policy drafting and implementation as well as capacity building for CIMMYT that will have a direct impact in CRP Wheat).
3. CIMMYT IP counsel with background in legal matters related to data and information products development and deployment. (10% FTE devoted to CRP Wheat, in addition to 25% FTE approximately to be invested in projects that are linked to CRP Wheat and 20% FTE approximately devoted to policy drafting and implementation as well as capacity building for CIMMYT that will have a direct impact in CRP Wheat).
4. CIMMYT Legal specialist to support IP Counsel’s activities. (5% FTE devoted to CRPs in addition to 20% FTE approximately to be invested in projects that are part of CRP Wheat).
5. CIMMYT Administrative support (as needed).

Additional Annexes

## Annex 4.1 Geographic, climatic and biotic stress characterization (12 Mega environments)

Geographic, climatical and biotic stress characterization of 12 Mega-environments for wheat production in Less Developed Countries							
ME	Lat N and S	Wheat area (M ha)	Importance for WHEAT	Climatical characterization	Major biotic and abiotic stresses	Representative locations/regions	Change in ME due to climate change and consequences for germplasm development; N=negative P=positive U=unknown (adopted from Hodson and White, 2008).
<b>SPRING WHEAT</b>							
1	<40°	33.0	High	Low rainfall irrigated, coolest quarter (3 consecutive months) mean min temp > 3oC < 11oC	Lodging tolerance Leaf yellow and stem rust, Karnal bunt, Alternaria	Yaqui Valley, Mexico Indo Gangetic Plains, Egypt, Central Iran, SE Turkey, China	N–Rising temperatures result in large areas evolving to ME5; reduced precipitation in subtropical regions restricts irrigation; suppl. irrigation with temporary drought periods requires high yielding wheat with drought tolerance (adapted to ME1 and ME4); increasing insect problems in part aphids P–Reduced irrigation due to positive impact of elevated CO <sub>2</sub> on water use efficiency
2A	<40°	2.9	High	High rainfall in summer; wettest quarter mean min temp >3°C < 16°C, wettest quarter (3 consecutive wettest months) precipitation > 500mm; elevation > 1500m	Lodging, 3 rusts Septoria spp. Root diseases BYD, Sprouting	Highlands East Africa and Mexico, Andes	Rising temperatures result in some areas evolving to ME5 Reduced precipitation result in areas evolving to ME4
2B	<40°	2.7	High	High rainfall winter rain > 500mm; coolest quarter mean min temp >3°C <16°C; elevation < 500m	Lodging, Leaf Yellow Stem rust, FHB, BYD, Septoria spp., Root diseases, Sprouting	Mediterranean Coast, Caspian Sea	N-frequency of climate extremes at one location over years increases requiring wheat varieties combining high yield potential, wide spectrum of disease resistance and tolerance to temporary drought
3	<40°	1.7	Low	High rainfall acid soil; climate as in ME2 and pH < 5	As for ME2 + acid soil tolerance	Passo Fundo, Brazil	U–Changes in precipitation patterns in areas will have variable effects
4A	<40°	10.0	High	Low mostly winter rainfall, coolest quarter mean min temp >3oC <11oC; wettest quarter precipitation > 100 mm < 400mm	Drought and heat tolerance, Septoria spp., yellow stem and leaf rust, Bunt Hessian fly, Sawfly, root diseases, nematodes	N-Africa, Syria; SE Turkey, Iraq, Iran, N-Afghanistan	N–Rising temperatures exacerbates water deficits, reducing yields or making production uneconomical P–Reduced water deficits through impact of elevated CO <sub>2</sub> on water use efficiency

ME	Lat N and S	Wheat area (M ha)	Importance for WHEAT	Climatical characterization	Major biotic and abiotic stresses	Representative locations/regions	Change in ME due to climate change and consequences for germplasm development; N=negative P=positive U=unknown (adopted from Hodson and White, 2008).
4B	<40°	5.0	High	Low mostly summer rainfall (200-500mm); coolest quarter mean min temp >30C <11oC;	Drought tolerance, Septoria spp., leaf and stem rust, FHB	Marcos Juarez, Argentina	N–Changes in precipitation patterns likely to increase drought risk
4C	<40°	7.0	High	Mostly residual moisture; coolest quarter mean min temp >30C <16oC; wettest quarter precipitation > 100 mm < 400mm	Tolerance to drought, and heat in seedling stage, Stem rust,	Central India	U–Changes in precipitation patterns in areas will have variable effects
5A	<40°	11.5	High	Hot and humid, high rainfall/ irrigated, coolest quarter mean min temp >11oC <16oC;	Heat tolerance, FHB, Helminth. spp., leaf rust, sprouting; Brazil Bolivia Paraguay wheat blast	Eastern Gangetic Plains in Nepal India Bangladesh Londrina, Brazil;	N–Rising temperatures result in large areas becoming unsuitable for wheat; cropping systems and agronomy practices allowing early sowing of wheat paramount; increasing biotic stress
5B	<40°	3.2	High	Irrigated, low humidity; coolest quarter mean min temp >11oC <16oC;	Heat tolerance, stem and leaf rust	Gezira, Sudan; Kano, Nigeria, S-Egypt,	N–Rising temperatures result in large areas becoming unsuitable for wheat; increasing biotic stress
6	>45°	12.8	Medium	Spring sown; moderate summer rainfall; coolest quarter mean min temp <- 13°C; warmest quarter mean min temp > 9°C;	Drought tolerance, stem and leaf rust, tan spot, FHB, photoperiod sensitivity	Kazakhstan, Siberia, N-China	P–Rising temperatures allow wheat production in higher latitudes - wheat area expansion likely; lengthen growing season permits marginal areas to become productive; Reduced risk of winter-kill may allow sowing of more productive winter wheat
<b>Facultative Wheat</b>							
7 A	30°-45°	3.5	Medium	Irrigated	Rapid grain fill, cold tolerance, yellow & leaf rust, Powdery Mildew, BYD, Bunt, Loose Smut	Henan China;	U–Reduced cold stress allows fall sown spring wheat, possibly reducing yield potential but shortening growing season offering more options for diversifying cropping systems; P–Reduced irrigation due to impact of elevated CO <sub>2</sub> on water use efficiency
7 B	30°-45°	3.5	High	Irrigated, often only supplementary irrigation	Yellow, leaf and stem rust, Bunt, Loose Smut	Turkey, Iran, Central Asia, Afghanistan	P–Reduced cold stress allows fall sown spring wheat, possibly reducing yield potential but shortening growing season offering more options for diversifying cropping systems; reduced irrigation due to impact of elevated CO <sub>2</sub> on water use efficiency; N- suppl. irrigation with temporary exposure to drought requires germplasm adapted to ME7 and ME9

ME	Lat N and S	Wheat area ()	Importance for WHEAT	Climatical characterization	Major biotic and abiotic stresses	Representative locations/regions	Change in ME due to climate change and consequences for germplasm development; N=negative P=positive U=unknown (adopted from Hodson and White, 2008).
8A	35 <sup>0</sup> -45 <sup>0</sup>	0.2	Low	> 600 mm rainfall, medium cold, photosensitive	Yellow Rust, Septoria spp., Powdery Mildew, FHB, Root Diseases	Chillan, Chile;	
8B	30 <sup>0</sup> -45 <sup>0</sup>	1.2	Medium	More than 600 mm rainfall	Yellow and Leaf Rust Bunt, Root Diseases, Powdery Mildew	Transitional Zones and Trace, Turkey, S-Kazakhstan	N-frequency of climate extremes increase requiring germplasm with high yield potential, wide spectrum of disease resistance and tolerance to drought
9	30 <sup>0</sup> -45 <sup>0</sup>	8.4	High	Low rainfall < 400 mm, winter /spring rainfall dominant	Tolerance to drought, cold, heat at grain fill, Yellow and leaf rust Bunt; insects, nematodes	West and Central Asia, North Africa, mainly non-dwarf cultivars grown	N–Rising temperatures exacerbates water deficits, either further reducing yields or making production uneconomical; P–Reduced water deficits through impact of elevated CO <sub>2</sub> on water use efficiency
<b>Winter Wheat</b>							
10A	30 <sup>0</sup> -45 <sup>0</sup>	3.8	Medium	Irrigated	Tolerance to winterkill, Yellow and leaf rust, Powdery Mildew BYD,	Beijing, China,	P–Reduced winterkill, increasing yields, Red. Irrig. due to impact of elevated CO <sub>2</sub> on water use efficiency; N–Warmer spring and summer hasten grain-filling
10B	30 <sup>0</sup> -45 <sup>0</sup>	1.5	Medium	Often supplementary irrigation	Tolerance to winterkill, Yellow and leaf rust, BYD, Bunt, Smut, Root diseases complex	Turkey, Iran, Central Asia	P–Warmer winters reduce severity of winter-kill, increasing yields, Reduced irrigation due to impact of elevated CO <sub>2</sub> on water use efficiency N–Warmer spring and summer hasten grain-filling
11A	35 <sup>0</sup> -55 <sup>0</sup>	Area in LDC insignificant		High rainfall/ irrigated, long season	Septoria spp., FHB, Yellow and leaf rust, Powdery Mildew, Root disease complex, BYD,	Central and Western Europe, NW US, Pacific North West,	P–Warmer winters reduce severity of winter-kill
11B	35 <sup>0</sup> -55 <sup>0</sup>	Area in LDC insignificant		High rainfall/ irrigated, short season	Leaf and stem rust, Powdery Mildew, FHB, Septoria, BYD, Tolerance to winterkill, sprouting tolerance	Europe, N-Korea, China	P–Warmer winters reduce severity of winter-kill
12	30 <sup>0</sup> -45 <sup>0</sup>	12.8	High	Low rainfall between 300-450 mm,	Cold; drought, heat tolerance; yellow rust, bunt, nematodes, Root disease, Zn def. In Turkey/Iran non-dwarf varieties dominant	Turkey, West and Central Asia, China;	P–Warmer winters reduce severity of winter-kill P–Reduced water deficits through impact of elevated CO <sub>2</sub> on water use efficiency N–increased frequency of years with severe drought N increased insect problems
<b>Tot</b>		124.7					

Annex 4.2: Regional priority of non-rust diseases under anticipated climate change

Biotic stress	East Asia	South Asia	West Asia	Middle East North Africa	Central Asia/Caucasus	Sub-Saharan Africa	Latin Amer. Incl. Mex.	Developed countries	Significant loses area (million ha)	Likely impact of climate change	Negative impacts
<b>Non-Rust Major Diseases Attacking Wheat at Global Scale</b>											
<b>Fusarium head blight</b>	+++	0	+	+	+	0	++	+++	12	***	Yield, quality, mycotoxin contamination
<b>Septoria tritici blotch</b>	+	0	++	+++	++	++	++	+++	12	*	Yield, quality
<b>Spot blotch</b>	+	++	0	0	0	+	+	+	10	**	Yield, quality
<b>Tan spot</b>	0	+	0	+	+++	0	++	++	7	*	Yield, quality
<b>Wheat blast</b>	0	+++	0	0	0	0	++	0	2	***	Yield, quality
<b>Nematodes</b>	++	++	+++	++	0	+	++	++	10	**	Yield, quality
<b>Root diseases</b>	++	+	++	+++	++	+	+	++	9	***	Yield, quality, mycotoxin contamination
<b>Non-Rust Major Insects Attacking Wheat at Global Scale</b>											
<b>Sunn Pest</b>	0	0	+++	+	+++	0	0	+	10	***	Yield, quality
<b>Hessian Fly</b>	0	0	0	+++	+	0	0	+++	6	***	Yield
<b>Aphids</b>	++	++	+	++	+	++	++	+++	10	***	Yield
<b>Wheat stem saw fly</b>	0	0	++	++	+	0	0	++	5	***	Yield

## Annex 4.3: Overview CRP Budget, Value for Money, Use of W1&2 and Uplift Budget

### Budget and value for money

Despite its importance and performance, the WHEAT budget has been administratively capped by the Consortium both in Phase I and in the call for full proposals for Phase II (true for other CRPs; See 19 Dec 2015 document, Table 2). In addition, parts of the Dryland Systems CRP are to be integrated in Phase II without a proportional increase in the budget. WHEAT can use more resources in a strategic manner and productively to achieve the SLOs. The budget proposal below adheres to the caps imposed both on the core and uplift budgets.

The **core budget** below is based on the pre-proposal budget minus 30% (as per Fund Council guidance, November 2015). Reviewers and Fund Council members should note the consequent provisos:

1. Total W1&2 is based on agreed upon 2017 estimates and equal W1 distribution to all CRPs, are indicative and depend on end 2016 System Council decisions and donor W2 allocations for the 2017 budget. W3/Bilateral figures are based on 2012-16 annualized average plus 5% p.a.
2. 'Supplementary to CRP' refers to CRP-aligned downstream, scaling-out/up projects that are not considered in the CRP WHEAT budget, because the Consortium Office during 2013/2014 encouraged CRPs to take such type of funding out. We now see that only CIMMYT followed that advice. Currently, the CGIAR does not have a shared definition for supplementary/non-CRP and this caused the low indicative budget for WHEAT (CRP guidelines, Dec 19, Table2).
3. The figures reflect W1&2 (ca. \$1.25M) and bilateral funding (ca. 2.8M) that is required to integrate three Dryland Systems CRP action research sites into WHEAT.

In the **uplift budget** scenario, WHEAT II calls for more investment being made for strategic research (see Tables 13 & 14). The budget considers the importance of wheat for food security for the poor, well-documented returns on investment, and still marginal R&D investments by the private sector in developing countries. It also considers investments in new opportunities linked to donor and partner priorities (see Table 9a, Section 1.8.). Additional W1&2 would be invested in:

- Develop a phenotyping and breeding platform in Bangladesh to develop wheat lines for S-Asia, which are tolerant to wheat blast and humid heat.
- Analysis of the farm-to-fork value chain to assess post-harvest losses including wheat nutritional and end-use quality related interventions with high returns to investment in wheat agro-food systems.
- Stronger support to gender research to provide new opportunities for women in regions with deeply entrenched gender roles and social norms – and build competence, capacity and partner networks related to youth in agriculture R4D and WHEAT.
- Further strengthen foresight and targeting work (including wheat crop and bio-economic modelling capacity and scope) and associated strategic partnerships.
- Build the global Heat & Drought Wheat Improvement Consortium (HeDWIC) to develop climate change resilient wheat and develop further the heat and drought screening hub in Obregon, Mexico.
- Expand investments in breeding for higher yield potential
- Expand collaboration with JIRCAS within the BNI Consortium on biological nitrification inhibitors to reduce N<sub>2</sub>O emissions and improve N-use efficiency in wheat systems. Wheat receives around 20% of all N applied and N-use efficiency is with 30% at global average low.

- A stronger impact assessment and M&E framework that strengthen programmatic learning and support focused investments and increased scope of impact assessments (including more strategic country case impact studies and panel data).
- Systematizing and modeling lessons learned across sustainable intensification projects aligned with other agri-food systems CRPs.
- Support for a WHEAT Learning Platform to develop the next generation of wheat scientists.

Additional W3/Bilateral (see also Table 12):

- Genomics selection, genetic resource utilization and big data, and the development of a phenotyping network with NARS partners to accelerate breeding gains and reduce reliance on CGIAR centers (linkage with Genetic Gains and Genebanks Platforms).
- Pursuit of approaches (hybrid wheat, seed systems) that increase private sector investment in wheat R&D and reduce wheat’s vulnerability to shortfalls in public sector R&D.

CRP Management Budget uplift scenario is estimated at \$2.890M p.a. (versus 1.9M core). Additional W1&2 funds would be deployed to support IA/IP (100k), as per Annex 3.10, improved open access for wheat researchers globally (613k, as per Annex 3.9) and improved MEL outcomes-to-impact (250k, for collaboration with national partners).

The joint working group of Fund Council representatives, center members and Consortium Board summarized examples of the strategic use of W1-2 funds in a Memorandum for Fund Council discussions on December 11, 2015. It features strategic uses of W1-2 Funding, with multiple drivers affecting the identification and prioritization of these uses. The three broad categories of use of W1-2 funds are: (i) ensure effective management and optimization of the use of the gene bank collections; (ii) setting the direction of a CRP and creating coherence in a CRP, by which the whole is more than the sum of the parts (more impact); or (iii) providing crucial support for ‘One System’ building actions that deliver the foundations for improved impact on the ground.

WHEAT core W1&2 funds will be deployed using the prioritization logic shown below:

**Table 11. Focus of W1&2 use in different phases (upstream to downstream).**

	<b>Strategic, longer-term research, seed invests</b>	<b>Rapid response (incl flexibility)</b>	<b>Cross-Portfolio, -CRP learning for impact</b>	<b>CRP Gov. &amp; Mgmt.</b>
<b>Discovery (upstream)</b>	FP1, 4: New knowledge for better targeting, prioritizing; ARI, national partners  FP2-4: Generate new knowledge for R-to-D pipeline (e.g. FP2 New traits, HeDWIC, BNI); R&D partners	FP3 new diseases & pests (e.g. wheat blast in S-Asia)	FP2-3: Germplasm improvement methodologies, methods, data mgmt (e.g. Genetic gain, cross-crops)  FP4: Research on scaling out, innovation pathways	WHEAT-ISC, WHEAT-MC  Apply CGIAR Standards, Policies  Manage linkages at Portfolio level
<b>Validation</b>	FP3: New traits into elite lines, Precision Phenotyping Platforms with NARS partners; expanded yield testing		FP4: Country coordination, systems research approaches	
<b>Scaling out</b>	FP1, 4: Research on adoption dynamics, scaling	FP3-4: post-conflict	FP3.7, 4.4: Country coordination,	

<b>(downstream)</b>	out, targeting, prioritizing, M&E approaches FP3: Research on farmer adoption, seed systems innovation	emergency support	companion crops into wheat-based systems, capacity development	
<b>CGIAR-SRF Cross-cutting themes</b>	FP1-led: Gender strategic research incl. youth		FP1, 4: AFS-CRPs & CCAFS FP3: WHEAT & A4NH on improved nutrition Inter-CRP: How to improve gender mainstreaming into research	

Budget management is under the guidance of the ISC, directed by the WHEAT Director and discussed/recommended by the WHEAT-MC. It is principally based on the prioritization and approval of distinct work packages. New work packages are advertised on [www.wheat.org](http://www.wheat.org) and allocated through a competitive process. Further resource allocation depends on the achievement of milestones.

**Table 12. WHEAT Core Budget (US\$ M) for 2017-2019.**

<b>US\$'000</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>
CRP Mgmt	1,936	2,023	2,124
FP1	3,604	3,784	3,973
FP2	7,576	7,956	8,356
FP3	16,515	17,341	18,203
FP4	13,378	14,047	14,750
<b>Total</b>	<b>43,000</b>	<b>45,150</b>	<b>47,408</b>
<i>Funding Sources</i>			
W1&2	15,000	15,750	16,538
W3	10,831	11,372	11,941
Bilateral	17,169	18,028	18,929
<i>Other sources (in addition to Total)</i>			
Supplementary to CRP	13,70	14,40	15,10

The 3-year snapshot is based on the full 6 year budget provided to the Consortium via the submission tool. W1&2 figures shown include those for CRP Management and Governance. More detailed information about budgets per Flagship, as per Full Proposal Guidance requirements, are provided to reviewers by the Consortium Office.

WHEAT-MC allocates W1&2 to FPs, including for competitive and commissioned grants (e.g. WHEAT Partner Budget). WHEAT-MC is guided by Use of W1&2 as per Table 11. Any major variance in W1&2

total and per FP budgets is discussed and managed at WHEAT-MC level. WHEAT flexibility in reacting to annual budget variations downwards is driven by its ability to replace W1&2-funded activities with bilateral funding and adjust to changes in the per FP bilateral project portfolio. Upward variations would trigger R4D activities to be identified in the uplift budget, as prioritized by the WHEAT-Management Committee.

Dedicated (W1&2) Partner Budget: WHEAT-MC manages a partner budget, to assign competitive and commissioned grants to non-CGIAR R&D partners every year, to fill gaps in the CRP research-for-development portfolio. This budget is currently planned to be around \$1.4M (core) to 2.1M (uplift) p.a. During Phase 1, such partner grants added significant value to the WHEAT project portfolio and only one grant was not successful (e.g. project objectives not achieved).

WHEAT-MC has performed a 2015 W1&2 budget prioritization exercise based on the following criteria: A) Supports CGIAR cross-cutting (gender, youth, cap dev, climate change, other), B) matches recent ISPC or WHEAT-ISC guidance or feedback (to extension period proposal, pre-proposal, other) and C) is at core of CRP strategy (rated low, medium or high). This prioritization exercise will be repeated by WHEAT-MC on a needs basis (e.g. if W1&2 budget much lower than expected).

Major W1&2-funded capital investments are mainly likely in the context of the Global Precision Phenotyping Platforms Network, which is funded by WHEAT Partner Budget and NARS partner co-investments, on the basis of sub-grant agreements, which include annual or bi-annual budget plans.

Cross-cutting themes Intellectual Assets, Open Access and Impact Assessment are centrally managed by WHEAT-MC, by deploying the CRP Management and CRP Partner budgets (see above). Budgeting for cross-cutting themes: Gender research and mainstreaming is coordinated by FP1.3. Capacity development activities are coordinated or monitored by the cross-cutting CoA under the CRP Director. Improvement in project development and planning (e.g. project life cycle) will aid better monitoring of gender and capacity development-relevant activities. WHEAT applies the DAC marker approach adapted from UNPD, to account for both gender and capacity development-relevant activities in the different projects under the different FPs. CRP-level and per FP cross-cutting budgets shown in this Full Proposal were developed based on the DAC marker criteria below:

<i>Levels</i>		<i>Criteria/Examples</i>
4 - Projects with gender equality as the SOLE objective	100%	Sole use for (strategic) gender research. Budgets of gender specialists.
3 - ... a PRINCIPAL objective	75%	Majority are women beneficiaries and they are selected and will be likely the main partners/beneficiaries/users of the project results.
2 - ... a SIGNIFICANT objective	25%	Gender is mainstreamed in these projects and significant/substantive benefit by women is will be achieved and documented.
1 - ... with SOME CONTRIBUTION to gender equality	10%	Projects with evidence that they work on women prioritized constraints (eg processing, quality, HH food security) or generate products/outcomes that are particularly relevant for women (eg lower wheat prices). Effort to reach women needs to be made.
0 - Projects that do not expect to contribute significantly to gender equality	0%	Gender neutral research; Examples: Genebank, molecular breeding, bioinformatics.

For further information, see: [http://www.gender-budgets.org/index.php?option=com\\_joomdoc&task=document.download&path=resources/by-theme-issue/financing-for-gender-equality/tracking-gender-related-investments-in-undp&Itemid=823](http://www.gender-budgets.org/index.php?option=com_joomdoc&task=document.download&path=resources/by-theme-issue/financing-for-gender-equality/tracking-gender-related-investments-in-undp&Itemid=823), [http://www.wikigender.org/index.php/Gender\\_Equality\\_Marker\\_System](http://www.wikigender.org/index.php/Gender_Equality_Marker_System); <http://www.undp.org/content/dam/undp/library/corporate/fast-facts/english/FF-Gender-and-Institutional-Development2.pdf>

The WHEAT CRP Team (PMU) tracks W1&2 budget and expenditure in collaboration with CIMMYT and ICARDA program managers, per FP, once WHEAT-MC has endorsed and assigned the annual W1&2 budget. In the case of CIMMYT and ICARDA, FP Leaders are also Center Program Directors, which aligns CRP/FP financial and technical management with Centers' financial and technical management.

**Table 13. Overview of Uplift Budget-funded additional research scope, R4D outputs or outcomes.**

	<b>Discovery</b>	<b>Validation</b>	<b>Scaling out</b>
<b>FP1</b>	Further strengthen foresight and targeting work (including wheat crop and bio-economic modelling capacity and scope) and associated strategic partnerships.	Comprehensive farm-to-fork value chain analysis to support seed system innovation (FP3.7) and business models (FP4.3)	Increased scope of impact assessments (including more strategic country case impact studies and panel data).
<b>FP2</b>	Expand scope of heat & drought research (HeDWIC) Gene editing partnerships	Genetic approach to reduce N <sub>2</sub> O emissions and improve NUE (BNI); Optimal selection indices for wheat breeding (Genomic selection)	
<b>FP3</b>	Expand precision phenotyping platform network with national partners, yield testing	Global diseases and pests observatory covers more high likelihood & impact diseases, pests	
<b>FP4</b>		Comprehensive agronomic approach to lowering N <sub>2</sub> O emissions, improve NUE along N lifecycle (inter-FP, inter-CRP, partners) Inter-CRP: Systematize lessons learned across sustainable intensification projects	Improved outputs-to-development outcomes MEL Build in more ‘companion crops’ (inter-CRP)
<b>Gender</b>		Greater CGIAR and partner capacity for applied research <u>across FPs and projects</u>	Research on new opportunities for women in regions with deeply entrenched gender roles and social norms
<b>Youth</b>			Build competence, capacity and partner networks related to youth in agriculture R4D and WHEAT AFS
<b>Capacity Development</b>			Greater scope, more access to WHEAT Learning Platform
<b>Intellectual Assets and Open Access</b>		More policy development, improved approaches to PPP (see Annex 3.10)	More open access to more partner researchers (see Annex 3.9)
<b>CRP Management and Governance</b>		Improved (better aligned) outputs-to-outcomes MEL with more national partners	Improved outcomes-to-impact MEL (inter-CRP)

Further detail on additional investment needed is also shown in inter-CRP collaboration tables in Annex 3.7.

**Table 14. Uplift budget (6 years) per Flagship Project and additional 2022 outcome.**

FP	Discovery Validation Scale Out	associated subIDO	associated SLO target	Additional 2022 outcome	Total Uplift per FP	Total uplift \$ per outcome 6Yrs	of W1&2 in %	which W3 in %	Bilat in %
1	D	1.10 Farmers have greater awareness and access to, and increased adoption and adaptation of improved technologies	1.1, 1.2, 2.1, 3.4	Greater capacity and scope for foresight & targeting partnerships, including inter-CRP, improves CRP prioritisation and targeting, incorporating trade-off analysis across gender, climate change	16,349,531	4,087,383	45	15	40
1	V	1.9 Last mile provider (extension partners, farmer organization, community-based organizations, private sector) increased access and promotion of technologies to farmers	1.1, 1.2, 2.1	Greater capacity and scope of farm-to-fork value chain assessments contribute to more and better value chain innovation / transformation projects, incorporating gender, youth and nutrition dimensions		8,174,765	10	10	80
1	S	1.10 Farmers have greater awareness and access to, and increased adoption and adaptation of improved technologies	1.1, 1.2, 2.1	Improved baseline knowledge and greater capacity improves CRP/inter-CRP learning with partners about impact pathways, ToC		4,087,383	50	15	35
2	D	2.4 Crop researchers worldwide increase use of novel germplasm and tools ...; 2.5 Breeders have tools to develop improved varieties faster ...	2.1, 3.1	Earlier and greater knowledge and results-sharing of heat and drought research with breeders and researchers worldwide, leading to earlier genetic gain impacts on farmers' fields	28,071,382	14,035,691	40	20	40
2	V	2.5 Breeders develop improved varieties more efficiently ...	2.1, 3.2, 3.4	Expand capacity and scope on biological nitrification research to contribute to long-term N <sub>2</sub> O emission and N leakage reduction		7,017,845	25	10	65
2	V	2.5 Breeders develop improved varieties more efficiently through greater access and use of documented germplasm and tools	2.1, 3.1, 3.2	Expand research on genomic selection to contribute to faster CGIAR breeding cycle earlier		7,017,845	20	10	70

3	D	1.4.3 Enhanced genetic gain	1.2	Expand precision phenotyping platform network with national partners (to min. 15 countries) to contribute to faster and more precise breeding cycle for CGIAR and major national partners, leading to outcome of enhanced genetic gain	64,956,139	38,973,683	30	20	50
3	V	1.1.2 Reduced production risk & 1.4.1 Reduced pre- and post-harvest losses, including those caused by climate change	1.2, 2.1	Expand global diseases and pests observatory (monitored diseases; # of partners) to reduce production risk and pre-harvest losses		25,982,455	50	20	30
4	V	3.2.2 Agricultural systems diversified and intensified in ways that protect soils and water & 1.3.4 More efficient use of inputs	2.1, 3.1, 3.2	Greater collaboration with CCAFS, other CRPs and private sector on effective scaling out of combination of NUE-improving technologies	49,588,919	19,835,567	25	25	50
4	V	C.1.1. Increased capacity of beneficiaries to adopt research outputs	1.1	Increase capacity and scope of inter-CRP learning on systems research in priority target regions, with long-term outcome of beneficiaries' improved capacity to adapt and adopt combination of technologies		7,438,338	60	10	30
4	S	D.1.1. Enhanced institutional capacity of partner research organizations	1.1	Expand capacity to better partner with NARES and non-NARES partners on implementing comprehensive system of monitoring outcomes of sustainable intensification research outputs		7,438,338	50	40	10
4	S	1.4.2 Closed yield gaps through improved agronomic & animal husbandry practices	2.2, 3.4	Expand capacity and scope of large downstream sustainable intensification projects to include other crops (rotation, dual use), agroforestry and livestock components, to close yield gaps more comprehensively		14,876,676	10	10	80
GEND	V				tbd				
GEND	S				tbd				
YOU	S				CRP Partner Budget				
CAP	S				tbd				

IAIP	V				CRP Mgmt Budget				
IAIP	S				CRP Mgmt / Partner Budget				
MGMT	V				CRP Partner Budget				
MGMT	S				CRP Mgmt Budget				

## Annex 4.4 Follow-up of ISPC pre-proposal review and FC caveats

### Summary (10th November 2015) of WHEAT response/follow-up of Fund Council guidance and ISPC review of pre-proposal

#### Regarding FC Principles Portfolio and CRP levels

- i. WHEAT supports the establishment of a CRP “Genetic Gains” with clear focus on cross-commodity interventions. Crop specific pre-breeding activities characterization and utilization of genetic resources will stay within AFS CRPs closely linked to respective crop breeding program. **CIMMYT LEADS ON FULL PROPOSAL DEVELOPMENT**

#### ISPC review

- ii. Complete IPs/ToCs at CRP and FP level in terms of approach to monitoring progress on outcomes (RBM/M&E framework) and verifying assumptions. **DONE**
- iii. Complete the definition of impacts and identification of CRP IDO targets and indicators: Needs to be inter- (AFS)CRP effort; M&E specialists have taken the initiative; describe how WHEAT will monitor its contribution to SLO-level targets. (External Evaluation Recommendation). **IN PROGRESS**
- iv. Public private partnership opportunities to translate some of this cutting edge research into outcomes for the benefits of resource-poor farmers: Make clearer in Full Proposal, is already stated there. Take into consideration WHEAT-ISC comments on critical international public goods role of WHEAT. **DONE**
- v. Establish an inter-FP special traits team to accelerate delivery of multiple genes for multiple traits into multiple high performance lines, which WHEAT-ISC believes coincides with the Breeding Review recommendation to better integrate physiology with the mainstream breeding program. (External Evaluation Recommendation). **DONE**
- vi. Together with Dryland Systems, define where/what more research is needed on the dynamics, actors and interactions of sustainable innovation systems; provide more details on the components of the ongoing Dryland Systems CRP integrated into WHEAT. (External Evaluation Recommendation). **IN PROGRESS**
- vii. Substantially revise FP5: Coherent theory of change and impact pathway, focus on taking WHEAT outcomes to scale through a focus on seed systems, scaling sustainable intensification and associated capacity building; how to build, expand a W3/bilateral base with only limited W1/W2 support, via FP5-focused collaboration with GIZ and others. Integrate WHEAT gender and youth strategy into FP5, clearly articulating entry points and its relevance for scaling; develop overall WHEAT capacity development strategy, identify needs for different FPs, cognizant of limited W1/2 resources. **DONE SEE FP3.7, FP4.4**
- viii. How WHEAT is/will manage its partnership and major regional collaboration initiatives; further develop its partnership strategy: Follow up in Full Proposal. (External Evaluation Recommendation). **DONE SEE SECTION 1.8, ANNEX 3.2**
- ix. Perspectives on site integration opportunities: Elaborate on which ones WHEAT will concentrate, how, during Phase II, in coordination with other CRPs’ country coordination planning. **DONE SEE 1.7, 3.7**

WHEAT follow-up to ISPC pre-proposals review, ISPC on CRP portfolio

No	ISPC or SPPC review/proposal item	WHEAT-ISC & -MC Response	Action taken
	Portfolio-level issues		
FC1	<p>Position regarding: “Genetic Gains framing and the resulting consequences for the agri-food systems programs” (FC14).</p> <p>See CB-SPPC p.21-24: FP on modernizing genebanks, Diversity for Genetic Gain CRP: Harness economies of scale, avoid duplication, exploit inter-crop opportunities with regard to GWAS, GS, Genome editing for trait discovery (pre-breeding), crop modelling (cultivar design) &amp; informatics support to breeding (BMS, db, query tools, data analysis, genomic back-office; FP on Big Data/ICT</p> <p>See also Genetic Gains Platform proposal by CIMMYT/IRRI</p>	<p>Overall: Transformational research is high risk, not CGIAR system’s competitive advantage, which lies with ARIs, universities. Focus should be to leverage rather than duplicating in CRPs. CG should be clear on what % of its outlay it would like to deploy in these high risk transformational areas.</p> <p>WHEAT supports the establishment of a CRP “Genetic Gains” with clear focus on cross-commodity interventions, which are not already underway, represent efficiency gains from collaboration, and are likely to deliver cost-effective impact on breeding efficiency and progress.</p> <p>Crop specific pre-breeding activities characterization and utilization of genetic resources will stay within AFS CRPs closely linked to respective crop breeding program. Private sector is moving to teams that are integrated across the entire product development pathway, to ensure higher success rates. Breaking out pre-breeding would be disastrous.</p> <p>Genebank CRP should remain separate as it is not a research CRP but a stewardship obligation under the ITPGFA that needs appropriate support.</p> <p><b>See also 12 below</b></p>	<p>Genetic Gains Platform proposal developed, Lessons Learnt from GCP applied.</p> <p>Cross-commodity interventions from AFS CRPs (e.g BMS development) removed</p> <p><i>Note: Durum wheat global effort in merging all existing GWAS panels under the umbrella of WI-EWG (to date, over 2,000 entries from 12 countries).</i></p>
FC4	<p>See CB-SPPC p.24: Dryland systems rainfed mixed cropping systems CRP including FPs from WHEAT, DCL, MAIZE, FTA (dryland tree species)</p>	<p>Given the good performance of Systems Research under WHEAT &amp; MAIZE (SSA) during CRP Phase I, it is not advisable to detach it from WHEAT AGFS in Phase II. Detaching SI research would weaken the overall CRP and its coherent holistic approach in wheat based systems. The SI work under WHEAT led to significant scientific achievements in term of science and publications had impact at scale in South Asia and LAC. It has received good attention from the donors through W3/bilateral funding which did not prevent cross-center/cross CRP collaboration. Lateral learning needs to take place on systems research frameworks, methodology and approaches; this can be realized through low cost mechanisms outside of Systems CRPs which show limits to deliver and somehow having been lost in ‘complexity’.</p>	<p>Plan for integration of Dryland Systems’ specific Action Sites on sustainable intensification of wheat-based systems into WHEAT FP4 finalized; transition steps 2016 agreed; see section on FP4</p>
	Operationalization of SRF, inter-CRP collaboration		
4	<p>ISPC: “Overall, the ToC is consistent with SRF but further details are needed in the full proposal as was also noted by the IEA evaluation. WHEAT has responded that priorities are still in the process of being aligned with IDOs and SLOs which have been a moving target during 2012 to 2015... (was rated A). –</p> <p><u>IEA Ext Eval Recommend 1:</u> ... Validation of assumptions and progress along the impact pathway should be used by WHEAT management for learning and adjusting plans, and re-prioritizing projects when assumptions prove wrong or better options arise.</p>	<p>Complete IPs/ToCs at CRP and FP level in terms of approach to monitoring progress on outcomes (RBM/M&amp;E framework) and verifying assumptions</p>	<p>See Full Proposal Chapter on FPs, sections 2.3</p>

5	ISPC: complete the definition of impacts and identification of CRP IDO targets and indicators –	Requires inter-(AFS)CRP effort; M&E specialists will take initiative; describe how WHEAT will monitor its contribution to SLO-level targets...	See section 1.2; limited progress by MEL CoP so far
7	ISPC: Show more convincing integration across the Portfolio: Key connecting points to Global Integrating Programs, horizontal integration among AFS-CRPs (e.g. science of impact/scaling out; aspects of systems research), show how overlaps are complementary, not duplicative (relates chiefly to site integration / country coordination)	Build on June 2015 Montpellier definition/identification of connecting points. Requires inter-CRP planning effort	See Annex 3.7; Follow-up at future inter-AFS CRP and AFS-GIP meetings, with clear agendas June 2016?
	FP-specific		
10	ISPC on FP2: “Major lessons from previous research are noted. However, the <i>pre-proposal does not elaborate on what relevant research gaps are being addressed by FP2, based on the comparative advantage of the CGIAR.</i> ”	See To Do FC1 above Make clear impact pathway of germplasm and knowledge flow from genebank to farmers; various possible new tools to make it more efficient, where they might fit, what their chances of success – in parallel to ongoing, central role of existing successful core breeding activities.	Partner feedback from global partners meeting Dec 2014, IWC 2015 Sydney and online consultation reviewed; see revised FP2 section
11	ISPC on FP2-3: “The proposers state that “Private sector incentives to invest in wheat are dampened by the self-pollinating nature of wheat...”; however, multinationals and others in the private seed sector –particularly in the EU– invest in wheat [hybrid] breeding (and genetic engineering), and <i>WHEAT could take advantage of partnership opportunities to translate some of this cutting edge research into outcomes for the benefits of resource-poor farmers.</i> ” –	Make clearer in Full Proposal, is already stated there Take into consideration WHEAT-ISC comments on critical IPG role of WHEAT. As of today, European wheat companies do not do hybrids by and large. Key challenges: How to engage private sector in the self-pollinated varieties & how WHEAT should respond to future hybrids and GM.	Negotiations for a revised Hybrids PPP Consortium initiated
12	ISPC on FP2-3: As recommended by the IEA evaluation (2015), better coordination of pre-breeding efforts is needed among existing FP2 projects and with FP3 breeding programs to ensure complementarities, synergies and lateral learning; and establishing inter-FP special trait teams would further increase the chances of success for this approach. – <u>Note WHEAT-ISC:</u> Implement External Eval Recommendation 6, “to establish an inter-FP special traits team to accelerate delivery of multiple genes for multiple traits into multiple high performance lines”, which W-ISC believes coincides with the Breeding Review recommendation to better integrate physiology with the mainstream breeding program.	See To Do FC1 above (pre)breeding needs to address the urgent needs of farmers in the field for productivity increasing and climate change adaptation. Re FC1 above, the case for molecular-bred varieties in farmers’ fields remains a researchable issue with some promise (e.g. GS), whilst marker-assisted breeding has been successful. CGIAR runs best and largest global wheat breeding programme. The best way to deliver on IDOs is through excellence in breeding (e.g. improve on the scale and quality). Funding priority should be on year-to-year hard work (CGIAR/NARS) of producing new varieties for farmers.	See section on FP3
14	ISPC: FP3: Impact pathway appears feasible with <i>a minor concern about seed systems ...</i> noted that FP3 is linked to FP 5.1 on seed systems; <i>the link is important but breeding research and the seed systems research are separated into two different FPs. Other CRPs e.g. RAFS and RTB have included them in the same FPs</i> to keep the breeding pipeline and delivery integrated together	See To Do below (W-MC decision on Scaling out FP incl. for seed systems or not)	FP3.7 seed systems scaling moved from disbanded FP5 to FP3 (WHEAT-MC decision)
17	ISPC: FP4 “As argued by proposers, <i>more research is also needed on the dynamics, actors and</i>	Take up in Full Proposal development Greater farmer adoption impact remains	Dec 2015 workshop on WHEAT & MAIZE

	<i>interactions of locally embedded, sustainable innovation systems ... need to provide more clarity and details on the components of the ongoing Dryland Systems CRP that will be integrated into WHEAT and how and where this will be implemented (target areas)."</i>	key goal. Still massive scope to improve productivity and livelihoods in target areas through better varieties and agronomy (e.g. large parts of India are still under 20+ year old varieties).	with CRP-DS and HT; see revised FP4 section
21, 22	<p>ISCP: FP5 needs to be substantially revised, to articulate clearly its theory of change and impact pathway, building on the expertise and comparative advantage of the proposers and a specific partnership strategy that would take the CRP outcomes to scale"</p> <p>FP5: On paper team appears to be weak for task at hand, should be strengthened through key strategic partnerships. FP5 will benefit from collaboration with GIZ to facilitate WHEAT's scaling-out partnership building ... more clarity will be needed on the nature of this partnership and the way it will be implemented across target areas</p> <p>FP5 "Gender and youth are given priority for scaling-up by reinforcing the understanding of the adoption, adaptation and scaling- up processes. More details are needed in the proposal on how this will be achieved".</p> <p>"Adoption of CapDev Framework is mentioned under specific FPs, but there does not appear to be a WHEAT capacity development strategy."</p>	<p>FP5 will be substantially revised and strengthened with a coherent clear theory of change and impact pathway and focus on taking WHEAT outcomes to scale through a focus on seed systems, scaling sustainable intensification and associated capacity building. The FP5 will build and expand a W3/bilateral base with only limited W1/W2 support – incl. a clear and specific partnership strategy that will leverage additional support such as the proposed closer collaboration with GIZ and others. Given good inter FP3-5 coordination, seed systems scaling-out should remain part of FP5.</p> <p>The WHEAT gender and youth strategy (also see next item) will clearly articulate entry points and its relevance for scaling under FP5. FP5 will develop the overall WHEAT capacity development strategy and identify needs for different FPs building on the CapDev framework – again being cognizant of the limited W1/2 resources.</p>	On agenda WHEAT-MC meeting 3-4 Dec; decision to merge FP5 into FP3.7, FP4.4 and cross-cutting CoA on capacity development (all new). FP4.4 with BMZ-GIZ scaling out p'ship; cross-cutting CoA with BMZ-CIM support
	Cross-cutting		
24	ISPC: "Much more attention is needed by WHEAT to strengthen its gender strategy, and how it will address the problems facing youth in the wheat agri-food system and target regions ... Apart from mentioning that age will be taken into account in gender research and analysis, the coverage of youth is still poor.	Strengthening the WHEAT gender strategy and its implementation is high on the priority list – but suffered a severe setback due to the demise of Paula Kantor in 2015. Youth will receive more attention both as an integral part of the WHEAT gender strategy and as a key entry point for scaling (FP5) and the transformation of wheat AFS. The operationalization of the WHEAT gender and youth strategy will again be cognizant of the limited W1/2 resources.	See sections 1.4, 1.5, Annexes 3.4, 3.5. WHEAT asked YPARD to review its youth strategy.
25	ISPC: 'need to document how the CRP is managing its partnership and major regional collaboration initiatives (... should include an analysis of motivations, needs, capabilities and working relationships). As recommended by the IEA evaluation, WHEAT still needs to further develop its partnership strategy	Follow up in Full Proposal development and in contributions to site integration / country coordination planning with other CRPs.	WHEAT participated (and co-led for Nepal) in country coordination meetings – key challenge is resourcing such coordination! See Annex 3.7; Partnership strategy documented, see section 1.8, annex 3.2
	"WHEAT perspectives on site integration opportunities are described in a comprehensive matrix .. does not elaborate further on this ... not clear how many activities have already been agreed, and most of the investments seem to be from bilateral funds	Focus on important partnerships are with NARES, SMEs and farmer groups and others, if it makes real sense for efficient and sustainable impact.	

WHEAT Accountability Matrix – Fund Council Caveats to address

As set out in Annex 1 to the Final Guidance for the 2<sup>nd</sup> Call for Full Proposals, the collective portfolio submitted by the Centers/partners in response to this call for full proposals must be accompanied by a summary of how the 23 caveats raised in that annex by the respective stakeholders have been addressed. This annex sets out those caveats, grouped by the body putting forward the topic for added attention in the full proposals

**1.1 Caveats expressed by the Joint Consortium Board/Centers/Fund Council Working Group, in its Memorandum to the Fund Council to express support for a ‘green light’ to move to full proposal development, dated 30 November 2015**

Recognizing the advances already made in the re-submitted portfolio in the highly constrained time available, **the full proposals submitted by 31 March 2016 for ISPC review must address to the satisfaction of the ISPC, and contributors, the points set out below, to strengthen further the rationale and coherence of the planned research agenda.** Thereby delivering increased confidence that with funding from 2017 onwards, it has the capacity to deliver on SDGs in general and the Results Framework and CGIAR targets as set out in the SRF:

No	Item to address	Relevant CRP(s)	Summary of how the matters has been adequately addressed (Full Proposal sections are referenced)
1	Greater attention to discerning the role of regionally focused yield-gap closing/ sustainable intensification research in the system, as distinct from and a complement to global public goods research in areas such as crop breeding, livestock health, food policy, and others.	AFS programs; genetic gain platform)	<ul style="list-style-type: none"> <li>✓ Changes to FP4, namely new p’ship on scaling out with GIZ, incorporate Dryland Systems ‘systems research’ in 3 action sites. See section 1.1, 1.6 and section on FP4, annex 3.7 on relevant collaboration with other CRPs:</li> <li>✓ “The theory and practice of scaling out will receive more attention in FP4, in collaboration with other CRPs working in these systems. Significant impact is based on successfully dealing with a level of complexity that is greater than that associated with farmer adoption of improved cultivars. Even with new tools ... substantial resources will be needed.”</li> </ul>
2	More clearly articulating the strength of the arguments for maintaining genebanks and genetic gain as two separate platforms rather than an integrated effort <sup>7</sup>	Genebank; Genetic gain platforms	Not relevant for WHEAT. See Genetic Gains Platform proposal.

<sup>7</sup> There were a number of different views expressed during working group deliberations on this topic. Whilst there was no fundamental opposition to separate platforms, there was a call for making a much stronger case as to why they should be separate.

No	Item to address	Relevant CRP(s)	Summary of how the matters has been adequately addressed (Full Proposal sections are referenced)
3	Crosschecking that consolidation at the cluster of activities or flagship level has not delivered unintended adverse consequences such as removing clarity for key research priorities and/or increasing transaction costs	All	<ul style="list-style-type: none"> <li>✓ WHEAT-MC decided to integrate FP5 into FP3 and FP4. Advantages and disadvantages were considered. FP5 lacked critical mass of resources. Seed systems innovation / scaling-out is clearly linked to FP3, whilst complex scaling-out interventions build on other FP4 CoAs.</li> <li>✓ November 2015 (Rome workshop) approach to reducing total # of Flagships was rushed, thus faulty. Did not consider difference between organizing research activities and resources (e.g. FPs, CoAs) AND defining reasonably distinct domains (research areas), nor 'critical mass'.</li> </ul> <p>Major caveat: Bilateral funding dominates most FPs and CoAs, limiting the opportunity to better align an FP/CoA project portfolio and better link with other CRPs' projects. Unpredictable W1&amp;2 funding makes it worse.</p>
4	Providing a clearer understanding of National Partners' requirements, and how the scientific and financial program elements support them	All	<ul style="list-style-type: none"> <li>✓ Not a deficit for WHEAT (see IEA External Evaluation).</li> <li>✓ See Partnership strategy, section 1.8 and Annex 3.2; Capacity Development strategy, Annex 3.3</li> </ul>
5	Setting out more clearly the interconnection and resources available for the proposed Communities of Practice in gender/youth and capacity development, with particular attention to ensuring engagement of partners in the respective Communities of Practice. Specifically, ensuring that the proposed communities of practice operate in a way that will result in meaningful progress towards sustainable engagement and impact	All	<ul style="list-style-type: none"> <li>✓ See PIM FP6 (Cross-cutting Gender Research and Coordination)</li> </ul> <p>Major caveat: Communities of Practice rely on voluntary commitments by people who have a full-time job. Expectations about their 'impact' must be commensurate with this level of investment.</p>
6	Reducing as many transaction costs as possible, particularly regarding management burden	All	<ul style="list-style-type: none"> <li>✓ If at CGIAR Consortium-level progress has been made by summer 2016 (based on Rome November 2015 workshop discussions/initial ideas), WHEAT-Independent Steering Committee will consider this issue in their Sept 2016 or early 2017 meeting.</li> </ul>

No	Item to address	Relevant CRP(s)	Summary of how the matters has been adequately addressed (Full Proposal sections are referenced)
7	Providing greater emphasis on soils, animal genetic conservation and the potential impact of big data across the portfolio, not limited to genetic gain	WLE, all AFS, Livestock, Big Data platform	<ul style="list-style-type: none"> <li>✓ WHEAT identified key Big Data opportunities per Flagship in section 1.7; Soils has been in scope for FP4 since CRPs Phase I.</li> <li>✓ See Big Data Platform proposal (IFPRI/CIAT).</li> </ul> <p>PS: This seems like a mixed bag of priority issues that are not shared among all FC members.</p>

## 1.2 Caveats expressed by the ISPC, dated 9 December 2015

ISPC comments on the portfolio (a paraphrase of a longer document)

No	Item to address	Relevant CRP(s)	Centers' summary of how the matters has been adequately addressed
<b>Portfolio level</b>			
8	Seek explicit prioritization within CRPs (and also between CRPs); balancing research on 'upstream' science with research on how to scale out and up relevant new knowledge and technologies (while leaving the delivery of impact at scale to organizations with that remit)	All	<ul style="list-style-type: none"> <li>✓ WHEAT explains its up-/downstream research mix in section 1.3 and use of W1&amp;2 for upstream (e.g. discovery) in Annex 4.3</li> </ul>
9	Important to capture synergies between CRPs so that the System delivers more than the sum of the CRPs (the One System One Portfolio mantra)	All (statement of portfolio synthesis required)	<ul style="list-style-type: none"> <li>✓ WHEAT proposes a net increase in inter-CRP collaboration, much of which would depend on sufficient 'coordination' funding, see tables in annex 3.7. See sections 1.7 (in particular WHEAT approach to 'country coordination') and 1.8, annexes 3.2 and 3.7.</li> </ul> <p>Major concern: The CGIAR Consortium and its donors would be well advised to apply the principles of 'less is more' and 'within our circle of influence'. The current notion of 'site integration' (e.g. country coordination) is quite CGIAR Center-centric, whilst in fact, national actors will be the drivers and leaders of such coordination</p>

No	Item to address	Relevant CRP(s)	Centers' summary of how the matters has been adequately addressed
			efforts. Also, the costs of coordinating with many actors in a particular country are systematically underestimated.
10	Clearer explanations of what W1&2 funding will be used for	All	✓ See Annex 4.3, as well as section 1.3 and annex 3.7 (tables on inter-CRP collaboration indicating need for W1&2 and/or bilateral investments)
11	CRPs should not be expected to adhere to the 'prioritization' undertaken in a very short time-frame to produce the 'Refreshed' submission, but should hold serious discussion with their partners on which activities to prioritize according to the principles which were agreed at FC14	All	<ul style="list-style-type: none"> <li>✓ WHEAT has done so before: Global Partners Meeting, December 2014 and Partner Priorities Survey 2013-14.</li> <li>✓ Priorities were clearly stated in WHEAT Extension Period Proposal (2015-16), including for 'additional W1&amp;2' funding requested. W1&amp;2 funding in 2015-16 was lower than 2014. Thus, the same priorities will be included in the Full Proposal.</li> </ul>
<b>Platforms</b>			
12	2 new platforms are proposed: Genebanks and Genetic gains. The ISPC is comfortable with the platform on Genebanks	Not applicable	NA
13	Have concerns about the focus of the proposed Genetic Gains and what the creation of such a platform will mean for the AFS CRPs (and theories of change). The ISPC also found the title of 'Genetic gains' to be inappropriate as what is proposed is only part of the research required to deliver 'genetic gains'. The budget needs to be reviewed	Genetics Gain platform	NA
14	Supports the concept of an initiative in Big Data and does not want to see this de-emphasized	Big Data platform	Major Concern: WHEAT does see a CGIAR competitive advantage in contributing to a Big Data initiative for IAR4D/ARD, but not leading one.
15	Identify where budget is placed for other arrangements to meet cross cutting system work originally considered through Expressions of Interest at the pre-proposal stage	All c.f. Guidance doc	NA

No	Item to address	Relevant CRP(s)	Centers' summary of how the matters has been adequately addressed
<b>AFS CRPs</b>			
16	DCLAS: The rationale for DCLAS receiving a 'C' rating overall (from the ISPC) related to the breadth of species being considered; the funders are requested to indicate their priorities for this CRP	This addressed to funders not to CRPs	NA
17	FTA has moved tenure and rights to PIM – although PIM don't mention that. FTA also wants to move the restoration work to WLE. Given the decreased budgets overall, these 2 CRPs may not accept these moves and the topics may hence disappear. Clarity on the potential loss of these areas is required	FTA, PIM, WLE	NA
18	Livestock and FISH both wish to move some genetics research across to the new platform as may other CRPs, yet the budget sources for those moves are not clear	Livestock, Fish, Genetic Gain platform	NA
19	Maize propose to move some bilateral projects out of the CRP due to budget cuts. What is an appropriate balance of W1/2 bilateral at the base funding scenario?	MAIZE	NA
20	RAFS (and presumably other CRPs) proposes to reduce the number of targeted IDOs and sub-IDOs – and both RAFS and Wheat make reference to cutting back on capacity development due to budget cuts. Realistic adjustments to current funding and base scenario funding will need to be considered by CRPs and funders	RAFS, WHEAT.	<ul style="list-style-type: none"> <li>✓ Based on per FP theory of change workshops with scientists, WHEAT has reduced number of subIDOs targeted (and thus IDOs, SDGs), driven by need for credibility, the differentiation between multi-CRP (portfolio) versus per-CRP impacts and by need for realism about capacity to monitor progress towards impact.</li> <li>✓ WHEAT proposed core Phase II budget is equivalent to average annual budgets during Phase I. Proposed uplift budget is nearly identical to proposed budget in Extension Period Proposal.</li> </ul>

No	Item to address	Relevant CRP(s)	Centers' summary of how the matters has been adequately addressed
<b>Global Integrating Programs</b>			
21	The ISPC is glad that PIM has agreed to take on the role of co-ordination of a System-wide platform or Community of Practice for gender work, although we hope that it will be possible to reinstate the original budget. It is hoped that down-rating gender from a Flagship to 'Cross-cutting work' does not reflect diminishing importance of gender	PIM re role of the FP on gender	NA
22	A4NH and WLE seem to be following the ISPC recommendations (through additional steps for integration with CRPs through defined flagships, while the CCAFS Summary in Annex 2 suggests the budget cuts: 'need a totally new business model', the ISPC understands that only minor changes are now being proposed	A4NH, WLE, CCAFS, PIM	✓ WHEAT proposes increased collaboration with A4NH, CCAFS and WLE, depending on additional W1&2 and/or bilateral investments. See Annex 3.7

### 1.3 Additional caveats expressed by the Fund Council during its ad hoc meeting on 11 December 2015.

The Fund Council noted that its granting of a 'green light' to move to full proposal development was subject to the caveats noted by the Working Group and ISPC (in their written submission) and the Fund Council's request for enhanced focus on gender and capacity building. The Fund Council also specifically acknowledged that CGIAR is engaged in an incremental process and some concerns raised by Fund Council members will require additional time and attention before the new portfolio of CRPs is approved.

No	Item to address	Relevant CRP(s)	Summary of how the matters has been adequately addressed
23	Enhanced focus on gender and capacity building	All	WHEAT describes priority investments under gender in section 1.4 and annex 3.4 WHEAT describes priority investments under capacity development in section 1.10 and annex 3.3

## Annex 4.5. References (per section)

### Section 1.1: Rationale and Scope and 1.2

Abis, Sébastien 2015. Géopolitique du blé. Un produit vital pour la sécurité mondiale, IRIS Editions/Armand Colin, Juillet.

- Geographic distribution of producers/exporters and major consumer countries raises strategic issues for the next decades: Abis predicts increasing importance of international wheat trade. India will become net importer around 2030. He describes the enormous challenge of North African & Middle Eastern (MENA) food security with per capita wheat consumption is highest globally. Points to need to improve conditions for long-term investment in ag productivity to feed world's wheat-eating population by 2050. Note that wheat global trade is special case: 20-25% of global prod traded, compared to 10% rice, 5% fruits and vegetables.

Arnell, N.W., J. A. Lowe, S. Brown, S. N. Gosling, P. Gottschalk, J. Hinkel, B. Lloyd-Hughes, R. J. Nicholls, T. J. Osborn, T. M. Osborne, G. A. Rose, P. Smith and R. F. Warren. 2013. A global assessment of the effects of climate policy on the impacts of climate change. *Nature Climate Change*, 1793, 13 Jan 2013

Asseng S. et al. 2013. Uncertainty in simulating wheat yields under climate change. *Nature Climate Change*. DOI: 10.1038/NCLIMATE1916, 9 June.

Centre for Science and Policy (CSap), University of Cambridge: [Climate change—A Risk Assessment](#).

CGIAR-IEA (2015) Evaluation of CGIAR Research Program on Wheat. Rome, Italy: Independent Evaluation Arrangement (IEA) of CGIAR [iea.cgiar.org](http://iea.cgiar.org), p.43 (item 78-80).

Cook-Anderson, G., 2009. NASA satellites unlock secret to northern India's vanishing water. NASA Earth Science News Team 12.

D'Odorico et al, Feeding humanity through global food trade, *Earth's Future* 2, 458-469, doi:10.1002/2014EF000250. <http://onlinelibrary.wiley.com/doi/10.1002/2014EF000250/full>

Fischer R.A., Byerlee D. and Edmeades G.O. 2014. Crop yields and global food security: will yield increase continue to feed the world? ACIAR Monograph No. 158. Australian Centre for International Agricultural Research: Canberra. xxii + 634 pp.

FAO, 2011. [The State of Food and Agriculture, 2010-11](#). FAO. (see Foreword).

Foley et. al., 2011. Solutions for a cultivated planet, *Nature* 478, 337–342 (20 Oct 2011) <http://www.nature.com/nature/journal/v478/n7369/full/nature10452.html#ref-link-25>. Four food security and four environmental goals are identified in Figure 2.

King, D. et al 2015. [Climate change—A Risk Assessment](#). Centre for Science and Policy (CSap), University of Cambridge.

Lantican et al., in press. Impacts of International Wheat Improvement Research, 1994-2014. CIMMYT.

Lobell, David B. Wolfram Schlenker, Justin Costa-Roberts. 2011. Climate Trends and Global Crop Production Since 1980. *Science* 29 Vol. 333 no. 6042 pp. 616-620 . DOI: 10.1126/science.1204531.

Maynard, T., 2015: Food System Shock. Lloyds Emerging Risk Report: The insurance impacts of acute disruption to global food supply; [emergingrisks@lloyds.com](mailto:emergingrisks@lloyds.com) [https://www.lloyds.com/~media/files/news%20and%20insight/risk%20insight/2015/food%20system%20shock/food%20system%20shock\\_june%202015.pdf](https://www.lloyds.com/~media/files/news%20and%20insight/risk%20insight/2015/food%20system%20shock/food%20system%20shock_june%202015.pdf)

[NASA Satellites Unlock Secret to Northern India's Vanishing Water](#).

OECD-FAO Agricultural Outlook 2014. [Statistical Annex](#).

Pardey, P.G., Beddow, J.M., Kriticos, D.J., Hurley, T.M., Park, R.F., Duveiller, E., Sutherst, R.W., Burdon, J.J., Hodson, D., (2013). Right-Sizing Stem-Rust Research. *Science* 340, 147-148.

Patpour, M., Hovmoller, M., Shahin, A., Newcomb, M., Olivera Firpo, P.D., Jin, Y., Luster, D.G., Hodson, D., Nazari, K., Azab, M., in press(a). First Report of the Ug99 race group of Wheat Stem Rust, *Puccinia graminis* f. sp. tritici, in Egypt in 2014. *Plant Disease*.

Patpour, M., Hovmøller, M.S., Justesen, A.F., Newcomb, M., Olivera, P., Jin, Y., Szabo, L.J., Hodson, D., Shahin, A.A., Wanyera, R., Habarurema, I., Wobibi, S., in press (b). Emergence of Virulence to SrTmp in the Ug99 Race Group of Wheat Stem Rust, *Puccinia graminis* f. sp. tritici, in Africa. *Plant Disease*, PDIS-06-15-0668-PDN.

Ray DK, Mueller ND, West PC, Foley JA (2013) [Yield Trends Are Insufficient to Double Global Crop Production by 2050](#). *PLoS ONE* 8(6): e66428.

Rosegrant et al. 2010. Global food demand, supply, and price prospects to 2050. International Food Policy Research Institute.

Subbarao et al., 2016 Biological Nitrification Inhibition (BNI) in Plants - Implications for Improving Nitrogen-use Efficiency and Reducing Nitrous oxide Emissions from Agricultural Systems

Stevenson J. R., N. Villoria, D. Byerlee, T. Kelley, and M. Maredia. *PNAS* 2013 110(21)8363-68;doi:10.1073/pnas.1208065110 Green Revolution research saved an estimated 18 to 27 million hectares from being brought into agricultural production

Sumner, Andy, 2012. [Where Do the World's Poor Live? A New Update](#), Institute of Development Studies (IDS) Working Paper 393.

UK-US Taskforce 2015. Extreme weather and resilience of the global food system. Final Project Report from the UK-US Taskforce on Extreme Weather and Global Food System Resilience, The Global Food Security program, UK. <http://www.foodsecurity.ac.uk/assets/pdfs/extreme-weather-resilience-of-global-food-system.pdf>

Valin, Hugo et al. 2014. [The future of food demand: understanding differences in global economic models](#). *Agricultural Economics*, 45, 51-67.

Vermeulen, S., P. Aggarwal, B. Campbell, E. Davey, E. Grainger-Jone, and X. Yao. 2014. [Climate change, food security and small-scale producers](#); Analysis of findings of the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). Info Note, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Wageningen FSC, 2016. Multi-level Mapping and Exploration of Wheat production and consumption and their potential contribution to alleviation of poverty, malnutrition and gender inequality. Wageningen University Food Security Center study. WHEAT competitive grant. Final Report to be published by end 2016. For more information, see section on Flagship Project 1. WHEAT works with several universities and their socioeconomic modeling teams.

- Analyses of worldwide impacts of wheat production, consumption and nutrition scenarios with their global economic modelling tool (MAGNET), with a maximum of four scenarios.
- Note that the overview of countries with high production and consumption but low welfare indicators includes countries with missing data for specific indicators. Central Asian countries appear repeatedly, as well as Egypt, Pakistan, Syria and Morocco.
- “Gender inequality is a problem in a substantial share of countries in all production and consumption terciles.”.

World Bank 2014. World Development Report 2014

- “Over the last decade, apart from developing countries in Europe and Central Asia, low- and middle-income countries in general are increasing land under cereal production....Since most of the land available for current and future food requirements is already in production ....further expansion will likely involve fragile and marginal land ... .”

World Bank 2015. <http://data.worldbank.org/about/country-and-lending-groups>. The World Bank identifies 139 “developing” countries. The World Bank definition of two poverty lines of \$1.25 and @2 a day; see <http://data.worldbank.org/indicator/SI.POV.2DAY>

1.4%: We calculate: 1.0 for popln + 0.4 for per capita demand across half the world (2 x 0.4 x half).

## Section1.3

Warburton, M.L. et.al.. "Bringing wild relatives back into the family: recovering genetic diversity in CIMMYT improved germplasm." *Euphytica* 149: 289-301 (2006)

The 2015 review of the CIMMYT Breeding Program noted: "The breeders are also very aware of the need for fast cycle systems and use SSD and 'shuttle breeding' to great effect. The cycle time for varieties is just 5 years...." See FP3.

Van Wart, 2013: Agro-ecological framework developed for the Global Yield Gap Atlas ([www.yieldgap.org](http://www.yieldgap.org)), expanded to include key socioeconomic and nutrition data (Van Wart et al., 2013; van Bussel et al, 2015)

## WHEAT and Gender (section 1.4, annex 3.4)

Abdelali-Martini, M. 2011. Empowering Women in the Rural Labor Force with a Focus on Agricultural Employment in the Middle East and North Africa (MENA). *UNWOMEN. EGM/RW/2011/EP. 9. Sep 2011.*

Ali, A., Erenstein, O., Rahut, D.B., 2015. Impact of gender participation in non-farming activities on household income and poverty levels in Pakistan. *Work* 52, 345–51.

Ali, A.; Erenstein, O.; Rahut, D. 2014. Gender Contribution in Production of high value crops: empirical evidence from Pakistan. *The Journal of Animal & Plant Sciences*, 24(3)

Aryal, J.P., CR Farnworth, R Khurana, S Ray, TB Sapkota (2014). [Gender dimensions of climate change adaptation through climate smart agricultural practices in India](#). Presented at: Conference: Innovation in Indian Agriculture: Ways Forward, At India International Centre, New Delhi, India.

Aryal, J.P.; Mehrotra, M.B.; Jat, M.L.; Sidhu, H.S. 2015. Impacts of Laser Land Leveling in Rice–Wheat Systems of the North–Western Indo-Gangetic Plains of India. *Food Security*. Netherlands. Springer. DOI: 10.1007/s12571-015-0460-y

Ashrafi, H. 2009. Gender dimension of agriculture and rural employment: Special focus on Afghan rural women's access to agriculture and rural development sector. FAO, IFAD, ILO.

Behera, B.; Rahut, D.; Aryal.; Ali, A. 2015. Household collection and use of biomass energy sources in South Asia. *Energy* 8, 468e480

[Beuchelt, T.D.; Badstue, L.B. 2013. Gender, nutrition- and climate-smart food production: Opportunities and trade-offs. \*Food Security\* 5 \(5\): 709-721. DOI: 10.1007/s12571-013-0290-8](#)

Echavez, Chona R. 2012. Gender and Economic Choice: What's old and what's new for women in Afghanistan. AREU.

Eerdewijk van, A., &Danielsen, K. (2015) Gender Matters in Farm Power. Research Report, CRP MAIZE – KIT.

Farnworth, C.R. 2010. Gender-aware approaches in agricultural programmes: a study of Sida-supported agricultural programmes. *Sida Evaluation 2010: 3*

Farnworth, C.R. and Colverson, K.E. 2015. Building a Gender-Transformative Extension and Advisory Facilitation System in Sub-Saharan Africa. *Journal of Gender, Agriculture and Food Security*. Vol 1 (1), 31-50, 2015. <http://www.agrigender.net/views/Building-gender-transformative-extension-JGAFS-112015-2.php>

Galiè A. 2013: 'Empowering women farmers: the case of participatory plant breeding in ten Syrian households'. *Frontiers: a Journal of Women's Studies*, 34, 1, 58-92.

Galiè A. 2014: 'Syrian women farmers: seeking gender balance in participatory plant breeding' in S. Brisolara, D. Seigart, S. Sengupta (eds.), *Feminist evaluation and research: theory and practice*, Guilford, New York: 284-310.

Galiè A., J. Jiggins and P. Struik. 2012: 'Women's identity as farmers: a case study from ten households in Syria'. *NJAS: Wageningen Journal of Life Sciences*, 64-65, 25-33. DOI: 10.1016/j.njas.2012.10.001

Jafry, T. (2013) Scoping Study on the Integration of Gender and Social Equity in R4D on Wheat-Based Systems in South Asia. CIMMYT.

Kabeer, N. 2011. Between affiliation and autonomy: navigating pathways of women's empowerment and gender justice in rural Bangladesh. *Development and Change*, 42(2), 499-528.

Klawitter, M.; Henson Cagley, J.; Yorgey, G.; Gugerty, M.K. and Anderson, L. (2009) Gender Cropping Series: Wheat in Sub-Saharan Africa, Evans School Policy Analysis and Research, University of Washington.

Mehar, M., Mittal, S., & Prasad, N. 2016. Farmers coping strategies for climate shock: Is it differentiated by gender? *Journal of Rural Studies*, 44, 123-131.

## **Section 1.7 (country coordination)**

“CGIAR-SRF: “The CRPs will coordinate with each other to ensure that, in key geographies, their activities are aligned for maximum impact. The CRPs’ collective, coordinated commitments in these geographies will be summarized in site integration plans to enable transparent interaction with local stakeholders. The consultation process will be pursued through the GCARD.”

Definition of country coordination (site integration) in the CGIAR-SRF: “The CRPs will coordinate with each other to ensure that, in key geographies, their activities are aligned for maximum impact. The CRPs’ collective, coordinated commitments in these geographies will be summarized in site integration plans to enable transparent interaction with local stakeholders. The consultation process will be pursued through the GCARD.”

Partner Survey for the CGIAR Research Program WHEAT: National and International Priorities and Engagement. 2014. Audley, M.; Kommerell, V.; Jakobi, N.; Velasco, C.; Crossa, J.. : iii, 24 p. Mexico, DF (Mexico). CGIAR.

## **Section 1.9**

Partner Priorities Survey: Partner Survey for the CGIAR Research Program WHEAT: National and International Priorities and Engagement. 2014. Audley, M.; Kommerell, V.; Jakobi, N.; Velasco, C.; Crossa, J.. : iii, 24 p. Mexico, DF (Mexico). CGIAR.

In developing countries there are at most 5 competitive private wheat breeding programs that meet international standards in terms of use of marker technology, scale of operation etc. By far the most important provider of wheat cultivars continues to be the public sector and CIMMYT/ICARDA. This will only change if hybrid wheat becomes a reality or policies are developed that allow collection of royalties.

Yadvinder-Singh, Surinder S. Kukal, , Mangi Lal Jat†, Harminder S. Sidhu, 2014, *Advances in Agronomy* 127, Chapter Four – Improving Water Productivity of Wheat-Based Cropping Systems in South Asia for Sustained Productivity; <http://www.sciencedirect.com/science/article/pii/B9780128001318000042#>

## Section on FP1 References

- Alexandratos, N., & Bruinsma, J. (2012). World agriculture towards 2030/2050: the 2012 revision ESA Working paper 12-03. Rome: FAO.
- Ali, A., Rahut, D. B., Behera, B., & Imtiaz, M. (2015). Farmers' Access to Certified Wheat Seed and its Effect on Poverty Reduction in Pakistan. *Journal of Crop Improvement*, 29(2), 247-265.
- Ali, A., Bahadur Rahut, D., Behera, B., 2016. Factors influencing farmers' adoption of energy-based water pumps and impacts on crop productivity and household income in Pakistan. *Renewable and Sustainable Energy Reviews* 54, 48-57.
- Aravindakshan, S., Rossi, F. J., & Krupnik, T. J. (2015). What does benchmarking of wheat farmers practicing conservation tillage in the eastern Indo-Gangetic Plains tell us about energy use efficiency? An application of slack-based data envelopment analysis. *Energy*, 90, Part 1, 483-493.
- Aryal, J. P., Mehrotra, M. B., Jat, M. L., & Sidhu, H. S. (2015a). Impacts of laser land leveling in rice-wheat systems of the north-western Indo-Gangetic Plains of India. *Food Security*, 7(3), 725-738.
- Aryal, J. P., Sapkota, T. B., Jat, M. L., & Bishnoi, D. K. (2015b). On-farm economic and environmental impact of zero-tillage wheat: a case of north-west India. *Experimental Agriculture*, 51(01), 1-16.
- IBRD (2007). World Development Report 2008: Agriculture for development. Washington DC: IBRD.
- Beuchelt, T.D., Badstue, L., 2013. Gender, nutrition- and climate-smart food production: Opportunities and trade-offs. *Food Security* 5, 709-721.
- Christiaensen, L., Demery, L., Kuhl, J. (2011). The (evolving) role of agriculture in poverty reduction--An empirical perspective. *Journal of Development Economics* 96, 239-254.
- Elsevier (2014). CGIAR Research Output and Collaboration Study. Amsterdam: Elsevier.
- El-Shater, T., Yigezu, Y.A., Mugeru, A., Piggan, C., Haddad, A., Khalil, Y., Loss, S., Aw-Hassan, A., 2016. Does Zero Tillage Improve the Livelihoods of Smallholder Cropping Farmers? *Journal of Agricultural Economics* 67, 154-172.
- Eerdewijk van, A., & Danielsen, K. (2015) Gender Matters in Farm Power. Research Report, CRP MAIZE – KIT.
- Erenstein, O. (2012). Resource scarcity gradients and agricultural technologies: Scoping implications in the Post-Green Revolution Indo-Gangetic Plains. *Outlook on Agriculture*, 41(2), 87-95.
- Erenstein, O., Sayre, K., Wall, P., Hellin, J., & Dixon, J. (2012). Conservation Agriculture in Maize- and Wheat-Based Systems in the (Sub)tropics: Lessons from Adaptation Initiatives in South Asia, Mexico, and Southern Africa. *Journal of Sustainable Agriculture*, 36(2), 180-206.
- Ghimire, S., Mehar, M., & Mittal, S. (2012). Influence of Sources of Seed on Varietal Adoption Behavior of Wheat Farmers in Indo-Gangetic Plains of India. *Agricultural Economics Research Review*, 25, 399-408.
- Hyman, G., Hodson, D., & Jones, P. (2013). Spatial analysis to support geographic targeting of genotypes to environments. *Frontiers in Physiology*, 4(Art 40), 1-13.
- Keil, A., D'souza, A., & McDonald, A. (2015). Zero-tillage as a pathway for sustainable wheat intensification in the Eastern Indo-Gangetic Plains: does it work in farmers' fields? *Food Security*, 7(5), 983-1001.
- Krishna, V. & Veetil, P. (2014). Productivity and efficiency impacts of conservation tillage in northwest Indo-Gangetic Plains. *Agricultural Systems*, 127, 126-138.
- Krishna, V. V., Spielman, D. J., & Veetil, P. C. (2016). Exploring the supply and demand factors of varietal turnover in Indian wheat. *The Journal of Agricultural Science*, 154(02), 258 - 272.
- Krupnik, T. J., Ahmed, Z. U., Timsina, J., Shahjahan, M., Kurishi, A. S. M. A., Miah, A. A., Rahman, B.M.S., Gathala, M.K., McDonald, A. J. (2015a). Forgoing the fallow in Bangladesh's stress-prone coastal deltaic environments: Effect of sowing date, nitrogen, and genotype on wheat yield in farmers' fields. *Field Crops Research*, 170, 7-20.

- Krupnik, T. J., Ahmed, Z. U., Timsina, J., Yasmin, S., Hossain, F., Al Mamun, A., Mridha, A.I., McDonald, A. J. (2015b). Untangling crop management and environmental influences on wheat yield variability in Bangladesh: An application of non-parametric approaches. *Agricultural Systems*, 139, 166-179.
- Lantican, M.A., Dubin, H.J., Morris, M.L., (2005). Impacts of International Wheat Breeding Research in the Developing World, 1988-2002. CIMMYT, Mexico, D.F.
- Lantican, M.A., H.J. Braun, T.S. Payne, R.P. Singh, K. Sonder, M. Baum, M. van Ginkel, and O. Erenstein. 2016. *Impacts of International Wheat Improvement Research, 1994-2014*. Mexico, D.F.: CIMMYT.
- Mason, N. M., Jayne, T. S., & Shiferaw, B. (2015). Africa's Rising Demand for Wheat: Trends, Drivers, and Policy Implications. *Development Policy Review*, 33(5), 581-613.
- Mazid, A., Keser, M., Amegbeto, K.N., Morgounov, A., Bagci, A., Peker, K., Akin, M., Kucukcongar, M., Kan, M., Semerci, A., Karabak, S., Altikat, A., Yaktubay, S., (2015). Measuring The Impact Of Agricultural Research: The Case Of New Wheat Varieties In Turkey. *Experimental Agriculture* 51, 161-178.
- Mehar, M., Mittal, S., & Prasad, N. (2016). Farmers coping strategies for climate shock: Is it differentiated by gender? *Journal of Rural Studies*, 44, 123-131.
- Mittal, S., & Mehar, M. (in press). Socio-economic Factors Affecting Adoption of Modern Information and Communication Technology by Farmers in India: Analysis Using Multivariate Probit Model. *The Journal of Agricultural Education and Extension*, 1-14.
- Mittal, S., & Mehar, M. (2012). How mobile phones contribute to growth of small farmers? Evidence from India. *Quarterly Journal of International Agriculture*, 51(3), 227-244.
- Morgounov, A., Haun, S., Lang, L., Martynov, S., & Sonder, K. (2013). Climate change at winter wheat breeding sites in central Asia, eastern Europe, and USA, and implications for breeding. *Euphytica*, 194(2), 277-292.
- Neufeldt, H., Jahn, M., Campbell, B., Beddington, J., DeClerck, F., De Pinto, A., Gulledge, J., Hellin, J., Herrero, M., Jarvis, A., LeZaks, D., Meinke, H., Rosenstock, T., Scholes, M., Scholes, R., Vermeulen, S., Wollenberg, E., Zougmore, R., 2013. Beyond climate-smart agriculture: toward safe operating spaces for global food systems. *Agriculture & Food Security* 2, 12.
- Pardey, P.G., Beddow, J.M., Kriticos, D.J., Hurley, T.M., Park, R.F., Duveiller, E., Sutherst, R.W., Burdon, J.J., Hodson, D., (2013). Right-Sizing Stem-Rust Research. *Science* 340, 147-148.
- Qureshi, A., Ahmad, Z., & Krupnik, T. (2015). Moving from Resource Development to Resource Management: Problems, Prospects and Policy Recommendations for Sustainable Groundwater Management in Bangladesh. *Water Resources Management*, 29(12), 4269-4283.
- Rahut, D.B., Ali, A., Imtiaz, M., Mottaleb, K.A., Erenstein, O., in press. Impact of irrigation water scarcity on rural household food security and income in Pakistan. *Water Science and Technology: Water Supply*.
- Sapkota, T. B., Jat, M. L., Aryal, J. P., Jat, R. K., & Khatri-Chhetri, A. (2015). Climate change adaptation, greenhouse gas mitigation and economic profitability of conservation agriculture: Some examples from cereal systems of Indo-Gangetic Plains. *Journal of Integrative Agriculture*, 14(8), 1524-1533.
- Schulthess, U., Krupnik, T. J., Ahmed, Z. U., & McDonald, A. J. (2015). Technology targeting for sustainable intensification of crop production in the Delta region of Bangladesh. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XL-7/W3, 1475-1481.
- Shiferaw, B., Smale, M., Braun, H.J., Duveiller, E., Reynolds, M., Muricho, G., (2013). Crops that feed the world 10. Past successes and future challenges to the role played by wheat in global food security. *Food Security* 5, 291-317.
- Shiferaw, B., Kassie, M., Jaleta, M., and Yirga, C., (2014). Adoption of improved wheat varieties and impacts on household food security in Ethiopia. *Food Policy* 44:272-284.

Singh, R., Erenstein, O., Saharawat, Y.S., Chaudhary, N., & Jat, M. L. (2012). Adoption analysis of resource-conserving technologies in rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system of South Asia. *The Indian Journal of Agricultural Sciences*, 82(5), 405-409.

Stirling, C., Hellin, J., Cairns, J., Silverblatt-Buser, E., Tefera, T., Ngugi, H., Gbegbelegbe, S., Tesfaye, K., Chung, U., Sonder, K., Cox, R.A., Verhulst, N., Govaerts, B., Alderman, P., Reynolds, M. (2014). Shaping sustainable intensive production systems: improved crops and cropping systems in the developing world CABI Climate Change Series No.5 (pp. 186-203). Wallingford: CABI.

Teshome, A., de Graaff, J., Kassie, M., in press. Household-Level Determinants of Soil and Water Conservation Adoption Phases: Evidence from North-Western Ethiopian Highlands. *Environmental Management* 57, 620-636.

Teshome, A., de Graaff, J., Ritsema, C., Kassie, M., in press. Farmers' Perceptions About The Influence Of Land Quality, Land Fragmentation And Tenure Systems On Sustainable Land Management In The North Western Ethiopian Highlands. *Land Degradation & Development*.

Valbuena, D., Erenstein, O., Homann-Kee Tui, S., Abdoulaye, T., Claessens, L., Duncan, A. J., Gerard, B., Rufino, M.C., Teufel, N., van Rooyen, A., van Wijk, M. T. (2012). Conservation Agriculture in mixed crop-livestock systems: Scoping crop residue trade-offs in Sub-Saharan Africa and South Asia. *Field Crops Research*, 132, 175-184.

Valbuena, D., Tui, S.H.-K., Erenstein, O., Teufel, N., Duncan, A., Abdoulaye, T., Swain, B., Mekonnen, K., Germaine, I., Gérard, B., (2015). Identifying determinants, pressures and trade-offs of crop residue use in mixed smallholder farms in Sub-Saharan Africa and South Asia. *Agricultural Systems* 134, 107-118.

Yigezu, Y.A., Mugeru, A., El-Shater, T., Piggan, C., Haddad, A., Khalil, Y., Loss, S., 2015. Explaining Adoption and Measuring Impacts of Conservation Agriculture on Productive Efficiency, Income, Poverty, and Food Security in Syria. In: Farooq, M., Siddique, K.H.M. (Eds.), *Conservation Agriculture*. Springer International Publishing, pp. 225-247.

Yigezu, Y.A., Ahmed, M.A., Shideed, K., Aw-Hassan, A., El-Shater, T., Al-Atwan, S., 2013. Implications of a shift in irrigation technology on resource use efficiency: A Syrian case. *Agricultural Systems* 118, 14-22.

## FP2 References

### FP2.3

Araus JL, Cairns JE: Field high-throughput phenotyping: the new crop breeding frontier. *Trends Plant Sci.* 2014, 19:52–61.

Asseng S, et al., 2015. Rising Temperatures Reduce Global Wheat Production. *Journal name: Nature Climate Change* 5 143–147

Braun H, Atlin G, Payne T: Multi-location testing as a tool to identify plant response to global climate change. In *Climate change and crop production*. . Wallingford, UK: CABI Publishers; 2010:115–138.

Challinor AJ, Watson J, Lobell DB, Howden SM, Smith DR, Chhetri N: A meta-analysis of crop yield under climate change and adaptation. *Nat. Clim. Chang.* 2014, 27:1–5

Chapman S, Merz T, Chan A, Jackway P, Hrabar S, Dreccer M, Holland E, Zheng B, Ling T, Jimenez-Berni J: Pheno-Copter: A Low-Altitude, Autonomous Remote-Sensing Robotic Helicopter for High-Throughput Field-Based Phenotyping [Internet]. *Agronomy* 2014, 4:279–301.

Cossani CM and Reynolds, MP. 2012. Physiological traits for improving heat tolerance in wheat. *Plant Physiology* 160 1710-1718

Griffiths S, Wingen L, Pietragalla J, Garcia G, Hasan A, Miralles D, Calderini DF, Ankleshwaria JB, Waite ML, Simmonds J, et al.: Genetic Dissection of Grain Size and Grain Number Trade-Offs in CIMMYT Wheat Germplasm. *PLoS One* 2015, 10:e0118847.

Lopes MS, Dreisigacker S, Peña RJ, Sukumaran S, Reynolds MP. Genetic characterization of the Wheat Association Mapping Initiative (WAMI) panel for dissection of complex traits in spring wheat. *TAG: Theoretical and Applied Genetics* 128: 453-464

Pinto RS, Reynolds MP, Mathews KL, McIntyre CL, Olivares-Villegas JJ, Chapman SC. 2010. Heat and drought adaptive QTL in a wheat population designed to minimize confounding agronomic effects. *Theoretical & Applied Genetics* 121:1001–1021

Pinto RS, Reynolds MP: Common genetic basis for canopy temperature depression under heat and drought stress associated with optimized root distribution in bread wheat. *Theor. Appl. Genet.* 2015, 128:575–585.

Prins A, Douglas J, Orr P, Andralojc PJ, Reynolds MP, Carmo-Silva E, Parry MAJ: Rubisco catalytic properties of wild and domesticated relatives provide scope for improving wheat photosynthesis. *J. Exp. Bot.* 2016, doi: 10.1093/jxb/erv574

Reynolds MP, Foulkes J, Furbank R, Griffiths S, King J, Murchie E, Parry M, Slafer G, 2012. Achieving yield gains in wheat. *PCE* 35: 1799–1823

Reynolds et al., An Integrated Approach to Maintaining Cereal Productivity under Climate Change. *Glob. Food Sec.* In press (2016).

Reynolds MP, Tattaris M, Cossani CM, Ellis M, Yamaguchi-Shinozaki K, Saint Pierre C: Exploring genetic resources to increase adaptation of wheat to climate change. In *Advances in Wheat Genetics: From Genome to Field*. Edited by Ogiwara Y, Takumi S, Handa H. Springer Japan; 2015

Rutkoski J, Poland J, Mondal S, Autrique E, González Pérez L, Crossa J, Reynolds MP, Singh RP: Predictor traits from high-throughput phenotyping improve accuracy of pedigree and genomic selection for yield in wheat. *Genet.* 2016

## FP3 References

### FP3.3

Pardey, P.G. et al. 2013. Right-Sizing Stem-Rust Research, *Science* 12. Vol 340, issue 6129, p 147-148; AND: Beddow et al. Research investment implications of shifts in the global geography of wheat stripe rust. *Nature Plants*, 2015; 1513 DOI:[10.1038/nplants.2015.132](https://doi.org/10.1038/nplants.2015.132)

## FP4 References

Andersson, J.A., D'Souza, S., 2014. From adoption claims to understanding farmers and contexts: A literature review of Conservation Agriculture (CA) adoption among smallholder farmers in southern Africa. *Agric. Ecosyst. Environ.* 187, 116 – 132.

Baudron, F., Delmotte, S., Corbeels, M., Herrera, J.M., Tittonell, P., 2015a. Multi-scale trade-off analysis of cereal residue use for livestock feeding vs. soil mulching in the Mid-Zambezi Valley, Zimbabwe. *Agric. Syst.* 134, 97–106.

Beuchelt, T.D., Camacho Villa, C.T., Göhring, L., Hernández Rodríguez, V.M., Hellin, J., Sonder, K., Erenstein, O., 2015. Social and income trade-offs of conservation agriculture practices on crop residue use in Mexico's central highlands. *Agric. Syst.* 134, 61–75. doi:10.1016/j.agsy.2014.09.003

Beuchelt, T.D., Zeller, M., 2013. The role of cooperative business models for the success of smallholder coffee certification in Nicaragua: A comparison of conventional, organic and Organic-Fairtrade certified cooperatives. *Renew. Agric. Food Syst.* 28, 195 – 211.\

Boulangier, P.-M., Bréchet, T., 2005. Models for policy-making in sustainable development: The state of the art and perspectives for research. *Ecol. Econ.* 55, 337–350.

Dendooven, L., Patiño-Zúñiga, L., Verhulst, N., Boden, K., García-Gaytán, A., Luna-Guido, M., Govaerts, B., 2014. Greenhouse Gas Emissions from Nontilled, Permanent Raised, and Conventionally Tilled Beds in the Central Highlands of Mexico. *J. Crop Improv.* 28, 547–574.

- Farnworth, C.R., Baudron, F., Andersson, J.A., Misiko, M., Badstue, L., Stirling, C.M., 2015. Gender and conservation agriculture in East and Southern Africa: towards a research agenda. *Int. J. Agric. Sustain.* 1–24. doi:10.1080/14735903.2015.1065602
- Giller, K.E., Titttonell, P., Rufino, M.C., van Wijk, M.T., Zingore, S., Mapfumo, P., Adjei-Nsiah, S., Herrero, M., Chikowo, R., Corbeels, M., Rowe, E.C., Baijukya, F., Mwijage, A., Smith, J., Yeboah, E., van der Burg, W.J., Sanogo, O.M., Misiko, M., de Ridder, N., Karanja, S., Kaizzi, C., K'ungu, J., Mwale, M., Nwaga, D., Pacini, C., Vanlauwe, B., 2011. Communicating complexity: Integrated assessment of trade-offs concerning soil fertility management within African farming systems to support innovation and development. *Agric. Syst.* 104, 191–203.
- Giller, K.E., Andersson, J.A., Corbeels, M., Kirkegaard, J., Mortensen, D., Erenstein, O., Vanlauwe, B., 2015. Beyond conservation agriculture. *Front. Plant Sci.* 6.
- Giller, K.E., Andersson, J.A., Corbeels, M., Kirkegaard, J., Mortensen, D., Erenstein, O., Vanlauwe, B., 2015. Beyond conservation agriculture. *Front. Plant Sci.* 6.
- Herrera, J.M., Verhulst, N., Trethowan, R.M., Stamp, P., Govaerts, B., 2013. Insights into Genotype × Tillage Interaction Effects on the Grain Yield of Wheat and Maize. *Crop Sci.* 53, 1845. doi:10.2135/cropsci2013.01.0071
- Justice, S., Biggs, S., 2013. Diverse Patterns of Rural and Agricultural Mechanisation in Bangladesh and Nepal: Status and Emerging Themes. *Mech. Rural Dev. A Rev. patterns Prog. from around world.* Rome Food Agric. Organ. United Nations.
- Kebede, B., 2009. Community wealth ranking and household surveys: an integrative approach. *J. Dev. Stud.* 45, 1731–1746.
- Kelly, R.A., Jakeman, A.J., Barreteau, O., Borsuk, M.E., ElSawah, S., Hamilton, S.H., Henriksen, H.J., Kuikka, S., Maier, H.R., Rizzoli, A.E., 2013. Selecting among five common modelling approaches for integrated environmental assessment and management. *Environ. Model. Softw.* 47, 159–181.
- Koehler, A.-K., Challinor, A.J., Hawkins, E., Asseng, S., 2013. Influences of increasing temperature on Indian wheat: quantifying limits to predictability. *Environ. Res. Lett.* 8, 34016.
- Krupnik, T.J., Ahmed, Z.U., Timsina, J., Shahjahan, M., Kurishi, A.S.M.A., Miah, A.A., Rahman, B.M.S., Gathala, M.K., McDonald, A.J., 2015a. Forgoing the fallow in Bangladesh's stress-prone coastal deltaic environments: Effect of sowing date, nitrogen, and genotype on wheat yield in farmers' fields. *F. Crop. Res.* 170, 7–20.
- Krupnik, T.J., Ahmed, Z.U., Timsina, J., Yasmin, S., Hossain, F., Al Mamun, A., Mridha, A.I., McDonald, A.J., 2015b. Untangling crop management and environmental influences on wheat yield variability in Bangladesh: An application of non-parametric approaches. *Agric. Syst.* 139, 166–179.
- Loos, J., Abson, D.J., Chappell, M.J., Hanspach, J., Mikulcak, F., Tichit, M., Fischer, J., 2014. Putting meaning back into “sustainable intensification.” *Front. Ecol. Environ.* 12, 356–361.
- Mottaleb, K.A., Krupnik, T.J., 2015. Uptake of scale-appropriate agricultural machinery in Bangladesh: policy insights from historical and census survey analyses.
- Mottaleb, K.A., Mohanty, S., 2014. Farm size and profitability of rice farming under rising input costs. *J. Land Use Sci.* 1–13.
- Powlson, D.S., Stirling, C.M., Thierfelder, C., White, R.P., Jat, M.L., 2016. Does conservation agriculture deliver climate change mitigation through soil carbon sequestration in tropical agro-ecosystems? *Agric. Ecosyst. Environ.* 220, 164–174.
- Pretty, J., Bharucha, Z.P., 2014. Sustainable intensification in agricultural systems. *Ann. Bot.* 114, 1571–1596.
- Pretty, J., Toulmin, C., Williams, S., 2011. Sustainable intensification in African agriculture. *Int. J. Agric. Sustain.* 9, 5–24.
- Sapkota, T.B., Jat, M.L., Aryal, J.P., Jat, R.K., Khatri-Chhetri, A., 2015. Climate change adaptation, greenhouse gas mitigation and economic profitability of conservation agriculture: Some examples from cereal systems of Indo-Gangetic Plains. *J. Integr. Agric.* 14, 1524–1533. doi:10.1016/S2095-3119(15)61093-0

- Sapkota, T.B., Jat, M.L., Shankar, V., Singh, L.K., Rai, M., Grewal, M.S., Stirling, C.M., 2015. Tillage, residue and nitrogen management effects on methane and nitrous oxide emission from rice–wheat system of Indian Northwest Indo-Gangetic Plains. *J. Integr. Environ. Sci.* 1–16. doi:10.1080/1943815X.2015.1110181
- Sapkota, T.B., Majumdar, K., Jat, M.L., Kumar, A., Bishnoi, D.K., McDonald, A.J., Pampolino, M., 2014. Precision nutrient management in conservation agriculture based wheat production of Northwest India: Profitability, nutrient use efficiency and environmental footprint. *F. Crop. Res.* 155, 233–244. doi:10.1016/j.fcr.2013.09.001
- Schut, M., Klerkx, L., Rodenburg, J., Kayeke, J., Hinnou, L.C., Raboanarielina, C.M., Adegbola, P.Y., van Ast, A., Bastiaans, L., 2015. RAAIS: Rapid Appraisal of Agricultural Innovation Systems (Part I). A diagnostic tool for integrated analysis of complex problems and innovation capacity. *Agric. Syst.* 132, 1–11.
- SUMBERG, J., ANDERSSON, J., GILLER, K., THOMPSON, J., 2013. Response to “Combining sustainable agricultural production with economic and environmental benefits.” *Geogr. J.* 179, 183–185. doi:10.1111/j.1475-4959.2012.00472.x
- Tittonell, P., Gérard, B., Erenstein, O., 2015. Tradeoffs around crop residue biomass in smallholder crop-livestock systems - What’s next? *Agric. Syst.* 134, 119–128. doi:10.1016/j.agry.2015.02.003
- van Bussel, L.G.J., Grassini, P., Van Wart, J., Wolf, J., Claessens, L., Yang, H., Boogaard, H., de Groot, H., Saito, K., Cassman, K.G., 2015. From field to atlas: Upscaling of location-specific yield gap estimates. *F. Crop. Res.* 177, 98–108.
- van Wart, J., van Bussel, L.G.J., Wolf, J., Licker, R., Grassini, P., Nelson, A., Boogaard, H., Gerber, J., Mueller, N.D., Claessens, L., 2013. Use of agro-climatic zones to upscale simulated crop yield potential. *F. Crop. Res.* 143, 44–55.
- Vanlauwe, B., Wendt, J., Giller, K.E., Corbeels, M., Gerard, B., 2014a. Response to Sommer et al. (2014) Fertiliser use is not required as a fourth principle to define conservation agriculture. *F. Crop. Res.* 167, 159.
- Vanlauwe, B., Wendt, J., Giller, K.E., Corbeels, M., Gerard, B., Nolte, C., 2014b. A fourth principle is required to define Conservation Agriculture in sub-Saharan Africa: The appropriate use of fertilizer to enhance crop productivity. *F. Crop. Res.* 155, 10–13. doi:10.1016/j.fcr.2013.10.002

### Annex 3.3 References

CGIAR Partner Perceptions Survey: See: <http://www.cgiar.org/consortium-news/stronger-partnerships-for-development-impact/>

Breeding Program Review: “ ... on-going activity that CIMMYT has with the ‘hubs’ across the world. These hubs generate good agronomic information (using a range of inputs). A recent Report ‘ (Measuring the Effectiveness of Crop Improvement research in Sub-Saharan Africa from the Perspectives of Varietal output, Adoption, and Change: 20 Crops, 30 countries and 1150 Cultivars in Farmers’ Field (July 2014) is an example of the follow up that takes place. ... CIMMYT distributes a range of nurseries with high value traits as well as genetic material for development by cooperators. This program is sophisticated and extremely important.” See: Accelerating Plant Breeding Program Outcomes: Findings from CIMMYT Review Visit 26th March – 1st April 2015 Bill & Melinda Gates Foundation.

G-20 Wheat Initiative: “Created in 2011 following endorsement from the G20 Agriculture Ministries, the Wheat Initiative provides a framework to establish strategic research and organization priorities for wheat research at the international level in both developed and developing countries.” Note the focus is currently on developed countries and globally relevant research challenges. See <http://www.wheatinitiative.org/>

### Youth Strategy (Annex 3.5) References

- Adedugbe, A. (2013) Engaging youths in agriculture through Information and Communications Technology. FAO Regional Office for Africa (2013) *Nature & Faune* 28(1): 60-63.
- Bennell, P. (2007) Promoting Livelihood Opportunities for Rural Youth, IFAD, Rome.
- Bennell, P. (2010) Investing in the future. Creating opportunities for young rural people, IFAD, Rome.

- Bertini, C. (2011) *Girls Grow: A Vital Force in Rural Economies. A Girls Count Report on Adolescent Girls*. The Chicago Council on Global Affairs, Chicago.
- Bezu, S. and Holden, S. (2014) Are Rural Youth in Ethiopia Abandoning Agriculture? *World Development* 64: 259-272.
- Chinsinga, B. and Chasukwa, W. (2012) Youth, Agriculture and Land Grabs in Malawi. *IDS Bulletin* 43(6): 67-77.
- CGIAR Consortium Office (2015) Report on 'Workshop on Mobilizing Youth within Phase 2 CGIAR Research Programs (CRPs)'. Organized by IITA, The African Development Bank, and the CGIAR Consortium. Final Version 22<sup>nd</sup> October 2015, Montpellier.
- Dryland Systems (2015) *Youth Strategy 2014-2017*.
- FAO (2014) Youth and agriculture: Key challenges and concrete solutions; [www.fao.org/3/a-i3947e.pdf](http://www.fao.org/3/a-i3947e.pdf)
- Farnworth, C.R. and Sillah, B. (2013) Involving young women in agriculture in sub-saharan Africa: Some lessons learned. *FAO Regional Office for Africa (2013) Nature & Faune* 28(1): 60-65.
- IFAD (2013) Youth. Policy Brief. Improving young rural women's and men's livelihoods - The most sustainable means of moving to a brighter future; [www.ifad.org/pub/ruralyouth/youth\\_policybrief.pdf](http://www.ifad.org/pub/ruralyouth/youth_policybrief.pdf)
- ILO (2012) Investing in youth for rural transformation. *Rural Policy Briefs*.
- [Keesing](#), R.M. (1981) *Cultural Anthropology: A Contemporary Perspective*. Holt, Rinehart and Winston, 1981.
- Kokanova, N. (2013) The potential of agriculture to create a positive job outlook for rural youth in Africa. *FAO Regional Office for Africa (2013) Nature & Faune* 28(1): 42-45.
- Leavy, J. and Hossain, N. (2014) Who Wants to Farm? Youth Aspirations, Opportunities and Rising Food Prices. *IDS Working Paper* 439.
- Levine, R. et al. (2008) *Girls count: a global investment & action agenda. A girls count report on adolescent girls*. The Center for global Development, Washington.
- Paroda, R. et al. (2014) *Regional Workshop on Youth and Agriculture: Challenges and Opportunities. Proceedings and Recommendations, 23-24 October 2013, Islamabad, Pakistan*. Asia-Pacific Association of Agricultural Research Institutions, Bangkok.
- Proctor, F. and Lucchesi, V. (2012) *Small scale farming and youth in an era of rapid rural change*. International Institute for Environment and Development/ Humanist Institute for Development Cooperation, London/The Hague.
- Quisumbing, A.R. et al. (Eds.) (2014) *Gender in Agriculture – Closing the Knowledge Gap*. Dordrecht: Springer Netherlands.
- Sumberg, J. et al. (2012) Introduction: The Young People and Agriculture 'Problem' in Africa. *IDS Bulletin* 43(6): 1-8.
- White, B. (2012) Agriculture and the Generation Problem: Rural Youth, Employment and the Future of Farming. *IDS Bulletin* 43(6): 9-19.
- World Bank (2006) *World Development Report: Development and the Next Generation*, Washington.

Annex 4.6: Performance Indicator Matrix Tables B, C & D

**WHEAT Full Proposal: PIM Tables B, C**

**WHEAT targeted subIDOs, matched to key research outcomes, broken down into achievement milestones over 2017-2022**

279	97	182	25	47
	35	65	9	17

Table C		Tables B, D				6YR Budget ex-Mgmt (US\$M)				
Sub-IDOs	% total FP budget 2017-2022	absolute 2017-2022	2022 R&D Outcomes from CRP ToCs	%outcome per subIDO	absolute 2017-2022	Absolute per FP outcome	W1&2	W3/Bil	Total dedicated to Cap Dev	Total dedicated to gender, youth
<b>Flagship 1: <i>Enhancing WHEAT's R4D strategy for impact</i></b>										
<b>Totals per FP \$M</b>	<b>24.514281</b>									
1.3.4 More efficient use of inputs	40	9.806	1.10 Farmers have greater awareness and access to, and increased adoption and adaptation of improved technologies	100	9.806	17.160	5.99	11.17	1.8	5.5
B.1.3 Improved capacity of women and young people to participate in decision-making	30	7.354	1.10 Farmers have greater awareness and access to, and increased adoption and adaptation of improved technologies	100	7.354	see above				
C.1.1 Increased capacity of beneficiaries to adopt research outputs	30	7.354	1.9 Last mile provider (extension partners, farmer organization, community-based organizations, private sector) increased access and promotion of technologies to farmers	50	3.677	3.677	1.28	2.39	0.9	0.9
			1.8 National and regional policy makers improved policy-making and increased investment based on evidence	50	3.677	3.677	1.28	2.39	0.9	0.9
		24.514			24.514	24.514	8.55	15.96	3.68	7.35

<b>Flagship 2: <i>Novel diversity and tools</i></b>										
<b>Totals per FP \$M</b>		<b>51.531135</b>								
1.4.3 Enhanced genetic gain	40	20.612	2.4 Crop researchers worldwide increased use of novel germplasm and tools for validation, refinement and development of products 2.5 Breeders develop improved varieties more efficiently through greater access and use of documented germplasm and tools	50	10.306	20.61	7.19	13.42		
1.4.4 Increased conservation and use of genetic resources	40	20.612	2.2 Crop researchers world-wide and across disciplines access more novel germplasm and tools 2.3 Genebanks enabled to increase utilization of accessions by crop researchers	100	20.612	20.61	7.19	13.42	2.06	5.2
<b>assign to Genebanks Platform</b>				0						
D.1.1 Enhanced institutional capacity of partner research organizations	20	10.306	2.4 Crop researchers worldwide increased use of novel germplasm and tools for validation, refinement and development of products	100	10.306	see above				
		51.531			51.531	51.53	17.98	33.56	2.06	5.15
<b>Flagship 3: <i>Better varieties reach farmers faster</i></b>										
<b>Totals per FP \$M</b>		<b>112.333818</b>								
1.1.2 Reduced production risk	30	33.700	3.6 National regulators of crop variety release improved enabling environment to speeding-up release of improved varieties (merge with 3.5 National partners increased improved variety release) 3.7 Extension partners (universities, national /state / provincial governments) increased access and promotion of adoption of improved varieties to farmers, and increased investment in emerging private sector circumstances (merge with: 3.8 Farmer organizations increased access and promotion of adoption of improved varieties to farmers)	50	16.850	16.85	5.88	10.97	1.69	1.69
				50	16.850	16.85	5.88	10.97	1.69	4.21

1.4.1 Reduced pre- and post-harvest losses, including those caused by climate change	20	22.467	3.3 Partner breeding teams improved breeding processes by adopting new technologies, methodologies, genetic resources	50	11.233	28.0834545	9.80	18.29		
			3.12 Non- and -subsistence farmers adopted improved varieties	50	11.233	11.23	3.92	7.31		2.81
1.4.3 Enhanced genetic gain	20	22.467	3.1 Partner breeding teams improved exchange and utilization of germplasm and data	50	11.233	11.23	3.92	7.31	1.12	
			3.2 Partner breeding teams increased multidisciplinary and multi-institutional collaboration (merge with: 3.3 Partner breeding teams improved breeding processes by adopting new technologies, methodologies, genetic resources)	50	11.233	11.23	3.92	7.31		
A.1.4 Enhanced capacity to deal with climatic risks and extremes	15	16.850	3.3 Partner breeding teams improved breeding processes by adopting new technologies, methodologies, genetic resources	100	16.850	see above				
B.1.2 Technologies that reduce women's labor and energy expenditure developed and disseminated	15	16.850	3.7 Extension partners (universities, national /state / provincial governments) increased access and promotion of adoption of improved varieties to farmers, and increased investment in emerging private sector circumstances (gender and other social identities as customer attributes in relation to seed diffusion interventions, including varietal promotion and replacement)	0		NA				
			3.8 Farmer organizations increased access and promotion of adoption of improved varieties to farmers (gender and other social identities as customer attributes in relation to seed diffusion interventions, including varietal promotion and replacement)	100	16.850	16.85	5.88	10.97	4.21	4.21
		112.334			112.334	112.33	39.19	73.15	8.71	12.92

**Flagship 4: Sustainable intensification of wheat-based farming systems**

Totals per FP \$M		90.999011									
1.3.4 More efficient use of inputs	20	18.200	4.2 Donors, policy-makers (local, regional and national), advocacy NGOs and private sector increased investment and improved enabling environment for adoption of SI practices and products & 4.3 Local and regional actors (NGOs, farmer groups, extension agents, private sector) increased promotion of SI practices and & 4.6 Private sector (and public sector) increased provision of services to smallholder farmers increased their ability to adopt SI practices and products	100	18.20	36.400	12.70	23.70			3.64
1.4.2 Closed yield gaps through improved agronomic & animal husbandry practices	20	18.200	4.7 Actors in SI increased participation in feedback loops via monitoring, evaluation and sharing of lessons learned & 4.8 Actors in SI increased consideration and integration of gender and social inclusion into policies, processes and practices & 4.10 Smallholder farmers adopted and adapted SI practices and products	100	18.20	27.300	9.52	17.78	6.82		6.82
3.2.2 Agricultural systems diversified and intensified in ways that protect soils and water	20	18.200	4.2 Donors, policy-makers (local, regional and national), advocacy NGOs and private sector increased investment and improved enabling environment for adoption of SI practices and products & 4.3 Local and regional actors (NGOs, farmer groups, extension agents, private sector) increased promotion of SI practices and products & 4.6 Private sector (and public sector) increased provision of services to smallholder farmers to increased their ability to adopt SI practices and products	100	18.20	see above					

A.1.4 Enhanced capacity to deal with climate risks and extremes	20	18.200	4.9 Smallholder farmers increased their capacity to adopt and adapt SI practices and products (associated with crosscutting sub-IDO) & 4.6 Private sector (and public sector) increased provision of services to smallholder farmers to increased their ability to adopt SI practices and products & 4.3 Local and regional actors (NGOs, farmer groups, extension agents, private sector) increased promotion of SI practices and products	100	18.20	18.200	6.35	11.85	1.82	5
C.1.1. Increased capacity of beneficiaries to adopt research outputs	10	9.100	4.7 Actors in SI increased participation in feedback loops via monitoring, evaluation and sharing of lessons learned & 4.8 Actors in SI increased consideration and integration of gender and social inclusion into policies, processes and practices	100	9.10	see above				
D.1.1. Enhanced institutional capacity of partner research organizations	10	9.100	4.6 Private sector (and public sector) increased provision of services to smallholder farmers to increased their ability to adopt SI practices and products & 4.4 NARS increased use of participatory approach in system research, enhanced capacity and knowledge to create awareness and develop improved technologies	100	9.10	9.100	3.17	5.93	2.27	6.82
		90.999			91.00	90.999	31.74	59.25	10.92	21.84

**Table D. 2017-2022 Milestones per 2022 Outcome per Flagship.**

WHEAT Full Proposal: PIM Table D

WHEAT targeted subIDOs, matched to key research outcomes, broken down into achievement milestones over 2017-2022

see also Annex 3.6

Table C		Table D						
Tables B, D		Milestones per R&D Outcomes						
Sub-IDOs	2022 R&D Outcomes from CRP ToCs	2017	2018	2019	2020	2021	2022	Means of verifying performance against outcomes
<b>Flagship 1: <i>Enhancing WHEAT's R4D strategy for impact</i></b>								
1.3.4 More efficient use of inputs	1.10 Farmers have greater awareness and access to, and increased adoption and adaptation of improved technologies		Rapid value chain assessments with proper gender lens conducted to identify opportunities and bottlenecks in WHEAT	Beneficiaries in 3 WHEAT target regions, plus 6 target countries exposed to more appropriate innovations through better targeting	Benchmarking information of wheat value chain collected in selected countries to support identified of priorities and effective interventions	Beneficiaries' increased innovation adoption and associated factors credibly documented in plus 6 WHEAT target countries	Farm to fork value chain analyses in both established and emerging wheat producers to assess implication for WHEAT priorities	Perform, review annual portfolio analysis; Supporting publications (foresight; ex ante; impact pathways; value chains) publicized
B.1.3 Improved capacity of women and young people to participate in decision-making	1.10 Farmers have greater awareness and access to, and increased adoption and adaptation of improved technologies	Gender / social inclusion lenses will be applied to 2 to 4 WHEAT innovation pipelines and assessments		Measure of women's empowerment quantified based on global recognized indicators (baseline)		Study of the implementation of gender mainstreaming in WHEAT and its impact on inclusivity and equity	Gender / social inclusion lenses will be routinely applied to major WHEAT innovation pipelines and assessments	Reports, global recognized women empowerment indicators, case studies

C.1.1 Increased capacity of beneficiaries to adopt research outputs	1.9 Last mile provider (extension partners, farmer organization, community-based organizations, private sector) increased access and promotion of technologies to farmers	Ex-ante impact assessments identify potential opportunities, threats and game changes for WHEAT to support outcomes 1.1, 1.2, 1.3	targeting incorporates competition for land and spatial dimensions of soil & water degradation	Ex-ante impact assessments assess how major drivers like climate change and rural transformation will alter WHEAT in the developing world to support outcomes 1.1, 1.2, 1.3	Climate change and other dynamics integral to foresight research, showing how they transform agri, rural landscapes	value chain research identifies new entrepreneurial, job opportunities, options to address (post)-harvest losses	Ex-ante impact assessments assess future preferences of wheat producers and consumers and implications for wheat innovation to support outcomes 1.9 and 1.10	Supporting publications: Reports, policy briefs, dissemination documentation
	1.8 National and regional policy makers improved policy-making and increased investment based on evidence	Adoption and impact studies on technologies—rolling plan based on progress of technologies along the theory of change	Adoption and impact studies on technologies—rolling plan based on progress of technologies along the theory of change	Adoption and impact studies on technologies—rolling plan based on progress of technologies along the theory of change	Adoption and impact studies on technologies—rolling plan based on progress of technologies along the theory of change	Adoption and impact studies on technologies—rolling plan based on progress of technologies along the theory of change	Adoption and impact studies on technologies—rolling plan based on progress of technologies along the theory of change	Adoption and impact studies on technologies—rolling plan based on progress of technologies along the theory of change
<b>Flagship 2: <i>Novel diversity and tools</i></b>								
1.4.3 Enhanced genetic gain	2.4 Crop researchers worldwide increased use of novel germplasm and tools for validation, refinement and development of products	improved precision of GS models using high throughput phenotyping data		Increased accuracy of predictive G&E and multi-trait models of use for breeders	Prediction accuracy of GS-HTPTS is 0.4;	GS models with environmental co-variates 10% more accurate than without		see FP3

	2.5 Breeders develop improved varieties more efficiently through greater access and use of documented germplasm and tools		Greater number (compared to 2016) of breeder-ready markers/high-value haplotypes for prioritized traits identified and validated (under FP2) and deployed in CGIAR breeding programs (FP3)	FP2-developed tools and methods that enable more efficient management of breeding programs used by all WHEAT breeders		Greater number (compared to 2016) of breeder-ready markers/high-value haplotypes for prioritized traits identified and validated (under FP2) and deployed in non-CGIAR breeding programs (FP3; partners)	FP2-developed tools and methods that enable more efficient management of breeding programs used by 20 % of national partner breeders	Marker deployment tracking; tool use tracking
1.4.4 Increased conservation and use of genetic resources	2.2 Crop researchers worldwide and across disciplines access more novel germplasm and tools		New alleles for heat and drought, other climate change-related traits identified and moved into breeding pipeline	international multi-location testing of new allelic combinations provides best bets	Comprehensive characterization of genebank accessions including geospatial, adaptive distribution	in-situ conservation successfully implemented with 3-5NARS in major centers of diversity	molecular characterization used by more CGIAR and non-CGIAR breeders to investigate uncharacterized germplasm	Diversity Allele distributed via new varieties (genetic studies); % legally and physically available accessions in the CIMMYT, ICARDA wheat banks
<b>assign to Genebanks Platform</b>	2.3 Genebanks enabled to increase utilization of accessions by crop researchers							
D.1.1 Enhanced institutional capacity of partner research organizations	2.4 Crop researchers worldwide increased use of novel germplasm and tools for validation, refinement and development of products	Shared low cost high throughput SNP-genotyping platform for low density markers (1-200) for CG centers and partners	More partners use IWYP Platform for precision phenotyping	enhanced researchers access to accessions (easier, more targeted across different criteria)	Integration of gender and youth-based preference data for germplasm into breeding management informatics systems	Global phenotyping data curated and made available to global community through integrative system	More interoperable data in more data sets exchanged, used by researchers, using efficient procedures	Database usage/user monitoring (e.g. platforms available/used, open access databases, reports)  Change # of markers used by non-WHEAT scientists

**Flagship 3: *Better varieties reach farmers faster***

1.1.2 Reduced production risk	3.6 National regulators of crop variety release improved enabling environment to speeding-up release of improved varieties (merge with 3.5 National partners increased improved variety release)		National regulators of variety release and seed supply provide enabling environment to speed up release of improved varieties and farmers' access to quality seed, in 2-3 target countries	national variety release process 1-3 years shorter in 2-4 WHEAT target countries			national variety release process 1-3 years shorter in a further 2-3 WHEAT target countries	policy change tracking
	3.7 Extension partners (universities, national /state / provincial governments) increased access and promotion of adoption of improved varieties to farmers, and increased investment in emerging private sector circumstances (merge with: 3.8 Farmer organizations increased access and promotion of adoption of improved varieties to farmers)	New options, approaches piloted to fast track release of varieties, accelerated seed multiplication and dissemination	improved, documented understanding of specific wheat seed systems (farmer's seed commercial behavior, seed demand and marketing, economics of seed production) / 2-3 NARES identified performance gaps, capacity development needs, to identify, realize relevant cap dev interventions at apt levels		sustainable functional seed units for early generation seed multiplication established with plus 2-3 NARS (public, private sector)	Based on learning from pilots, seed sector/ extension partners (all types) increase access to and farmer adoption of improved varieties	sustainable functional seed units for early generation seed multiplication established with plus 2-3 NARS (public, private sector)	change in sustainable farmer access to improved seeds; farmer uptake of seeds (vs own); Number of farmers with access to quality seeds / change in degree of commercialisation of seed sector (public, private) / change in scaling-up of new technologies and practices through Agricultural Innovation Platforms, innovation hubs

1.4.1 Reduced pre- and post-harvest losses, including those caused by climate change	3.3 Partner breeding teams improved breeding processes by adopting new technologies, methodologies, genetic resources	public or private sector seed producer investment increased in 2-3 target countries, compared to 2016		broad genetic-based germplasm resistant/ tolerant to pests, diseases predicted to become worse with climate change	variety adoption increases protection from post-harvest losses (e.g. mycotoxins, other) in 2-3 sites (incl value chain FP1, FP4)	adoption of shorter duration varieties increases cropping intensity & diversification in 3-6 target countries/sites	public or private sector seed producer investment increased in further 2-3 target countries, compared to 2016	Performance of superior resistant germplasm in multi-location/year disease/pest trials
	3.12 Non-and -subsistence farmers adopted improved varieties	greater farmer adoption of released varieties (based on CGIAR research) in specific WHEAT target countries, compared to 1994-2014 average	sustainable seed system optimised in 2-3 countries (pilots, with scaling-out potential)	nitrogen-use efficient varieties adopted, reducing water pollution in 3-6 target countries/sites	faster replacement rate (farmers use same variety fewer years before replacing) in specific WHEAT target countries	greater farmer adoption of released varieties (based on CGIAR research) in specific WHEAT target countries, compared to 1994-2014 average	release and adoption data, via national focal point network, documented in wheatatlas.org	
1.4.3 Enhanced genetic gain	3.1 Partner breeding teams improved exchange and utilization of germplasm and data	All molecular markers linked to traits of agronomic importance converted onto SNP-based platforms. SNP-based low and high density genotyping hubs established		fully operational, integrated network of 15 precision phenotyping platforms, germplasm exchange between NARS platforms	SNP-based markers transferred to sequence based markers for genomics-assisted breeding	increased on-farm genetic diversity of farmer-adopted varieties in 3 key target regions	increased cultivar replacement rates in 2-3 key target regions	Effects of markers and genes linked to target traits in diverse genetic backgrounds; rates of genetic gain by incorporating and combining new alleles (genetic studies) / Change in cultivar replacement rates Change in income attributable to yield gain/stability, quality traits
	3.2 Partner breeding teams increased multidisciplinary and multi-institutional collaboration (merge with: 3.3 Partner breeding teams improved breeding processes by adopting new technologies, methodologies, genetic resources)	Initiate Global Pests & Diseases Observatory with user inputs, to monitor, assess races/biotypes of key diseases and pests	sustainable seed system optimised in 2-3 countries (pilots, with scaling-out potential)	pest, disease-resistant varieties adopted and less chemicals used in 3-6 target countries/sites	nitrogen-use efficient varieties adopted, reducing water pollution in 3-6 target countries/sites		functional Global Pests & Diseases Observatory with user partners (geographies tbd)	no of cooperators (data contributors) and users

<p>A.1.4 Enhanced capacity to deal with climatic risks and extremes</p>	<p>3.3 Partner breeding teams improved breeding processes by adopting new technologies, methodologies, genetic resources</p>		<p>improved knowledge of genetic basis of climate change adaptation on global scale thru combination of GS, platforms, unified databases</p>		<p>high quality phenotypic data &amp; germplasm with heat, drought tolerance, putative traits into CGIAR and NARS breeding programs</p>		<p>better climate change-adapted lines used by wheat breeders globally, early farmer adoption successes</p>	<p>effect of applying genomic tools to improve CC-relevant traits / Rate at which high-quality phenotypic data, associated germplasm with heat, drought tolerance available for wheat breeders globally</p>
<p>B.1.2 Technologies that reduce women's labor and energy expenditure developed and disseminated</p>	<p>3.7 Extension partners (universities, national /state / provincial governments) increased access and promotion of adoption of improved varieties to farmers, and increased investment in emerging private sector circumstances (gender and other social identities as customer attributes in relation to seed diffusion interventions, including varietal promotion and replacement)</p>	<p>develop disease/pest resistant germplasm that do not lodge, and have high vigor and test weight</p>		<p>elite lines validation of labour, energy reduction (farmer evaluation, PVS)</p>	<p><i>Move to FP4.3: Combine with agronomic, farm mgmt tools</i></p>			
	<p>3.8 Farmer organizations increased access and promotion of adoption of improved varieties to farmers (gender and other social identities as customer attributes in relation to seed diffusion interventions, including varietal promotion and replacement)</p>	<p>Develop wheat with enhanced healthy properties: reduce chronic diseases risk (incl high content of dietary fiber to address obesity)</p>	<p>Improve consumer acceptability of high flour extraction rate and whole grain flour</p>			<p>prebreeding lines with high iron, zinc and inulin and low phytic acid concentration, lines with high total AX and WE-AX content developed</p>	<p>studies conducted to understand effect of increased resistant starch on grain yield, industrial quality</p>	<p>With A4NH: Verify if consumption of wheat varieties with enhanced nutritional and healthy components reduces malnutrition rates, cardiovascular diseases, type 2 diabetes, cancer in CGIAR target geographies</p>

**Flagship 4: Sustainable intensification of wheat-based farming systems**

<p>1.3.4 More efficient use of inputs</p>	<p>4.2 Donors, policy-makers (local, regional and national), advocacy NGOs and private sector increased investment and improved enabling environment for adoption of SI practices and products &amp; 4.3 Local and regional actors (NGOs, farmer groups, extension agents, private sector) increased promotion of SI practices and &amp; 4.6 Private sector (and public sector) increased provision of services to smallholder farmers increased their ability to adopt SI practices and products</p>	<p>Increase resource use efficiencies (irrigation water, N, P) while maintaining high, stable yields: NW Mexico, the Indo-Gangetic Plains</p>	<p>adapt precision water mgmt practices w/ use of remote, proximal sensing info</p>		<p>Increase resource use efficiencies (irrigation water, N, P) while maintaining high, stable yields: Horn of Africa, Southern Africa</p>			<p>change in nutrient, water &amp; labor use</p>
<p>1.4.2 Closed yield gaps through improved agronomic &amp; animal husbandry practices</p>	<p>4.7 Actors in SI increased participation in feedback loops via monitoring, evaluation and sharing of lessons learned &amp; 4.8 Actors in SI increased consideration and integration of gender and social inclusion into policies, processes and practices &amp; 4.10 Smallholder farmers adopted and adapted SI practices and products</p>		<p>increased adoption of combinations of SI strategies, technologies in specific target geographies compared to 2016</p>	<p>strengthened ability to synthesize and apply available knowledge related to SI oriented research methodologies (multi-criteria assessments), management practices, technologies, machinery, in 10-15 partner orgs</p>	<p>Adaptive research improves understanding of gender, youth and adoption, adaptation and scaling-up processes, with focus on market demand as trigger of innovation</p>	<p>more team work and interdisciplinary research practice in 10-15 partner organisations in specific scaling-out projects</p>	<p>increased adoption of combinations of SI strategies, technologies in specific target geographies with poverty reduction impact compared to 2019</p>	<p>CRP Commissioned External Evaluation, project/donor-driven impact studies; partner self-assessments</p>
<p>3.2.2 Agricultural systems diversified and intensified in ways that protect soils and water</p>	<p>4.2 Donors, policy-makers (local, regional and national), advocacy NGOs and private sector increased investment and improved enabling environment for adoption of SI practices and products &amp; 4.3 Local and regional actors (NGOs, farmer groups, extension</p>	<p>better understand smallholder farming systems diversity and trajectories (which drive adoption) and feedback</p>	<p>Smart mechanization lessons learnt routinely applied in other FP4 projects</p>	<p>extension of crop mgmt practices that arrest soil degradation</p>	<p>Decision support, mechanization and other tools, processes improve target groups' ability to seize opp's and avoid losses</p>		<p>Intensified, diversified farming systems developed, with increased systems intensity, reduces pressure on land</p>	<p>Farm/System scale: System health (nutrient cycling, biodiversity, biomass) Landscape scale: Land-use change; Soil loss/degradation; Soil health (AFSIS); - Net productivity (vegetation, biomass);</p>

	agents, private sector) increased promotion of SI practices and products & 4.6 Private sector (and public sector) increased provision of services to smallholder farmers to increased their ability to adopt SI practices and products	between farming systems and their operating landscapes						Ecosystem services (biodiversity, water); Documentation review, Survey of private sector CRP Commissioned External Evaluation
A.1.4 Enhanced capacity to deal with climate risks and extremes	4.9 Smallholder farmers increased their capacity to adopt and adapt SI practices and products (associated with crosscutting sub-IDO) & 4.6 Private sector (and public sector) increased provision of services to smallholder farmers to increased their ability to adopt SI practices and products & 4.3 Local and regional actors (NGOs, farmer groups, extension agents, private sector) increased promotion of SI practices and products	water-saving benefits of farmers using most water-efficient cultivars and optimum agronomy and irrigation systems validated for 2 WHEAT target regions	optimisation of cropping systems support adaptation to climate change validated in specific WHEAT target geographies	Farmers in 2 WHEAT (irrigated) target regions, using most water-efficient cultivars and optimum agronomy and irrigation systems, achieve water use efficiency of ca 450 l/ kg grain can be achieved (50% water saving over 2015)		More resilient farms and landscapes with doubled NUE reduce GHG emissions in 2-4 WHEAT target geographies	Farmers in a further 2-3 WHEAT (irrigated) target regions, using most water-efficient cultivars and optimum agronomy and irrigation systems, achieve water use efficiency of ca 450 l/ kg grain can be achieved (50% water saving over 2015)	% change in nitrate losses, P losses % change in herbicide/pesticide use per unit of production % change from baseline for fertilizer N consumption, soil C indices, erosion indices, soil biological properties SDSN 15: NUE in food systems (FAO, IFA as lead monitoring) SDSN 16: Crop water productivity (tons of harvested product per unit irrigation water, FAO lead monitor
C.1.1. Increased capacity of beneficiaries to adopt research outputs	4.7 Actors in SI increased participation in feedback loops via monitoring, evaluation and sharing of lessons learned & 4.8 Actors in SI increased consideration of gender and social inclusion into policies, processes and practices	multi-criteria assessments taking into account environmental and social acceptability aspects, based on standardized protocols for multi-criteria 'step' assessments of advanced crop management packages (not individual technologies)		Better understand and model relationship between commercialization / market-oriented production and diversification / productivity increases, for scaling-up purposes, e.g. consider input and output markets	better understand and model farmer perception, farmer diversity, and farm-level integration of technologies		improved understanding translated into ICT for improved farmer decision making projects	change in: Food sufficiency & security; - Income & Assets; - Investment & ROI of (system) technology

<p>D.1.1. Enhanced institutional capacity of partner research organizations</p>	<p>4.6 Private sector (and public sector) increased provision of services to smallholder farmers to increased their ability to adopt SI practices and products &amp; 4.4 NARS increased use of participatory approach in system research, enhanced capacity and knowledge to create awareness and develop improved technologies</p>	<p>build skills necessary to monitor soil, crop parameters ( to evaluate crop management practices)</p>	<p>better understand scaling up processes in multi-actor innovation networks, to ensure sustainability of institutional mechanisms, structures</p>	<p>improved skills and capacities necessary to manage innovation, extension networks</p>	<p>Improved understanding of complex interaction between the enabling environment and business propositions for ICT services for scaling up, social networking</p>			<p>CRP Commissioned External Evaluation; farmer organizations &amp; innovation platforms: Change in degree of linkages to (private, public sector) input suppliers &amp; output buyers</p>
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