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GRiSP responses to ISPC and CO comments
August 21, 2014

Submitted by:
CRP GRiSP

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General comments	
1. It is important to see more real "partnership" between the commodity and system CRPs. Therefore, the "added value" from more engagement and coordination with other relevant CRPs such as AAS and WLE should be explored.	Agreed. GRiSP is deepening its relationships with AAS and WLE (besides the already very strong links with CCAFS). We already collaborate intimately through the cross-cutting CSISA-Bangladesh and CSISA projects in Bangladesh where we explore the optimization of land and water resources use in rice-shrimp farming systems. We also collaborate intensively with WLE through the CPWF project in the Ganges Basin; this project was until 2014 a cross-cutting project between GRiSP and WLE as the rice project of the Ganges program (housed under WLE) was part of GRiSP. As of 2014, however, this project has moved administratively from GRiSP to WLE, though its activities are still fully linked with GRiSP (current Theme 3). GRiSP, WLE, and AAS executed a joint scoping study in 2014 in Myanmar to explore options for synergy and collaborative engagement. Closer collaboration between GRiSP and WLE in Africa is also being explored. Finally, there is strong link between GRiSP and CCAFS: GRiSP develops and tests crop and field-level technologies to reduce the emission of greenhouse gases from rice fields (for example, Alternate Wetting and Drying), and to adapt to climate change, which CCAFS uses to explore impact at regional to global scales. Also with CCAFS we have a very interesting collaboration in Colombia, in which we are producing tools for the farmers to better cope with weather instability.
2. The CRP IDO targets and indicators should be further refined; coordination with other linked CRPs on measurement of IDO indicators common to more than one program is recommended	Agreed; target and indicators are still under development. We developed a 'roadmap' of two years to develop, implement, and test a coherent set of indicators and targets as currently formulated. During this period, we expect to make refinements and adaptations so that we have a well-tested and workable set for GRiSP phase II. Currently (mid 2014), we started implementing the proposed set of indicators by collecting new baseline data in our target domains and meeting with our partners and stakeholders to agree on/adapt the proposals and to set targets. We also started coordination with other crop CRPs – especially WHEAT, MAIZE, Dryland Cereals and Grain Legumes – on the development of the indicators and the overall results-based management framework. By end 2014, we will be organizing a joined crop CRP M&E workshop in India.
3. More clarity of the power dynamics within and between partnerships is needed, i.e. mapping out who is doing what in the scaling out activities as well as more details in the allocation of the GRiSP budget to NARES partners for these activities.	We use tools such as PIPA (participatory impact pathway analysis) and stakeholder mapping to gain insight into partnership structures, and also to identify partners that are needed along the impact pathway. This is not limited to scaling out, but addresses the whole research-impact pathway, eg partners needed for upstream research or participatory technology testing. For example, detailed partnership analyses for reaching impact at scale were recently analysed and reported for various technologies and working groups of the Irrigated Rice Research Consortium. The template for the extension proposal did not allow for splitting out funding to partners in relation to specific outscaling activities. However, much more important than channeling CGIAR funds from W1 or W2 to partners for outscaling activities, is the leverage of local or national funds by our NARES partners – a funding stream which is many fold that of the CGIAR! A good example is the outscaling of stress-tolerant rice varieties in South Asia through the STRASA project: STRASA succeeded in generating considerable support from national and international sources and private sector. About 485 NARES partners, including research institutions, GOs, NGOs, private sector, small, medium and large seed companies, and public sector seed corporations are currently part of the STRASA regional network. Most of these partners are dependent on own resources. Besides, STRASA varieties are accepted as the major technology for promotion through major programs and initiatives related to food security and climate change, including the two mega schemes of India Government; the "National food

	Security Mission (NFSM)" and "Bringing Green Revolution in Eastern India (BGREI)", which are providing substantial support for upscaling of these new varieties. Most states in Eastern India are using own resources to bring these varieties to needy farmers.[1]
1. Intermediate development outcomes (IDOs), Theories of Change (ToCs) and Impact Pathways (IPs)	
The one feature that is missing in the ToC is the need to convey a strong impression that all of the research themes need to work in concert to produce the desired impacts.	Noted and agreed. We inserted a new figure in the extension proposal to highlight the interconnectivity among the Flagship Projects.
… however there is a need to further refine the CRP IDO targets and indicators.	See response to overall comment 2 above.
The ISPC would recommend that GRiSP communicate with linked CRPs on measurement of indicators common to more than one program; the ongoing ISPC strategic study on Metrics may also prove useful in this exercise.	See response to overall comment 2 above.
The ISPC would encourage GRiSP to explore the "added value" from more engagement and coordination with other relevant CRPs such as AAS and WLE.	See response to overall comment 1 above.
4. Partnerships	
The ISPC would suggest mapping out who is doing what in the scaling out activities as well as more details in the allocation of the GRiSP budget to NARES partners for these activities.	See response to overall comment 3 above.
CO comments	
1. Intermediate Development Outcomes (IDOs), Theories of Change (ToC) and Impact Pathways (IP)	
The generic GRiSP ToC, which was already in place before the reorganization of the program, is described in Fig. 1 (p.19). However, taking into account the new structure, with the newly proposed 5 FPs,	GRiSP has developed specific impact pathways (IPs) and theories of change (ToCs) for its Flagship Projects 2-5 (derived from ToCs and IPs for its current Themes). FPs 1 and 5 play a large role in facilitating the enabling actions for FPs 2-4. Therefore, FP1 has not developed its own IP and ToC, while a specific IP and ToC for components of FP5 is under construction. Because of space limitations, these FP-specific IPs and ToCs were not included in the extension proposal. They are given in Annex 1 to this document. A specific IP and ToC was developed for GRiSP's gender dimension, and is presented in detail in its gender strategy (follow the

[1] From brief progress report Dr Ismail, December 18, 2013

we recommend that GRiSP designs 5 sub-ToCs with their own related assumptions and links to corresponding CoAs. Other commodity programs used this approach for their Extension Proposals, as recommended by ISPC (see ISPC report on ToC, 2012)	embedded link) while a summary and updated description is provided in annex 3.
This part of the proposal could be improved by clarifying how the program claims and expected output will contribute to these 3 SLOs: rural poverty alleviation, hunger alleviation, and sustainable resource management. For instance, when discussing GRiSP's contribution toward the rural poverty and hunger SLOs, it is assumed that increased productivity and income will address this SLO. However, it has long been demonstrated that the persistence of poverty and hunger stems from the fact that these issues cannot be simply explained by the quantity of food produced; they result from a combination of quantity and accessibility. As long as GRiSP does not address the access dimension, it cannot claim that it will contribute to poverty and hunger alleviation. GRiSP also had to propose research on policy and institutional bottlenecks to the poor's access to food to allow the CRP to make claims beyond contribution to increased rice productivity. For poverty reduction, GRiSP has to demonstrate better how increases in productivity can be credibly linked to increases in income for the poor.	We agree with the importance of providing solid and scientific evidence for claims to contributions to all SLOs that CRPs contribute to. Our IP and ToC is based on a combination of 1) a solid (historic) evidence base as derived from scientific literature over the past decades, and 2) foresight and ex-ante impact analyses. Though still a work in progress, annex 2 presents a draft of the scientific evidence base for our claims to contributions to all 4 CGIAR SLOs. *"For instance, when discussing GRiSP's contribution toward the rural poverty and hunger SLOs, it is assumed that increased productivity and income will address this SLO*". It is, in fact, not "assumed" but actually well proven that increased productivity contributes to alleviating poverty and increasing food security; see annex 2 to this document. "*Various pathways can lead to reducing rural poverty, but increased agricultural growth through improved productivity, markets, and incomes have been shown to be particularly effective contributors (Hazel, 2008; Timmer et al., 2010)*". We agree that this is only part of the solution to these problems, but it is a considerable one that GRiSP has competitive advantage in contributing to. *"However, it has long been demonstrated that the persistence of poverty and hunger stems from the fact that these issues cannot be simply explained by the quantity of food produced*". Here, "productivity" is erroneously equated with "quantity of food'. Though increasing productivity is a main avenue to enhancing the quantity of food produced, it also contributes to reduced cost of production (which benefits producers) and hence low food prices (which benefit net consumers, including many poor and small farmers who are still net food buyers), and to reduced environmental footprints. *"they result from a combination of quantity and accessibility*". Yes, indeed. Accessibility is facilitated/explained quite a bit by the price of foodstuff. In Asia, poor consumers can spend up to 30-40% of their income on the purchase of rice alone – hence, keeping the price of rice low is an important avenue to increasing accessibility (the lessons of the rice price crisis of 2008 seem already forgotten). GRiSP contributes to keeping the price of rice low by addressing both the quantity aspect as well as the policy and institutional aspects (for example, FP1 undertakes research on food policy, provides market analyses, and develops rice production forecast systems, among many other relevant policy activities).
2. Flagship Projects	
FP3 tackles other sustainable approaches	Indeed, the testing, evaluation, and solicitation and incorporation of feedback are all critical elements in the development and

(apart from genetics & breeding) including marketing, post-harvest and processing technologies. GRiSP states that it will test and optimize water saving technologies, ecological pest management, labor-saving mechanization, new crop management practices and new cropping systems at the farming and systems levels. However, the feedback and evaluation of the sustainability of the intensification process in rice systems has to be more convincingly described.	deployment of sustainable intensification. We strengthened the text by making this clear (*These technologies are not only developed and tested on experimental stations, but are being co-developed, tested, evaluated and further improved through participatory and on-farm experimentation with farmers, partners, and pertinent stakeholders. An important mechanism is the Sustainable Rice Platform SRP which develops with its large and diverse constituency criteria, evaluation tools, and practices for sustainable rice production*). GRiSP/IRRI is co-convening the SRP and leading the development of sustainability criteria and evaluation principles and practices. It will develop a context-dependent modular standard for sustainable rice production and processing, including decision making tools and so-called Field Calculators that will compute quantitative sustainability indicators on multiple environmental, social, and economic dimensions (which will allow the quantification of potential trade-offs and win-win situations). FP3 is now FP4 in our new numbering and arrangements of FPs.
FP5 focuses on "outscaling and capacity building" with a special attention on the "scaling-up of GRiSP products and services to reach impact at scale". Empirical approaches are described in the corresponding narrative (p.9) but a more systematic research component on the scaling-up approach, would be helpful. Based on Figures 1 and 2 in Annex 1, different feedback loops could be tested at different levels; this would help the program to make better use of quantitative models of adoption.	Indeed, we use certain formalized and structured approaches to scaling out and scaling up that we failed to explain in the extension proposal. Though the space in the proposal is too limited to go into details, we added the brief sentence "*For scaling out and scaling up, we use tools and formalized approaches such as participatory impact pathway analysis (PIPA), participatory needs and opportunity (NAO) analyses, stakeholder mapping, 'message design workshops' , etc.*". We also analyse and evaluate various models and experiences with scaling out and up to draw lessons for improvement. For example, different approaches and models used for reaching impact at scale were recently analysed and reported for various technologies and working groups of the Irrigated Rice Research Consortium.
GRiSP could ask (FP3 or FP4?) by how much is the diet of farmers and consumers improved, overall, when rice's content in zinc, iron, vitamin A is improved, given that people do not eat just rice. The program should describe how to work more closely with A4NH to understand the impact of rice consumption –bio-fortified or not- on the overall improvement in the quality and nutritional contents of diets.	Yes, such analyses are done, and collaboration with the HarvestPlus program of A4HN is very intense (In fact, a substantial part of GRiSP's biofortification activities were administratively transferred to A4HN, while the linkages with our FPs 2 and 3 remain intensive). Developing rice with high iron and zinc through the process of "biofortification" aims to combine high mineral content with grain quality and agronomic characteristics, such as high yield and pest and disease resistance, to ensure acceptability by farmers and consumers. While certain specific biofortification (pre-)breeding activities are now part of A4HN, the mainstreaming of biofortification in breeding programs and the combination of the properties mentioned above are part and parcel of FP 2 and 3 of GRiSP. The Breeding for high iron and zinc is guided by the breeding objectives of the HarvestPlus program, which require that: 1. Crop productivity be maintained or increased to guarantee farmers' acceptance, 2. Micronutrient enrichment levels have a measurable impact on human nutritional status, 3. Micronutrient enrichment traits be relatively stable across various environments and climatic conditions, 4. Bioavailability of micronutrients in enriched lines be tested in humans to ensure the benefits to people preparing and eating them in traditional ways within normal conditions, and 5. Consumer acceptance be tested (taste and cooking qualities) and be acceptable to household members to assure maximum

	impact on nutritional health. Biofortified crops need to contribute at least 30% of the estimated average requirements for them to be meaningful to a target population group. For example, based on such consideration, the HarvestPlus Program of the CGIAR has set a minimum of 14 ppm iron in polished rice to benefit women and children. For Zn – specifically in Bangladesh – a target level of 24 ppm has been set. Together with HarvestPlus, target countries are determined and specific goals determined. For example, analyses and targets for Zn for Bangladesh and India are: • Deficiency: 41-43% of children under 5 are estimated to be zinc deficient. • Average consumption of rice: 400 grams/capita/day • Benefit to farmers: High yielding, disease and pest resistant • Goal: Provide 80% of daily zinc needs through fully biofortified rice, 35% more than commonly grown varieties. • Spillover countries: Cambodia, Indonesia, Philippines, Vietnam. On vitamin A: Human nutrition research indicates that the beta carotene in Golden Rice is readily converted to vitamin A in the body, providing encouraging evidence that eating Golden Rice could help reduce vitamin A deficiency. Though Golden Rice is not yet available for consumers to purchase or eat, research – in collaboration with the Helen Keller International and university partners - so far indicates that eating about one cup a day of Golden Rice could provide half of an adult's vitamin A needs. Finally, it should be noted that crop diversification is an important GRiSP strategy in relation to improved human health and nutrition.
3. Gender	
Achievements: The most important achievements expected from the integration of gender in research are identified in the narrative section on gender. However, these do not make explicit reference to how the CRP will address gender performance indicators (see above Annex 2 indicators). As a result, with respect to Indicator 1, the Gender section does not state whether a baseline study has been designed to determine the main dimensions of gender inequality in the CRP's main target populations, relevant to its expected outcomes (and IDO). The establishment of such baselines is identified as a main objective of the	The CO reviewers of this particular section on gender request a lot of detail that could not be provided in the limited space of maximum one page as set in the template for the extension proposal. We had therefore provided extensive links to GRiSP's gender strategy and to activities where most of the requested information is provided. Also, additional information was provided in the accompanying 2013 annual GRiSP report. Here, we provide specific responses to the comments and suggestions raised. First, to further highlight gender and give it more emphasis in GRiSP, we developed a specific (seventh) IDO: improving gender equity and empowerment (in the rice sector and in GRiSP itself). We agree that our gender performance indicators still needed more work; we collaborate with the CGIAR gender network team to improve the indicators. At the time of submitting the GRiSP extension proposal, no recommendations for performance indicators were available yet. Early June, indicators were suggested and have now been incorporated in the GRiSP set of indicators, which has been considerably expanded to: • Action site: as per CGIAR gender network: Women's control over resources (Men's and women's control over selected key agricultural resources: land, livestock water, forests, common property, seeds, fertilizers, machinery, financial assets and the income from sales of crop, livestock or forest products); Women's Participation in Decision Making (decisions over own labor and own income, and decisions made in groups or collective organization) We also collect and monitor indicators related to gender inclusion in GRiSP R&D itself: full gender disaggregation of survey data; gender-specific target setting (see page 1-2 of main text, and Table 2); tracking of # of technologies with explicit gender focus and

GRiSP Gender Strategy (version 2).	with gender impact assessment; involvement of women in training, R&D activities, and as target value-chain actors (eg small-scale millers and parboilers in Africa) All specified targets in the text on pages 2 and 3, and in Table 2 are now fully gender disaggregated. On baseline data: as reported in our 2013 annual reported – and as noted by the ISPC: "*Gender-disaggregated information on gender balance in the main target domains, on the impacts of adoption of GRiSP technologies, and on the impacts of climate change on men and women and on their specific response strategies has been collected and analyzed*". However, in light of improving on our performance indicators and the gender dimension of our (to-be-developed) results-based management framework, we will integrate gender dimensions in our new baseline and progress indicator collection efforts. As the reviewers observe themselves: "*The establishment of such baselines is identified as a main objective of the GRiSP Gender Strategy*".
Gender in the workplace: The requested 1-page is missing	The total space provided for the whole gender section is 1 page, including gender in the workplace. As a program, we rely mostly on the coordinating centers implementing gender-sensitive strategies on the workplace (which we encourage through GRiSP) – gender in the workplace (as the title implies) is mostly an institutional arrangement. We provided additional information in our proposal: "GRiSP 's coordinating Centers implement gender in the workplace strategies that aim at increasing women's participation and empowerment in all its activities, but especially in (senior) management, R&D, training, and outreach activities. We encourage the provision of a gender-sensitive workplace and environment. We also invest in training of our partners"
Integration: Information on gender should be provided for the 2015 budget. Details are missing on the sourcing of the gender budget in 2015 and 2016 from W1, 2, 3 (the Fund Council is monitoring this disaggregation by Window). The Flagship narratives should include brief mentions of the relevance of gender differences to their work. The work-plan needs to systematically reflect the fairly substantial allocations made to gender in the Flagship budgets because, as it stands, their significance is unclear to the reader. The TOC, targets and indicators need to reflect meaningful attention to gender.	Unfortunately, specific gender budgets cannot (yet) be supplied by window of funding as most W3-funded projects do not have a specific line item with associated budget for gender R&D. For now, the gender budget by FP is based on best knowledge on gender activities undertaken under those FPs. Our gender strategy provides for each current GRiSP Theme a detailed ToC, IP, and narrative of prioritized activities. The current versions for Themes 3 and 4 will be synthesized into a new version for FP 4. As the ISPC has observed: "*Notable developments include the development of a new Gender Strategy, with full impact pathways and ToCs for each FP, in which main entry points for technology development that respond to gender-specific needs and preferences are identified*." The workplan contains the following highlights, with links to more detailed information: *"We strengthen women's leadership and agribusiness skills, train women in the delivery of agrotechnologies, target women in training on seed preservation technologies, include women in the development and selection of new rice varieties, specifically reach women as beneficiaries of new stress-tolerant varieties, strengthen women's groups in branding and selling rice, and help former combatant women to re-integrate in society through rice production activities. We facilitate transformative changes through the development and dissemination of policy briefs, awareness raising, advocacy events, inclusion of gender aspects in planning workshops, training of own staff and NARES partners on gender and diversity, and working with our NARES partners in developing gender RD&E action plans."*
Targets are not Sex Disaggregated (SD): Other than the training of women professionals, Targets in Table 2 are not	All specified targets in the text on pages 2 and 3, and in Table 2 are now fully gender disaggregated.

SD; they refer to farmers and consumers and actors in the rice value chain generically. No SD targets are provided for a prominent activity in the work-plan: strengthened women's agribusiness skills along the rice value chain, mechanized transplanting and post-harvest (p.15).	
Theory of change has no gender dimension: Figure 1 has no gender dimension and does not reflect pathways shown in Fig 2 of the Gender Strategy. The narrative on the ToC includes no gender dimensions.	Our gender strategy provides for each current GRiSP Theme a detailed ToC, IP, and narrative of prioritized activities. Figure 1 in our extension proposal is a simplified and combined description of GRiSP's impact pathway and ToC. In annex 2 to this document, a more detailed IP is presented in Figure 1, which is rooted in scientific and historical evidence; it is this figure that is also presented as Figure 1 in GRiSP's gender strategy and that forms the basis for overlying GRiSP's gender IP and ToC as presented in Figure 2 of our gender strategy. For completeness' sake, and for clearly embedding our gender IP and ToC in GRiSP's overall activities, we have added an updated summary in annex 3 to this document – which is best be read in conjunction with annex 2.
Indicators are not SD: Indicators 1-5 in Table 1 include no sex disaggregation. IDO 6 refers to women's empowerment and the indicator refers to number of technologies with explicit women's focus, women's groups and use of the WEAI to measure empowerment. The direction or levels of expected change in these aspects of rice innovation are not backed up in the theory of change or in the targets.	Where relevant, we made explicit which indicators contributing to IDOs 1-5 in Table 5 are gender disaggregated, while we specifically state under the new IDO 7 that all survey data will be gender disaggregated (this involves all survey data contributing to indicators for all 7 GRiSP IDOs).
4. Partnerships	
It is very encouraging to see GRiSP engaged in public-private consortia, but it will be good to state the conditions under which GRiSP is partnering with private sector. Are the conditions dependent on the size (turnover) of the company? Is the support similar for start-ups and other SMEs? Which are the Intellectual Property arrangements in these collaborations, and are they aligned with the CGIAR Intellectual Assets Policy? How	"*State the conditions under which GRiSP is partnering with private sector*". GRiSP follows the guidelines and policies for public-private sector collaboration of its coordinating centers and does not aim to set up independent rules and regulations. An example of IRRI's four guiding principles for public-private sector collaboration is given: 1. Private companies or industry associations may make contributions to specific research areas or to international consortia that involve a large number of public- and private-sector partners. For example, since 1997, three international fertilizer industry associations have provided additional support to the Irrigated Rice Research Consortium (IRRC), which receives its main funding from several public-sector donors. These funds were used by IRRI and its national partners to conduct research on new approaches for efficient, sustainable nutrient management in rice-based systems. Another example is the Hybrid Rice Development Consortium (HRDC), in which more than 25 seed companies pay membership fees that are used to support research on hybrid rice improvement, hybrid management, and capacity building. 2. The primary method of bilateral private-sector research collaboration with IRRI is through Scientific Know-how and

will the impact on the poor and smallholders benefit be measured? How likely is it that supporting the private sector will benefit the smallholders?	Exchange Programs (SKEP). IRRI's SKEPs focus on research areas of mutual interest, scientist-to-scientist interaction, and capacity building for young scientists. We avoid areas that could cause complex intellectual property (IP) issues and we ensure that research results are made widely available. SKEPs do not involve any commercialization agreements. For example, IRRI has a SKEP with DuPont that includes joint research on genetic characterization of hybrid lines widely used by public- and private-sector breeders, understanding mechanisms for improving the resistance of rice to planthoppers, and funding for a doctorate scholarship for a young scientist from Asia. 3. The private sector has specific expertise and networks for delivering products and services effectively and efficiently to farmers. By working with our private-sector partners on a nonexclusive basis another channel for delivering our research solutions is enabled. In such cases, IRRI provides initial technical support and assistance with capacity building for delivering new technologies coming out of research conducted by IRRI and its national partners. Private companies, like other partners, use their own resources to deliver these technologies to farmers and also provide feedback for further improvement. An example of a technology delivery partnership we have is with Syngenta, which through its networks of agronomists and dealers in Bangladesh, promotes the use of alternate wetting and drying – a crop management method that can improve water-use efficiency in rice. 4. IRRI has established two new legal entities for fund-raising purposes in support of our mission - the IRRI Fund Singapore and the IRRI Foundation Hong Kong. They focus on private philanthropy, increasing private sector support, building an endowment, and generally increasing support for rice research within Asia. An example of one such donation is through 5 PRIME, a life science company, which has donated to IRRI a significant amount of laboratory chemicals for use in our research. *"Are the conditions dependent on the size (turnover) of the company? Is the support similar for start-ups and other SMEs?"* There is no 'one size fits all' condition for collaboration; this depends on the type of activities under the collaboration, goals, objectives, and – yes – sometimes on size of the private sector partner. For example, benefits of being a member of the Hybrid Rice Research and Development Consortium and of the Sustainable Rice Platform are independent of size of company, but in these cases, membership fees do depend on the nature of the company (public or private) and size of the company (for private companies). In the post-production value chain, we assist SMEs and start-up companies with developing business models – there is no need to do this for large and well-established companies. *"Which are the Intellectual Property arrangements in these collaborations, and are they aligned with the CGIAR Intellectual Assets Policy?"* Like guidelines and policies for public-private sector collaboration, the intellectual property arrangements are handled at Center level. Yes, these are aligned with the CGIAR intellectual assets policy. *"How will the impact on the poor and smallholders benefit be measured? How likely is it that supporting the private sector will benefit the smallholders?"* In adoption and impact assessment studies, we (or the commissioned party) analyse the pathways and effectiveness used by various collaborators in dissemination of GRiSP technologies. For example, detailed partnership analyses for reaching impact at scale were recently analysed and reported for various technologies and working groups of the Irrigated Rice Research Consortium. The results of these and other analyses again point to the 'no one size fits all' solution: there are cases where the public sector is still the main avenue for technology delivery, while the private sector is more effective in another. The delivery of new rice varieties is a case in point: whereas it is still the public sector that was most instrumental in delivering stress-tolerant

	inbred varieties in India, it is the private sector that is most effective in dissemination of hybrid rice varieties. The public sector has a dismal performance in distributing and maintaining equipment and machinery (laser levelers, combine harvesters, etc) while the private sector has a better track record. In general, the existence of a vibrant and innovative private sector is more and more recognized as catalyzing development.
5. Budget	
Based on the FinPlan, GRiSP W1/2 budget is expected to reach US$37,1 and US$40,8m USD for 2015 and 2016, respectively. However US$37,7m and US$41,4m are mentioned on page 17 of the Extension Proposal for these 2 years, with a 10% increased for 2016, giving a W1/2 budget of US$44,9m. If this extra budget is provided for 2016, GRiSP needs to indicate more precisely which CoAs this 10% extra budget will be supporting.	The difference in the FinPlan and the presented budgets lies in the additional 600 K $ for the fast-track M&E project awarded by the CO to GRiSP in 2014. The 10% increase is in line with the annual increases in the FinPlan for 2014 and 2015, and as noted by the ISPC, "*The budget for 2016 appears to be coherent with the original proposed and based on past years appears to be feasible".* Based on the suggestions by the CO, we have highlighted in each FP what results the10% budget increase in 2016 will additionally support (indicated with red font in Table 3).

2 Annex 1: GRiSP Flagship Project impact pathways and theories of change

Each GRiSP Flagship Project (FP) has its own impact pathway and associated theory of change. Even at levels below that of the FP, specific impact pathways and associated theories of change will exist for individual products and potentially for different regions where the products are being deployed. For example, a product such as "improved drying facilities", which is aimed at manufacturers and operators of drying equipment, will have a completely different impact pathway from "improved on-farm hermetic storage", which aims at small farmers as end users, even though both products are developed in the same FP (4) of GRiSP. In this chapter, we present either a generic or a typical impact pathway with its associated theory of change for FPs 2-4 of GRiSP. FPs 1 and 5 are primarily outcome-facilitating FPs and play a role in the "facilitating actions" identified in the theories of change of the FPs 2-4. Separate impact pathways, however, are being developed, and an early draft for FP 5 is also included in this section. The specific impact pathway and theory of change for GRiSP's gender component is presented in the GRiSP gender strategy.

2.1 FP 2: Harnessing genetic diversity

Genetic diversity is the foundation of the genetic improvement of crops. Knowledge of multiple facets of rice genetic diversity from the molecular to the phenotypic is essential for effective conservation and use to meet both current and future needs. Although a vast catalogue of genes has been revealed as a result of recent advances in sequencing technologies, most of their functions remain largely unknown. Thousands of undiscovered genes can potentially benefit rice productivity and quality but the processes to decipher their functions are complex—requiring cutting-edge technologies, modern phenotyping methods, and bioinformatics. FP 2 draws together germplasm conservation, diversity analysis, gene discovery, and dissemination of advanced genetic/breeding resources, presenting a unique opportunity to maximize the use of conserved and customized germplasm (Fig. 1). Research will include a wide spectrum of genes for traits that have high impact in the various rice production environments and to mitigate the effects of a changing climate. The basic approach is to improve the conservation, characterization, and use of the world's rice gene pool for varietal development by joining the resources of organizations across the globe. This will mean joint management of the world's rice genetic resources both in genebanks and in situ locations in research, development, and extension institutions. The FP will capitalize on the rapid advances in DNA sequencing technologies to reveal rice diversity in a comprehensive manner.

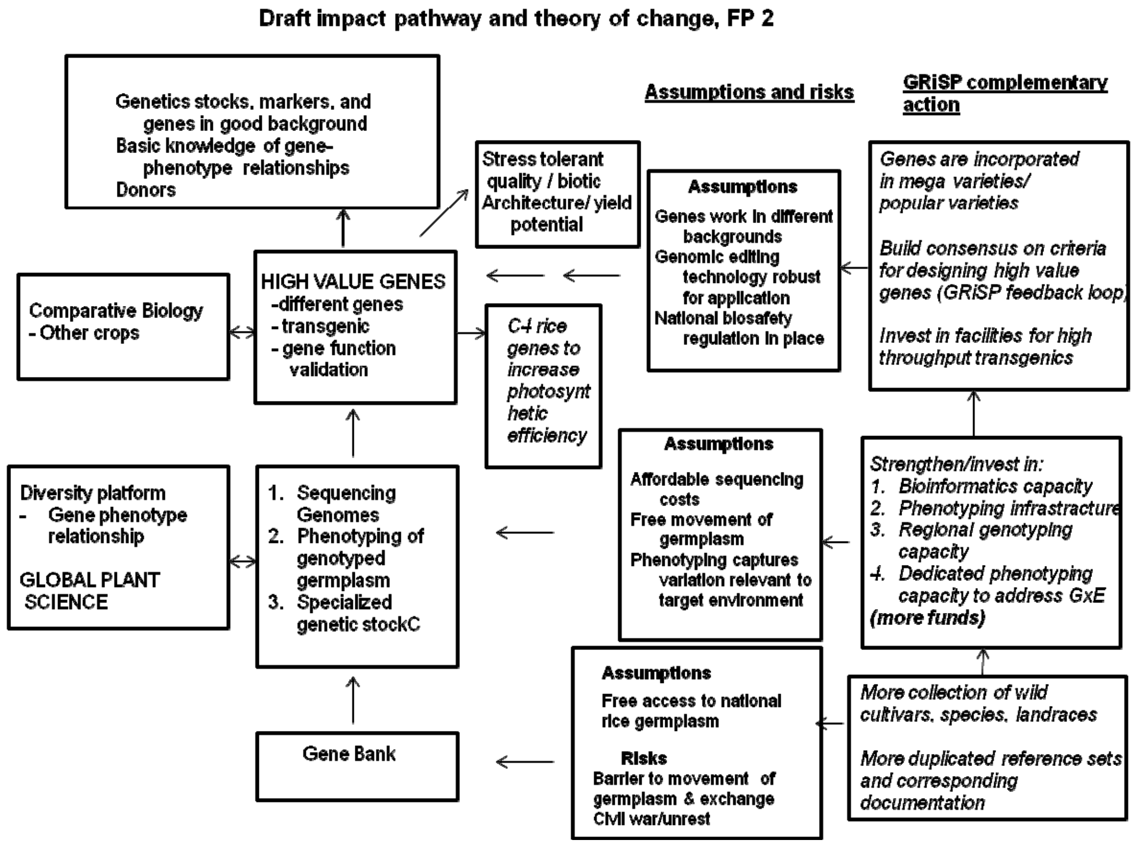

Fig. 1. Schematic diagram of GRiSP's FP 2 impact pathway and theory of change

A key assumption for effective conservation, dissemination, and characterization of rice germplasm is a system of free exchange of germplasm. However, there are barriers in the movement of germplasm between nations. While GRiSP alone cannot resolve this problem, we can play an advocacy role to promote free exchange of germplasm based on the principles articulated by the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). Another assumption for meeting uptake and impact targets is continued funding from the Global Crop Diversity Trust (GCDT) and its extension to AfricaRice and CIAT.

To sequence a large portion of Genebank collections, we assume that the cost of sequencing technologies continues to decline. We will form partnerships with sequencing technologies companies to ensure implementation of the project at an affordable cost.

To have accurate prediction of gene functions, we assume that the phenotypes capture variation relevant to a target environment. Complementary action to develop regional genotyping and phenotyping systems to address genotype by environment will be necessary.

The large datasets from sequencing and phenotyping pose a serious challenge to our capacity to handle and to use the data. A main assumption is that we invest in building bioinformatics capacity to archive, analyze and use the large datasets for the

long term. We will pursue a consortium approach to harness complementary expertise from the plant science community. An initiative on forming an International Rice Informatics Consortium (IRIC) was launched in January, 2013. Another assumption is the availability of a well-trained workforce to implement the project. This will require training and career building. A renewed effort is needed to expand graduate scholarships and postdoctoral opportunities to build a generation of scientists with new skill sets and disciplinary versatility.

We expect a large number of candidate genes from association genetics and gene network analysis. To use this wealth of information on hypothesized gene functions will require an efficient system to validate gene functions. Furthermore, since complex traits are often controlled by multiple genes, it is important to have a system to evaluate multiple genes and their interactions by multi-gene engineering. We will collaborate with partners who pioneer gene function validation technologies. To minimize investment risk, a consultative approach will be needed in prioritize what genes need to be studied in details.

2.2 FP 3: Developing improved rice varieties

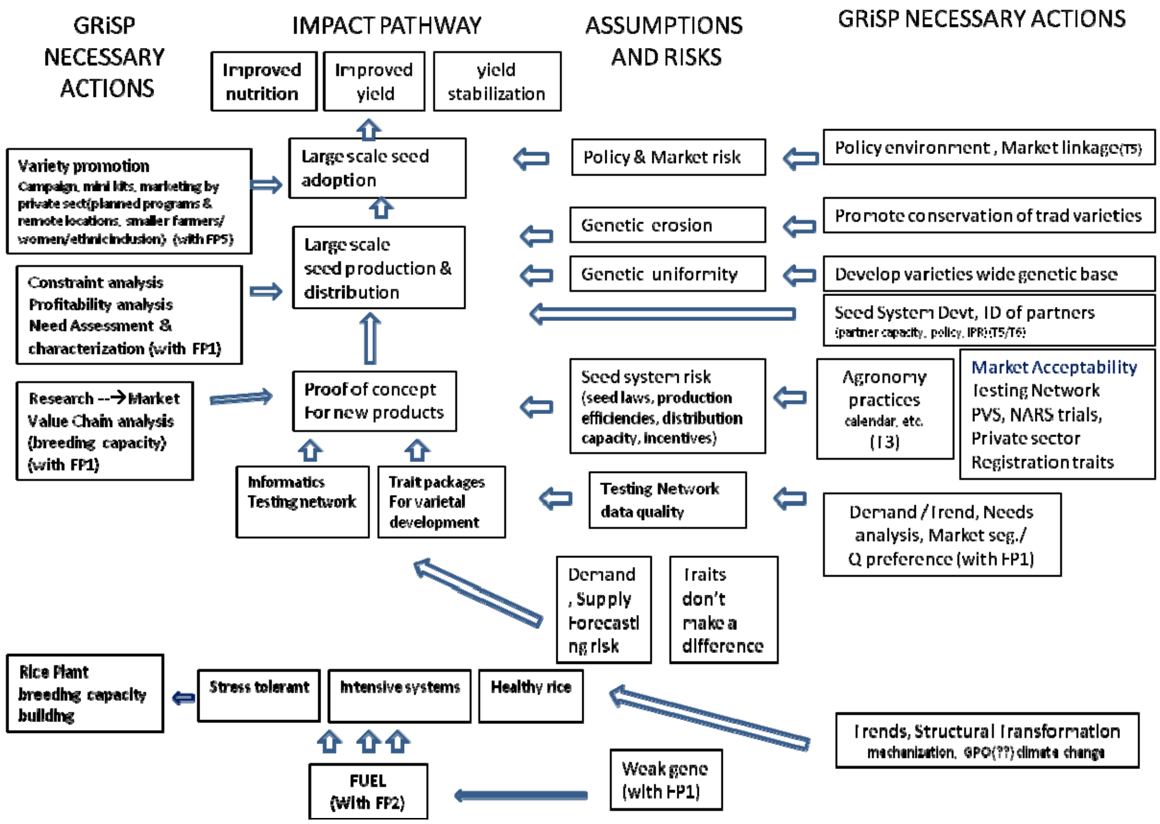

Fig. 2. Schematic diagram of GRiSP's FP 3 impact pathway and theory of change

Farmers across continents and countries, in which rice is a major commodity for food security, achieve improved yield, more stable yields and better nutrition through their adoption of new varieties with desired trait packages (Fig. 2). The products for this improvement are genetic materials with traits for stress tolerance, or intensive systems or for healthy rice. The product may be pre breeding materials for countries with breeding capability or direct release in countries with limited breeding capability. The proof of concept by NARES and private sector agents and farmers is achieved through a varietal testing network across countries. The testing may involve PVS, NARES trials and private sector trials. This is coupled with the development of agronomic practices that match the seasonal calendar and the ecosystem in which the materials are being targeted. The public sector and private sector and civil society organizations produce large quantities of quality seed to match farmer demand through formal and informal mechanisms of the seed system that is specific for each country. Through 'seeing in the field' and access to seed large numbers of farmers grow the new varieties.

Within the pathway there are assumptions and risks that require mitigating actions. The gene traits may not produce the desired trait response. The new material may not match market demand. The testing network may be poorly managed with unreliable data. The seed system may be weak with in appropriate seed laws and poor variety release mechanisms, inability to respond to market demand with seed in sufficient quantity and quality. The community seed system of remote locations may not be connected to the formal sector resulting in lack of observation of new varieties and lack of access to seed. The partner capacity at breeding and network varietal testing and the seed production and distribution system may be weak. The policy environment and market linkages may not be conducive to large scale uptake of the new variety. There may be a potential risk of genetic erosion through a potential significant mega variety success.

GRiSP will underpin its varietal program with need analysis and trend analysis to understand value chain demand in market preferences of the urban or international consumer. There will be trait needs assessment for specific ecosystems in relation to climate change or shifts in production practices due to labor shortages and the expansion of direct seeded rice or fitting a cropping calendar that enables farmers to achieve additional income through further crop intensification. The needs analysis will reduce risk of unacceptable variety development and will drive the trait development efforts. Weaknesses in the market acceptability testing network will be minimized through capacity building around the integrity of the approach through to the informatics that allows analysis and interpretation across sites and countries and regions. Attention to partner identification in the seed system for specific market segments and the capacity building of the actors in the seed system chain will lessen the risks of failure to deliver of the seed system itself. The active engagement with policy makers and their exposure to issues around trait development, release and seed system robustness will support the outcome of new variety development to large scale uptake by farmers.

2.3 FP 4: Sustainable intensification along the rice value chain

Specific impact pathways and theories of change are developed for the production and post-production phases of the rice value chain.

2.3.1 Rice production chain

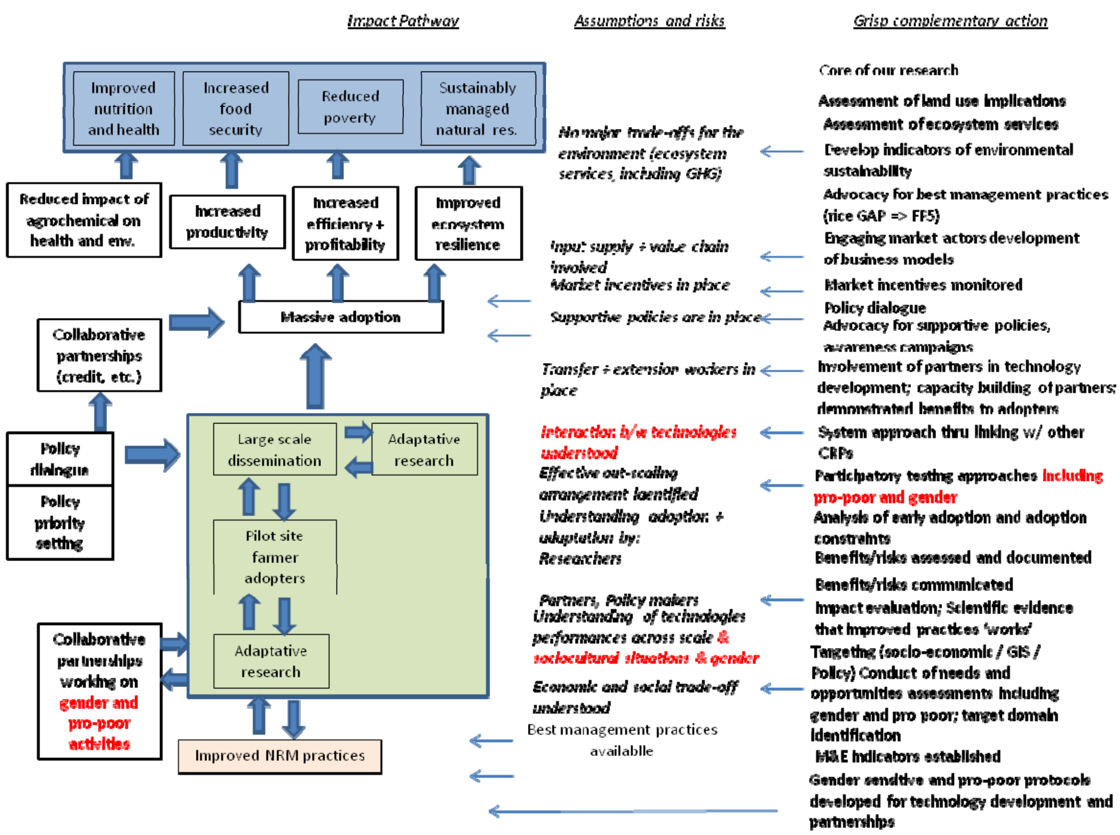

Fig. 3a. Schematic diagram of GRiSP's FP 4 impact pathway and theory of change for the rice production part of the rice value chain.

Natural Resources Management (NRM) practices and tools will be developed with the goal of achieving one or more Intermediate Development Outcomes (IDO) including reduced impact of agrochemicals on health and the environment, increased productivity, increased efficiency and profitability, and improved ecosystem resilience (Fig. 3a). Identifying NRM practices and tools which achieve one or more of these IDOs, that are a national priority and are simple for farmers to implement and for other farmers to observe and copy will increase the prospect for mass adoption.

Promising NRM practices are developed and then tested in farmer's fields to assess their performance and farmers' acceptance. Based on needs assessment at a national (policy) and local level, and identification of immediate and end-level users of the R&D,

benchmarking of technologies in fields of farmers (scientist led) and participatory testing (farmer led) are conducted to provide early information about potential adoption and constraints. Results from benchmarking, adaptive research, participatory testing, and early adoption studies contribute to further refinement of NRM practices and tools. These results feed into communication materials and approaches (e.g. message design workshops; learning alliances) for technology promotion and extension. Evaluations will be undertaken of the potential adoption constraints such as availability of credit, willingness of farmers to take risk, policy landscape, etc. Capacity building of partners and extension officials (link with FP 5) will be critical for achieving large scale and effective dissemination. Learning from past and present adoption studies in the targeted areas and feedback from stakeholders, identify improved dissemination and extension methods.

Socio-economic assessments, policy research, and GIS analyses (FP 1) will facilitate targeting for appropriate locales and agro-ecosystems. Assessments of ecosystem services will also guide the targeting process and assessments of NRM practices. To enable this, indicators of environmental sustainability will be developed through the Sustainable Rice Platform (SRP), IRRC and other initiatives. Targeting of NRM practices to suitable locations will be critical for achieving impact and aid the optimization of rice production.

Policy dialogue and advocacy for a favorable policy environment will be undertaken to support the scaling up (policy support) and scaling out (dissemination) of innovations, NRM options and practices. Dialogue with market and value chain actors will foster the development of sustainable business models that contribute to the scaling out of NRM practices and tools.

2.3.2 Post-production chain

The two main post-production outputs of FP3 are Best Management Practices (BMP) for Postharvest and improved postharvest technologies (PHT) for harvesting, threshing, drying, parboiling, milling storage, the utilization of rice straw and husk (Fig. 3b). Some of these technologies are produced centrally either in-country or abroad (e.g. combine harvesters, hermetic storage systems), others are better adapted to local conditions and produced locally by Small and Medium Enterprises (SME) to suit end users needs (e.g. threshers, dryers). Improved postharvest management options are included in Best Management Practice recommendations. Based on the results of need assessments and initial feasibility studies both outputs are verified in collaboration with NARES partners in NARES research trials and then in participatory verification trials by first adopter farmers and processors.

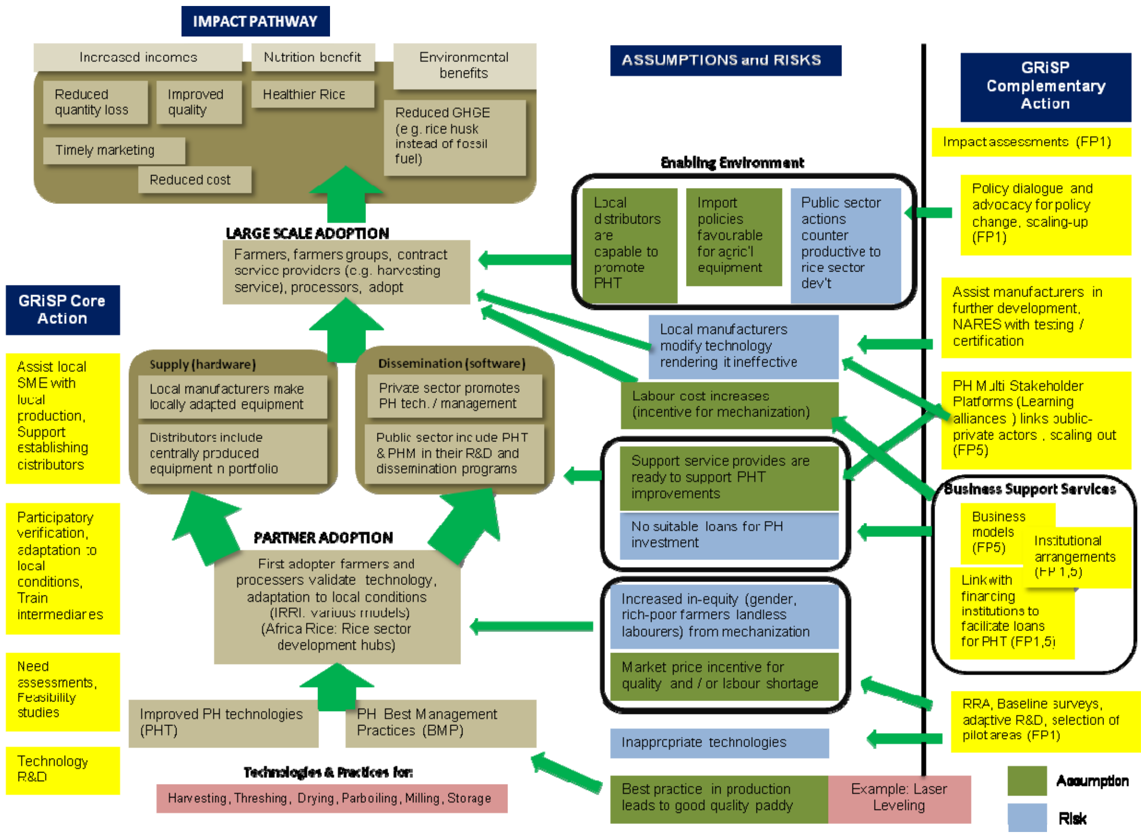

Fig. 3b. Schematic diagram of GRiSP's FP 4 impact pathway and theory of change for the post-production part of the rice value chain.

Once technical and economic feasibility is established and the technologies are suitable for local conditions the supply of the technologies (hardware) is established by either assisting local SME in building up a local production and after sales services for locally adapted technologies or by facilitating the set-up of a local distribution network for centrally produced machines. At the same time capacity is built at NARES partners and farmer intermediaries to enable them to promote the PHT and BPM through their national dissemination programs. Both, the establishment of the supply chains for equipment and the promotion of improved PH management through national programs and the private sector players who are involved in the supply chains lead to large scale adoption by one or more of the following end users: individual farmers, farmers groups, contract service providers (e.g. for providing a harvesting service), processors and other rice value chain actors. Large scale adoption of improved PHT and BMP leads to either one or more of the following: Improved product quality, reduced physical losses, timely marketing allowing producers to take advantage of seasonal price differences, and reduced cost, e.g. by mechanizing labor intensive operations where labor shortage exists, all leading to increased incomes. BMP lead to a reduction in mycotoxin contamination of the rice and thus contribute to healthier rice. Optimizing energy efficiency of agricultural and postharvest equipment, the development of solar drying technologies and the use of rice by-products for heating the air in rice dryers or for

generating energy for other purposes reduce greenhouse gas emissions and pollution and thus provide environmental benefits. Note that this impact pathway is represents a generic one of theoretical nature and in practice circular processes and shortcuts are possible. After initial small scale adoption by a few first adopter end users the PHT might undergo another round of technology R&D based on the experiences of the . To introduce the flat bed dryer, GRiSP had directly worked with manufacturers from Myanmar, Cambodia and Lao and trained them in Vietnam on dryer manufacturing, and once after local manufacturing was established, promoted the technology to first adopter farmers, which had led to sustainable adoption.

	Assumptions, risks	**Activities undertaken**
Product development	(1) Best practice in production leads to good paddy, which is a pre-condition for the production of high quality milled rice (2) Risk: Inappropriate PHT are either not economically feasible or are not matched to local conditions.	(1) Promote good quality paddy by linking with FP 3 and by promoting key mechanization technologies that lead to paddy quality improvements like Laser Land Leveling, which leads to more even maturing and thus to better paddy quality. (2) Rapid Rural Appraisals to determine needs, adaptive R&D to adapt PHT to local conditions and baseline surveys in key target areas to establish economic incentives.
Research outcome – intermediate user (partner adoption)	(1) Partners are enabled to research and promote improved PHT and BMP (Addressed by GRiSP Core Action. (2) Market incentives for better product quality exist and / or labor shortage leads to high processing cost. (3) Risk: Increased in-equity with respect to women or marginalized groups like landless laborers from mechanization (4) Local SMEs are not able to produce improved PHT (addressed by GRiSP Core Action) (5) National distributors of centrally produced equipment either don't exist or don't know PHT (Addressed by GRiSP CORE action) (6) Business support service providers (assisting with business planning) are ready to support improved PHT (7) Risk: Suitable loans for PHT investments are not available. (8) Labor cost continues to increase and provides an incentive to mechanize (9) Risk: Technical modifications made	(1) Training of partners / farmers intermediaries on improved PHT and BMP, partner managed technology verification research trials. (GRiSP Core Action) (2+3) Selection of suitable pilot areas based on RRA results and baseline surveys. (3) Identification of mitigation strategies (4) Capacity building for local SMEs on production techniques and new PHT, (5) Assist manufacturer in identification of local distributor, train staff from local distributor on PHT (6) Develop business models and business plan templates for PHT usage. (6, 7) Improve institutional arrangements for business support services (Africa) (6, 7) Conduct round tables to link PHT users with financing institutions (9) Assist manufacturers in further

	by manufacturers decrease technology performance and threaten successful introduction	development of the technology and with adapting it to end users needs. (9) Assist public sector with building capacity in equipment testing and protocols for machinery certification
Research outcome – end user	(1) Local distributors are able to promote PHT (2) Import policies and duties are favorable for agricultural machines and equipment (3) Risk: Public sector action like government machinery distribution programs are counterproductive to rice sector development	(1) Facilitate multi stakeholder platform (Learning Alliances) to link public and private sectors to support the out-scaling of PHT and BMP (2+3) Facilitate policy dialog and advocate for policy change (up-scaling)
Intermediate development outcome(s)	(1) Increased incomes from a. Reduced physical losses lead, b. Selling better quality rice, c. being able to store safely and selling when prices are high in the off season instead of right after harvest, and d. reduced cost of operations like mechanized harvesting compared to manual harvesting. (2) Health and nutritional benefits from consuming rice that has lower levels of mycotoxins. (3) Environmental benefits from a.) Reduced greenhouse gas emissions from using biomass as fuel in drying instead of fossil fuel, and from more energy efficient equipment, and b.) less pollution from reduced straw burning in the field.	Impact assessments to verify benefits

2.4 FP 5: Outscaling and capacity building

Tools, products and platforms for communication, extension and delivery involving a number of distinct set of FP 5 specific products construct the basis for the impact pathway. These products include: targeted knowledge products (e.g. fact sheets, brochure, book-lets), innovative communication tools (e.g. video, mobile apps), effective knowledge platforms/hubs across rice producing regions (RKB, country KB, CSISA portals), training modules and programs for capacity building for technical competencies, partnership skills, business acumen etc. Other products that directly contribute and complement to this set from other Programs are new varieties (FP 3), improved crop management systems innovations (FP 4), improved post-harvest technologies (FP 4) and policy and linkage (FP 1). These technology innovations in

combination with knowledge, tools and extension delivery systems, capacity building and skills development on developmental and values aspects and training modules and program form the diverse sets of products for FP 5.

Partnership, linkage and processes interface strategies for delivery and projects programs and initiatives and partners. Products are developed, pilot tested and further improved in different projects, programs and initiatives, by other donor agencies, national government projects and programs in partnership, network development and linkages with all concerned actors. Strategies effective for delivery are developed, tested and further improved to work out with the products to achieve improved systems such as improved seed delivery systems, improved post-harvest delivery systems, improved crop management delivery systems as outcomes.

Training and capacity development program contribute to enhanced capacity of extension and service providers, scientists and farmers and help develop a cadre of trained quality researchers and extension agents.

As an outcome of the delivery systems and enhanced capacity of extension agents and service providers large scale adoption of technologies and extension approaches take place which ultimately resulting to increased productivity and inclusive development. FP 5 considers these two results as intermediate development objectives (IDO). Inclusive development refers to inclusion of women, poor farmers and ethnic minority groups in the developmental processes.

Business model initial support comes from FP 4 but since the requirement for business support from FP 5 is far diverse compared to FP 4, it requires having its own strong component of business model that can address models for large scale initiatives in all sectors, public, private, civil society or even for mixed models.

It is assumed that targeted linkage and network partners will be willing to work together with GRiSP and the policy environment will support such initiatives taken independently by GRiSP partners or jointly with public, civil society, private agency partners. Enabling policy supports to engage in in-country programs with various agencies will be realized in collaboration with FP 1. Intermediate users – NARES, governments, civil society organizations, private sector and farmer organizations support, collaborate and partner with FP 5.

	Assumptions, risks	**Activities undertaken**
Product development	1)Innovative approaches are supported by government and other policies; 2)projects/other FPs allow FP 5 to participate in their activities	1)Communicate through ongoing projects and programs and country offices & keep close contact with governments; developing new projects with

	Assumptions, risks	Activities undertaken
	3)Partners allowing their personnel to get trained 4)Delivery systems are complementary and accepted by government, NGO & private sector initiatives 5)Knowledge products are recognized and accepted 6)Communication tools are recognized and accepted 7)Knowledge hubs are widely used 8)Market environment favorable/supports newly introduced technologies	governments; 2)Links with projects are ongoing but need to be further strengthened 3)Training centre has long relation with agencies for training which helps build the relation further; 4)Trying to develop delivery systems in partnership with such agencies which will help complement 5) &6)Following a participatory approach which needs to continue and also in partnership 7)Mostly supporting the existing knowledge hubs developed by in country partners instead of creating new; the approach will continue; 8) This can also be a risk; will keep close linkage with Program5 for this;
Research outcome – intermediate user (partner adoption)	1)Business analysis of extension models are viable 2)Business models for delivery are financially viable 3) Partnership and network development activities match with government and other policies	1)&2)Will link with FP 1 to understand viability of business models; will also strengthen the strength of FP 5 to understand Business models of different delivery approaches better 3)Working closely with network and linkage partners from government, civil societies and private agencies; this approach will to be strengthened further which will ensure that it matches with government and other policies; will also keep close link with FPs 2-4 and projects to get regular update on policies;
Research outcome – end user	1) Farmer associations & farmers finds these approaches viable for them 2) Local partners are able to promote technologies and extension approaches	1)Approaches are participatory, farmer associations and farmers can anticipate 2)Partnership development process takes care of partner buy-in from the beginning and help develop approaches that match partner agencies
Intermediate development	1) Favorable policy environments continue and are supportive	1)&2)Work closely with government agencies and develop approaches;

	Assumptions, risks	Activities undertaken
outcome(s)	2) National and donor funding regimes favor new initiatives	also keep close linkage with FP 1 to get update; Impact assessments to verify benefits

3 Annex 2: Evidence base for impact from rice research

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In its Strategy and Results Framework, the CGIAR has adopted four system level outcomes (SLOs) that serve as the focal point of all CGIAR research activities (CGIAR, 2012):

1. Reduced rural poverty (SLO 1)
2. Improved food security (SLO 2)
3. Improved nutrition and health (SLO 3)
4. Sustainably managed natural resources (SLO 4)

In accordance with the above SLOs, the mission of the Global Rice Science Partnership (GRiSP) is to reduce poverty and hunger, improve human health and nutrition, reduce the environmental footprint, and enhance ecosystem resilience of rice production systems through high-quality international rice research, partnership, and leadership. An evidence-based impact pathway (Figure 1) guides the research and development activities of GRiSP to deliver on its mission and on the CGIAR SLOs. In this chapter, we summarize this evidence base as derived from published literature.

3.1 Reduced rural poverty

Various pathways can lead to reducing rural poverty, but increased agricultural growth through improved productivity, markets, and incomes have been shown to be particularly effective contributors (Hazel, 2008; Timmer et al., 2010). Productivity growth in the agricultural sector can also contribute to growth of regional or national economies through so-called “growth linkages”, of which lowered food prices for workers is an important factor in rice-based Asia (Hazell, 2010). An important contributor to increased productivity is increased yields[2]: “*The most direct way in which R&D can impact on productivity growth is through yield levels and yield variability* (Hazel, 2008)”.

[2] Here, ‘productivity’ is treated synonymous with resource use efficiency (water, nutrients, agrochemicals, labor, energy, etc) while ‘yield’ is a special form of productivity, namely land productivity. For example, productivity with respect to water is defined as the amount of rice grains produced per unit water used.

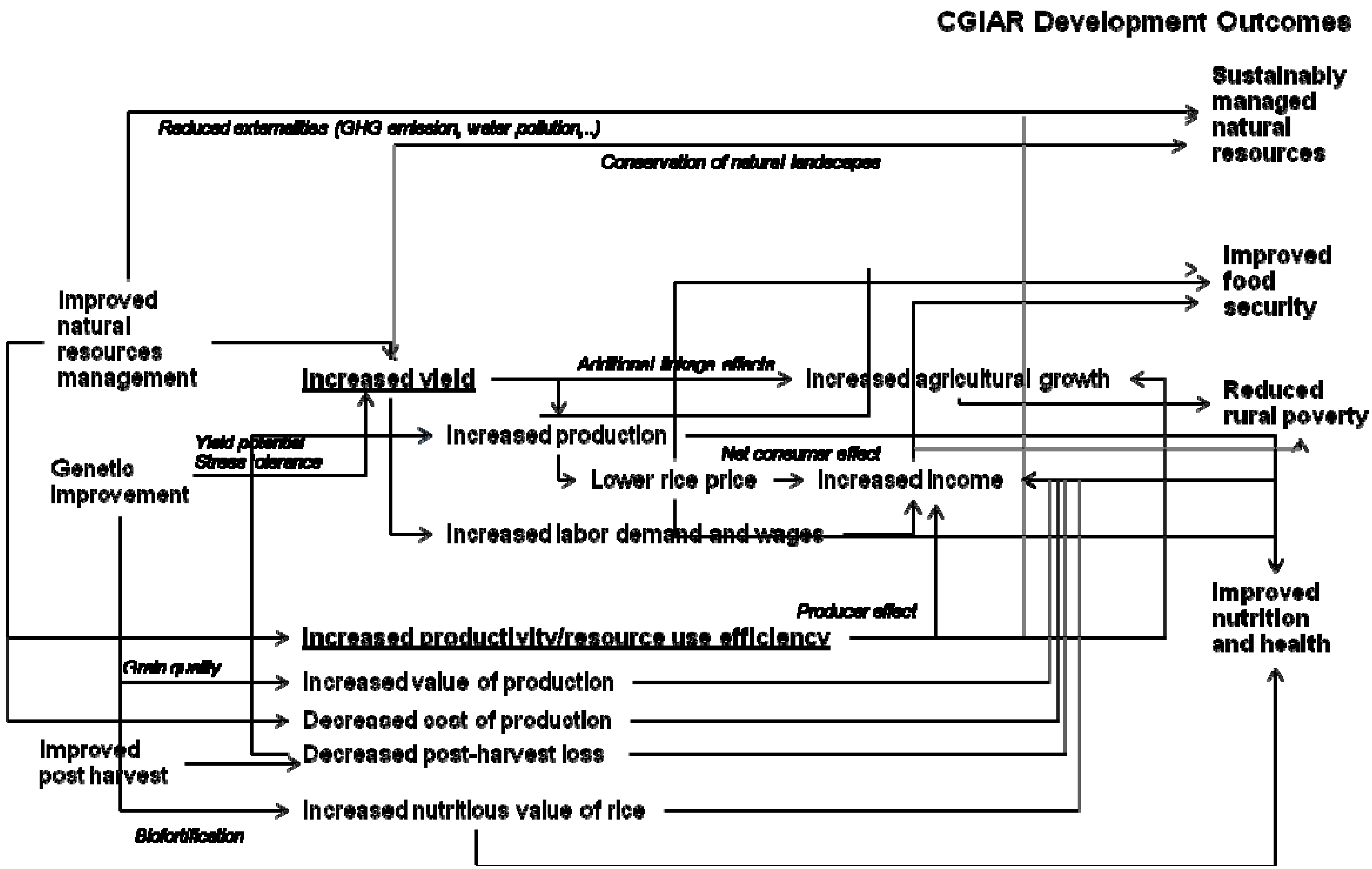

Figure 1. Schematic diagram showing how results of rice research feed into the system level outcomes of the CGIAR.

Fan et al (2005) list three major pathways through which increased rice yields contribute to poverty alleviation: farmers produce more output at the same cost which directly improves their income, increased rice production (through increased yields) lowers food prices, and the productivity consequences (higher yields) results in greater demand for labor and wages. The effect on lower rice prices is critical as poor people in Asia spend a large part of their income on rice, so lower rice prices increase net expandable income.

Evidence for the contribution of increased productivity of cereals, including rice, on poverty alleviation comes from the Green Revolution: the realized yield and productivity increases reduced the production cost per kg of cereals harvested (Hazell, 2010). "*This was a win-win outcome in which cereal prices could decline to the benefit of consumers even while farmers and agricultural workers increased their earnings*". For example, between 1971 and 1980, total factor productivity for rice production grew by 5.75% in Haryana, 2.38% in Punjab, and 3.62% in Tamil Nadu – all three major rice producing states of India (cited in Hazell, 2010). At the same time, the real cost of producing one kg of rice fell 5.67%, 2.68%, and 4.55% per year, in the same States, respectively, benefitting the rice farmers. Between 1961 and 2008, world average rough rice yields increased by 1.79%, or 52 kg ha^{-1}, annually (Dawe et al., 2010), while the real world price of rice dropped from around 900 US$ t^{-1} to around 300 US$ t^{-1} (in 1997 US$ prices) before the food price hikes of 2007-2008 (Barker and Dawe, 2002; Timmer et al., 2010). Using the IFPRI-developed international multimarket model IMPACT, Evenson and Golin (2003), computed that crop yields in developing countries in the year 2000 would have been 19.5-23.5% lower if the breeding improvements contributed by the CGIAR institutes during the Green revolution would not have taken place. At the same time, equilibrium prices for all crops combined would have been 35-66% higher than they actually were.

3.1.1 Increased yields

Increased yields and productivity can be brought about by genetic improvement, improved natural resources management, or a combination of both.

3.1.1.1 Genetic improvement

Genetic improvement for increased productivity consists of increasing the yield potential and/or increasing tolerance (or resistance) to biotic (drought, submergence, salinity) or abiotic (pests, weeds, diseases) stresses. Genetic crop improvement of rice, undertaken by the CGIAR and its partners, has a huge track record in contributing to crop improvement and subsequent yield gains and poverty alleviation (refs). In 1998, 29% of the world's 150 million ha rice area (harvested area) was grown to a variety that was crossed by CGIAR centers, while 58% was grown to a variety with any CGIAR ancestry (Renkow and Byerle, 2010). In a recent study, Brennan and Malabayabas (2011) found that in the 2000s, 40% of all new varieties released in the Philippines were

direct IRRI crosses while 70% of released varieties had an IRRI ancestry. In Indonesia, 89% of all new varieties released from the 1980s onwards had IRRI ancestry, while this number was 77% in Vietnam. Yield gains from IRRI's genetic improvements (only to increased yield potential, not to other traits such as pest and disease resistance) between 1985 and 2009 averaged 11% across these three countries. In 2000, 19% of the total rice area planted in China and 58% of the total rice area planted in India had an IRRI variety in their pedigree (Fan et al., 2005). Using different rules to assign weights to pedigree ancestry of IRRI varieties in actually released varieties, Fan et al. (2005) estimated that, in 2000, IRRI's genetic improvement program had contributed 12-64% to the $3.6 billion benefits from rice research in India, and 0-22% to those of the $5.2 billion in China. The economic value of IRRIs rice improvement in Indonesia, the Philippines and Vietnam averaged $1.46 billion per year over the 1985-2009 time period (Brennan and Malabayabas, 2011). The global average annual benefit of CGIAR research on rice [through genetic improvement] is estimated to be $10.8 billion, which is 47% of total benefits derived from all CGIAR research (Raitzer and Kelley, 2008).

Fan et al. (2005) calculated the impact on rural poverty reduction in India and China that could be attributed to IRRI's rice variety improvements. In India, some 2.73 million rural poor were lifted out of poverty in 1991 and some 0.56 million in 1999 because of IRRI's varietal improvement research. In China, 1.02 million rural poor were lifted out of poverty in 1981 and 30,000 in 1999 because of IRRI's rice improvement. The authors also note that similar or even larger poverty impacts were found in Bangladesh, Indonesia, and Vietnam, and that effects of agricultural research on urban poverty were as large as on rural poverty.

The evidence cited above of net benefits of genetic improvement reflects only the contribution from CGIAR work. When the breeding efforts of national parties are included, the benefits are even larger. For example, total rice variety improvement lifted 3-5 million people annually out of poverty between 1991 and 1999 in China, and 1.5-5 million people in India (Fan et al., 2005).

3.1.1.2 Improved natural resources management

While the genetic potential of varieties determines the maximum yield level farmers can obtain in their fields, their natural resources management (i.e., management of crop, soil, water, nutrients, pests, and diseases) determines how much of this yield potential is actually realized (Rabbinge, 1993). The increases in rice yield during the Green Revolution were based on a combination of improved high-yielding crop varieties with increased use of fertilizers, irrigation, and pesticides (Hazel, 2010). Improved natural resources management can lower, or even close, the yield gap between current farmers' yields and potentially attainable yields. Below, some examples are given on the effect of improved natural resource management practices, derived from research, on rice yields. The first examples deal with overall improved crop management, while the second and third examples deal with improved fertilizer management and improved pest, disease, and weed control, respectively (these examples, though, are far from complete or exhaustive).

In Australia, the department of Primary Industries has developed the Ricecheck system as a practical management guide for improving rice yields, profits, and sustainability of rice (State of New South Wales, 2011). Using the same rice variety *Amaroo*, yields of 1396 crops between 1994 and 1998 increased from an average of 8.5 t ha^{-1} to 10.9 t ha^{-1} when farmers adopted seven improved crop management practices (Lacy et al., 2002). Following a similar approach, improved agronomy was successful in increasing farmers' yields in South American countries. In Guangdong, China, the Rice Research Institute of the Guangdong Academy of Agricultural Sciences and IRRI developed the "Three Controls" technology based on years of research on soil fertility, crop nutrition, physiology, and pest and disease management (Zhong et al., 2010). The Three Controls technology is based on reduced fertilizer nitrogen inputs, controlling unproductive tillers, and reduced disease and insect damage. Applying this technology, farmers in Guangdong can typically get a 5-10% yield increase, save 20% of nitrogen fertilizer, save 1-2 pesticide/disease control sprays, and achieve an additional 220 US$ ha^{-1} income.

Increased use of fertilizers has been a major factor contributing between 30 to 50% of yield growth in developing countries since the Green revolution (Gregory et al., 2010). The system of Site Specific Nutrient Management (SSNM) was developed by IRRI and its partners to assist rice farmers with their fertilizer management to raise yields, improve fertilizer use efficiency, and reduce losses to the environment. In India, yields by adopting farmers in irrigated environments were 17% higher, and profit per hectare 48% higher, than those of nonadopting farmers (Pampolino et al., 2007). Across irrigated environments in India, the Philippines and Vietnam, farmers adopting SSNM obtained on average 7% increase in grain yield (Pampolino et al., 2007). On-farm trials in the Philippines showed an average yield gain of 0.6 t ha^{-1} (or 13%) and added net benefit of 109-130 US$ ha^{-1} for SSNM-adopting farmers (Gregory et al., 2010).

Yield in farmers' fields can be reduced by incidences of pests, diseases, and weeds. Oerke (2006) estimated that global crop losses in rice caused by weeds, animal pests, and diseases are 10.2%, 15.1%, and 12.2 of the attainable yield, respectively. In practice, however, a crop is exposed not to one but to several 'injuries' and complex crop health syndromes occur as combinations of weeds, pests, and diseases in any given production context (Savary et al., 2006). Using a modeling approach, estimated average rice yield losses due to complex health syndromes, range from 1.4-2.3 t ha^{-1} (or 25-43% of attainable yield) globally. Norton et al. (2010) list science-based management practices to control pests, diseases, and weeds in rice. Again using a modeling approach, they estimated that yield gains caused by the application of such practices can vary from 1.2 to 5.7 t ha^{-1} across a range of crop health syndromes.

3.1.2 Improved incomes

Pathways to increase farmers' incomes include raising productivity (yield), but also reducing the costs of production, increasing the value of production, decreasing post-harvest losses, and reducing expenditures on food (which increases net available income for other purposes).

The means to raising rice productivity and yield, and the causal pathways that then lead to increased income of farmers, are explained above (paragraph 3.1.1).

The cost of production can be decreased by improved management technologies that lower the use of inputs even while holding yield constant. For example, in West Bengal, India, farmers who adopted SSNM practices (see paragraph 3.1.1.2) to manage fertilizer applications realized 20% savings in fertilizer nitrogen use and 50% associated savings in pesticide use – without significant yield increase -, which resulted in economic benefits of 19-27 US\$ ha^{-1} (Islam et al., 2007). The "3-Reductions – 3 Gains (3R3G)" program in the Mekong delta of South Vietnam explicitly aims to increase farm profits by reducing input costs through reductions in the use of seed, (nitrogen) fertilizers, and pesticides, without incurring yield loss (Huelgas and Templeton, 2010). The 3R3G is essentially a knowledge-based crop management technology that includes, among others, principles of Integrated Pest Management (IPM) and site-specific nutrient management. In an adoption survey done in the provinces of An Giang, Can Tho, and Soc Trang, in 2006-2007, Huelgas and Templeton (2010) found that the unit cost of production was 4.4-12.4 US\$ t^{-1} lower (depending on season), and the average income from rice farming 60 US\$ ha^{-1} higher, for adopters than for nonadopters.

The value of production can be increased by increasing the value of rice grains, or by increasing the value and use of byproducts such as straw and husk. The value of rice grains can be increased by enhancing physical quality (decreasing chalkiness, increasing head rice recovery) or chemical quality (eg aroma, stickiness, cooking quality) for eating. Also, new rice grain products can add value, such as cosmetics. As the percentage of the population in the middle income bracket is rapidly increasing in some large Asian counties such as India and China, markets for such value-added products are increasing. Increased grain quality can be derived from genetic improvement (eg aromatic rice, less chalky rice, rice grains with specific qualities for cosmetics) as well as from improved post-harvest technologies. Gummert et al. (2010) estimate that losses in grain quality caused by outdated post-harvest equipment and infrastructure and low operators' skills, can lead to a reduced market value of milled rice of 10-30% or more. Rice straw can find a use as animal feed or renewable energy source, whereas rice husk can be used as renewable energy source and soil amendment (both through the production of biochar). All in all, research into novel rice products and added value of rice grain for human consumption can contribute to increased income from rice farming through increased value of production.

FAO estimates that physical post-harvest losses in the rice sector in Asia can be as high as 10-50%, consisting of 15-20% loss in weight through spillage, losses to pests, and low milling yields (Mejia, 2004). Gummert et al. (2010) list a number of interventions by which post-harvest losses can be reduced and hence the net value of milled rice increased: improved (mechanized) harvesting, drying, milling, transport, and storage.

Reduced expenditures on food can be realized through the lowering of the price of rice, as explained at the beginning of paragraph 3.1.

3.2 Improved food security

A direct pathway to increasing food security is by making staples more available and at lower costs through technological changes in agriculture (sources cited in Hazel et al., 2008, and Hazel, 2010). A low price of rice makes it more affordable to net rice consumers both in rural and urban areas. Improved rural household food security can be realized through increased on-farm production, and/or increased income (which translates into increased purchasing power). Again (like in reducing poverty; paragraph 3.1), rice research can contribute by developing technological that that increase yield and productivity, increase the value of rice products (grains, by-products), lower the cost of production, and lower post-harvest losses.

3.3 Improved nutrition and health

A healthy and nutritious diet consists of a sufficient quantity and quality of food intake. The Green Revolution was very successful in increasing the per capita supply of food, especially the cereals rice and wheat. For example, Hazel et al. (2008) and Hazel (2010) cite several studies that higher rice yields obtained during the Green Revolution led to greater calorie, energy, and protein intake among rural households in adopting regions. Lately, concerns have generally shifted from calorie and protein deficiencies to micro-nutrient deficiencies (Hazel, 2010). Various pathways of agricultural research can contribute to increasing nutritional quality of diets of the poor, such as 1) improving the productivity of, and accessibility to, 'healthy foods' such as fruits, vegetables, livestock and fish, 2) promotion of food crop biodiversity, and 3) biofortification (Hazel, 2008).

Human micronutrient deficiencies are relatively severe in areas where rice is the major staple. Increasing the density of provitamin A carotenoid, iron, and zinc in the grains of rice can contribute to the alleviation of these deficiencies, especially among urban and rural poor who have little access to alternatives such as enriched foods and diversified diets. Promising examples are the development of Golden Rice to combat vitamin A deficiency (Potrykus, 2003) and of iron-rich rice to combat iron deficiency (Haas et al., 2005).

3.4 Sustainably managed natural resources

Agricultural production can negatively impact on its own sustainability and on the environment in general by diminishing ecosystem services (Millennium Ecosystem Assessment, 2005). For example, overuse of agrochemicals can pollute soils and waterways, misuse of pesticides can reduce biodiversity and threaten human health, overuse of water can deplete groundwater and river resources, and agricultural production can emit greenhouse gases. Rice-growing environments provide valuable and unique ecosystem services, such as groundwater recharge, erosion control, flood control, climate control, and the provision of a unique habitat for wildlife such as water

birds (Bouman et al., 2007). Over the past decades, the provisioning of these services has come under increasing threat, especially by declining water availability.

The review of international agricultural research reveals a very thin record of accomplishments in environmental impact assessments (Renkow, 2011): "*There has been no work carried out to date that has successfully traced the entire impact assessment pathway from research investment through to measurement of off-site biophysical effects on ecosystem services, and on to the ultimate impacts on agents located in the receiving sites*". The recently concluded STRIPE review of natural resources management (CGIAR Independent Science and Partnership Council. 2012) concludes that "*Although there is a growing consensus that lack of evidence is in part an artifact of measurement and assessment methods, and while there is some progress in addressing this issue, the challenge of identifying robust impact metrics to assess natural resources management remains unresolved*". Despite these shortcomings in systematically collected evidence, different pathways exist by which agricultural research can increase the sustainability of rice production, reduce the use of precious resources (water, energy), increase ecosystem services, and reduce environmental externalities in rice production (Bouman et al., 2007; Hazel et al., 2008). Examples of these pathways are given below for rice.

Increasing the productivity of input use (e.g., water, energy, nutrients) reduces the amount of inputs used per unit production, and hence conserves these input resources. Usually, the increase in productivity is realized through an increase in effective use, or uptake, of the input in question, and by an accompanying reduction in emission to the environment. For example, many technologies exist to increase water productivity as expressed by amount of grains produced by amount of water inputted into rice fields (Bouman et al., 2006). The system of Alternate Wetting and Drying can increase water productivity by 15-30% and reduce water inputs by 15-30%, whereas the system of aerobic rice can typically increase water productivity by 30-50% and reduce water inputs by 30-50%.

Some technological innovations don't aim at increasing input use productivity, but directly target the reduction of negative externalities. For example, Integrated Pest Management (IPM) and Ecosystem Engineering aim to reduce the application of pesticides in rice landscapes by enhancing natural (bio)control functions and ecosystem resilience. The IPM rule-of-thumb of "Do not spray insecticides against leaf-feeding insects for the first 40 days of rice growth" resulted in a 50% reduction in insecticide use by farmers who had received this simple message in the Philippines and Vietnam (Heong and Escalada, 1997). More recently, the "3R3G" technology resulted in measured pesticides reductions of 13-33%, alongside an improved environment, among adopting farmers in the Mekong Delta of Vietnam (Huan et al., 2008).

The adoption of new agricultural technologies can impact on land use change, and multiple pathways exist between adoption of yield-increasing technologies and land use change in general and deforestation in particular. Using a model-based study, Stevenson et al., (2011) found ample evidence to "*support Borlaug's hypothesis that increases in cereal yields as a result of widespread adoption of CGIAR-related crop germplasm have saved natural ecosystems from being converted to agriculture*". Their

study found that "*the total crop area in 2004 would have been between 17.9 and 26.9 million hectares larger in a counterfactual world which had not benefited from crop germplasm improvement since 1965*". The impact pathway of increased productivity of rice on land use change/deforestation can be hypothesized as follows (Global Rice Science Partnership, 2010): productivity enhancing technologies reduce the unit cost of rice production, leading to a "supply shift", which reduces equilibrium market prices. The reduced rice price reduces the profitability of cultivation in marginal areas, which have less productivity potential, and, accordingly, less absolute opportunity for gain from productivity enhancing technologies. As a result, expansion into these areas is avoided, as the returns to rice cultivation fall below the opportunity cost of labor, reducing demand for agricultural land and agricultural incursion into remaining natural ecosystems. Using IRRI's global rice trade model, the area decline stemming from the rice price decline attributable to GRiSP research, is estimated to reach 1.8 million hectares by 2020 and 5.00 million hectares by 2035 (Global Rice Science Partnership, 2010). This analysis makes the simple assumption that the reduced land pressure has equal propensity to affect all forms of land use. Thus, the proportion of this averted expansion that translates into averted deforestation is assumed to be equal to the proportion of forest cover in a particular country. Using this approach, 491,000 hectares of deforestation would be averted by 2020, and 1,202,000 hectares would be averted by 2035.

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4 Annex 3. Gender impact pathway and theory of change

GRiSP's "gender impact pathways" provide the basis for understanding the role of gender in technology impacts as well as indicate areas for integrating gender considerations into the process of product development and deployment, including research planning, design, implementation, and evaluation. Here, we present the overall gender impact pathway for GRiSP, whereas specific impact pathways for each FP are described in chapter 5 of GRiSP's gender strategy. Fig. 1 schematically summarizes the gender impact pathway that links GRiSP's 'engendered' products to gender-specific outcomes and CGIAR system-level outcomes (SLOs) – and can be laid over GRiSP's historic IP and ToC (Fig. 1 in annex 2 of this document).

Female family members participate in rice production, post harvest, and processing operations. Through farming, they contribute to food security at household level and at regional to national to global levels, and hence benefit from the overall impact pathway for GRiSP (Fig. 1). However, women's roles in the rice sector are often overlooked and undervalued, and many impediments exist that hinder women realizing their full potentials. Access to and empowerment by women over the use and marketing of the rice they (help) produce specifically contributes to improved food security of family members and specifically of children. Through their labor participation in the rice value chain, women are income generators and contribute to poverty alleviation. Increasing productivity and production leads to increased marketable surplus, thus enabling women to have a greater income share and increased purchasing power to buy quality food, ensuring their roles in guarding household food, health and nutrition security, especially of young children. Also, with increased household rice supply women do not have to purchase rice (at higher price) or queue for rice ration during long periods of low supply. Empirical studies have proven that women tend to spend their additional income on food, healthcare and children's education (an important stepping stone out of poverty), while men spend more of their income on personal items (Hopkins et.al. 1994; Haddinot and Haddad (1991). In Bangladesh, a higher share of women's assets is associated with better health outcomes for girls (Halman 2000). Research from IFPRI finds that equalizing women's status would lower child malnutrition in South Asia by 13 percent (13.4 million children) and in Sub-Saharan Africa by 3 percent (1.7 million children) (Smith et al., 2001). Thus empowerment of women over the fruits of their labor (rice, income) has a strong contribution to household food security, poverty alleviation, and health and nutrition.

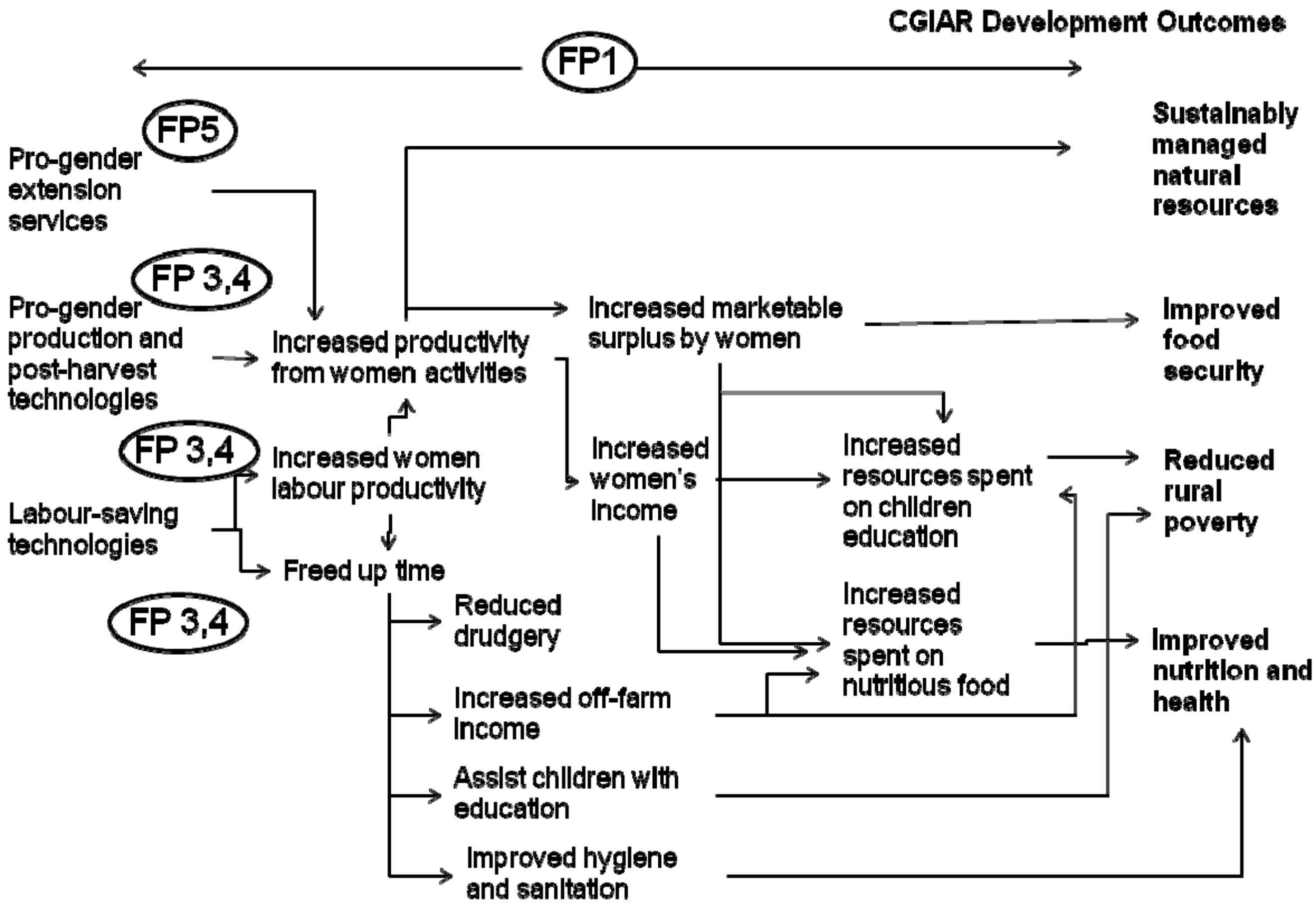

Fig. 1. Schematic gender impact pathway, linking engendered products and services to gender-specific outcomes and CGIAR system level outcomes. The circles indicate the entry points for each of GRiSP's FPs. FPs 1 and 5 facilitate transformative changes through technology targeting and ex-ante and post-ante impact assessment and through capacity building and training, respectively.

Improving access to resources (inputs, technologies, technical knowledge) will increase the productivity of women's labor. As a consequence, women may increase their income (which they can spend on health and education) and/or increase their time available to invest in other income-generating activities, in helping children with their education, and in strengthening of social networks. Increased resource access can be accomplished by developing technologies and know-how (GRiSP products and services) that are specifically targeted to their needs and by extension and advisory services that are geared toward reaching women. Labor-saving technologies and mechanization are especially relevant for women rice farmers who provide labor for back- breaking rice operations such as transplanting, weeding, harvesting, and threshing. With labor-saving technologies, women have more leisure, more time to take care of their children, teach them school lessons, prepare food, clean their house, and take care of livestock for additional income (Paris, et.al, 2012). Mothers might also have more time for collecting water and sanitation practices, which will lead to improved health. Examples of labor-saving practices are mechanical transplanters and direct seeding equipment, mechanical weeders and/or the use of herbicides, harvesting machinery (combine harvester-thresher), mechanical thresher, rice micro mill, which can reduce/eliminate women's drudgery, reduce health risks, and free their time. Studies have shown that with the adoption of the mechanical drum seeder in south Vietnam, women from farming households were relieved from transplanting work, enabling them to have more time for their personal care, leisure, socializing/networking with other women, coaching their children in their studies, and taking care of pigs for income and home consumption (Paris and Chi, 2005). Mechanical threshing at the farm level can improve efficiency in threshing, reduce losses, remove drudgery, and address health effects, mostly to women (Schmidley and Kumar, 2013). The adoption of combine harvester-threshers through custom services in eastern India, led to the decline in the demand for female family labor in harvesting and threshing. Obviously, care must be taken with the introduction of labor-saving technologies that women workers are not robbed of their means of income and that alternative use of their time really constitutes an improvement. Sometimes, improved conditions for women can be an unintended and unanticipated consequence of the development of a new technology. Preliminary studies on the impacts of adoption of submergence-tolerant rice varieties on women in eastern India reveal that, because of the ability of Swarna Sub1 to recover after 10-14 days of submergence, women do not have to do gap filling or replanting of crops that did not survive the flooding as well). Also, providing women farmers access to stress-tolerant seeds, such as the submergence-tolerant Swarna-Sub1, will increase the resilience to extreme climate variability due to reduction in crop losses.

Through their dominant role in post harvest and food processing activities, women can contribute to reduction in post harvest losses and increased quality of rice, which contributes to increased food security and health and nutrition. In many areas, women still practice the traditional methods of post harvest operations, such as manual threshing, winnowing, and poor seed management, which result in significant losses (Schmidley and Kumar 2012). Adoption of improved post harvest technologies will directly benefit women through reduced losses, thus increasing rice for food

consumption and ensuring food security. Value adding technologies will provide women additional income.

A study on the impact of male outmigration on rice production and women left behind in Southeast and South Asia, reveals that women are taking over men's responsibilities in rice management, for example spraying pesticides, irrigating the fields, other crop care management, and supervising hired laborers (Paris et al., 2010). Thus, involving women farmers, especially the *de facto* heads and *de facto* farm managers in the R&D process and training programs will lead to gender-equitable access to technologies, inputs, technical knowledge, and skills.

In general, gender-equitable access to seeds of improved varieties, improved natural resources management practices and technical know-how, and involvement in participatory experiments and agricultural training programs, reduces the gender gap.

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