RESEARCH PROGRAM ON Water, Land and Ecosystems

CGIAR

Led by:

IWMI International Water Management Institute

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CGIAR Research Program on Water, Land and Ecosystems: Strategic Plan

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1. Humanity's challenge: Living within our boundaries

1.1 The challenge

We are living in challenging times threatening the stability of current and future global food systems, resulting in growing concerns over natural resource availability (i.e. water, land, energy and biodiversity) and the provisioning of ecosystem services that support local and global food supplies. Drivers that are influencing these challenges include population growth, demographic change associated with urbanization, rising personal incomes, changes in dietary preferences and global trade, as well as the impact of climate change and associate increasing frequency of climate related shocks (i.e. floods and droughts). A consequence of these changes is uneven economic growth with a widening of the income gap, increases in the number of poor and undernourished both in developed and developing countries, increasing degradation of our natural resources, and unacceptable levels of youth unemployment that have contributed among others to conflict as evidenced in the Arab Spring.

Reflecting on the past 50 years our agricultural production systems have more than kept pace with global food demand and contributed to decreasing the proportion of the population that go hungry, despite a doubling of the total global population. Long-term decline in real food prices, however, led to a complacency by both donors and national agricultural research and extension systems regarding investments in agricultural R&D and rural infrastructure. The food price shocks of 2008 and projected future demand has placed food security and agriculture back on the political and global development agendas. The question that is on the minds of governments, decision makers and concerned groups is whether agriculture can continue to perform its role in feeding a global population projected to reach 9.1 billion in 2050. The short answer to this question is no, if we do not change our ways of approaching the challenge. Why not?

There is clear evidence to support the notion that human activities have pushed the Earth's systems outside their stable environmental state, with consequences that could lead to irreversible and, in some cases, abrupt environmental change. That, in turn, could lead to conditions that restrict global growth. Indeed, recent evidence suggests that we have exceeded three of the nine 'planetary boundaries' that ensure our planet's survival (Rockström et al., 2009). Climate change, rate of biodiversity loss and the nitrogen cycle, all of which have strong linkages to the agricultural sector, are now thought to be beyond the stable state for maintaining healthy ecosystems. Sadly, the success of our agrarian sector has been a major player in contributing to the breaching of these boundaries. This has occurred through our insatiable consumption of nitrogenous fertilizers; a dependence on fossil fuels and the massive changes in vegetation cover associated with land clearing for agriculture, thereby contributing to increasing greenhouse gases in our atmosphere; and the loss of biodiversity and of mass species extinction never before seen in human history.

The litany of issues that confront us with respect to land and water degradation especially in the South, that are a direct consequence of our current production systems, are well documented and portray a dismal assessment of the impact of agriculture (Box 1). These are what are considered "Wicked Problems". Wicked Problems are difficult to solve because of incomplete, contradictory, and changing requirements that are often difficult to reconciles and whose solution requires a great number of people to change their mindsets and behavior. Most often, technical solutions have proven ineffective because the solution requires a more integrated social approach which is often political in nature and requires flexible consultative processes that develop collective understanding and responses.

Box 1. Agricultural systems and the environment

- Globally, approximately 25% of all land is classified as being highly degraded, with a mere 10% being classified with improving conditions.
- Just over a billion hectares is affected by water erosion.
- Approximately 549 million hectares (Mha) of land suffer from wind erosion.
- Approximately 34 Mha of the global irrigated area is affected by salinization, representing a significant lost opportunity and underutilization of investments in infrastructure.
- It is estimated that 25% of the global freshwater storage capacity will be lost in the next 25-50 years, unless measures are taken to control sedimentation in reservoirs.
- Approximately 2 million tonnes (Mt) of waste is dumped into rivers, lakes and wetlands each day, causing eutrophication, and hypoxia and algal blooms.
- It is estimated that there are now 12,000 cubic kilometers (km^3) of polluted water on the planet, which is a volume greater than the contents of the world's 10 biggest river basins.
- Agriculture is a significant contributor of greenhouse gases, particularly if land use change is included.

Agriculture has been described as the biggest force unleashed on the planet with devastating impacts. The ability of these systems to continue to perform this function along with increasing output to meet future demand is in question and there is a growing consensus that we can no longer as a global community, continue in our profligate ways and that there is a need for a radical change in the way we view our food production systems. The planetary boundary framework suggests the need for novel and adaptive governance approaches at global, regional, and local scales.

1.2 The opportunity

There is cause for cautious optimism. If we accept the notion that sustainable management of water, land and ecosystems in the context of agricultural landscapes is a *sine-qua-non* for agricultural productivity and multiple benefits for human prosperity and wellbeing into the future, we have a basis for a paradigm shift. In this respect one could view the current status quo being best described as where **ecosystems and natural capital are wholly owned subsidiaries of our agricultural production systems.** The paradigm shift we in WLE are striving to achieve is where **agricultural production systems are viewed as a wholly owned subsidiary of the ecosystems and natural capital** they are dependent upon. From this it can be infer that our agricultural production systems and hence the future wellbeing of humanity, will be sustained provided we do not over-allocate or destroy ecosystems, associated services and natural capital. This shift will require a rethink of agricultural development in the context of the situation humanity is facing, with growing resource constraints, shrinking biosphere space on Earth, and rising risks of abrupt changes and tipping points affecting water, land and other ecosystems.

Given the tighter and more abrupt change prone food security situation of today, a paradigm shift toward **sustainable intensification** (see Box 2) has become both a necessary and attractive strategy for achieving the dual goals of: ensuring resilience and sustainability of production

systems that increasingly is acknowledged to be a prerequisite for both food security and poverty alleviation. Whilst sustainable intensification has a focus on the farming enterprise there is a need to go beyond this spatial scale to ensure that ecosystem services at the landscape level are explicitly incorporated into our thinking of future agricultural production systems that place ecosystems and people first. This is a key step beyond previous intensification efforts at farm scale and the ongoing extensification where land is still abundant, like in many parts of West Africa where farmers' livelihoods depend on ecosystem exploitation.

In this regard we recognize that sustainable intensification is a 'wicked problem' in which the technical innovations in Box 2 are complemented with more social and political changes. In other words, we need to address what prevented sustainable intensification approaches becoming successful to date. This is not the lack of technologies, data or concepts, but issues that include:

- Secured land tenure, missing land reform.
- Inheritance pattern favoring own children (e.g. not matrilineal).
- Awareness of benefits and (business) opportunities though intensification (including yield increases by 50% or more).
- Returns on investment and how NRM supports the functionality of our production systems.
- Social responsibility across watersheds (upstream-downstream).

Box 2. Sustainable intensification

Sustainable agricultural intensification is defined as producing more output from the same area of land while reducing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environmental services (Pretty, 2008; Royal Society, 2009; Conway and Waage, 2010; Godfray et al., 2010).

A sustainable production system would thus exhibit most or all of the following attributes:

- utilizing crop varieties and livestock breeds with a high ratio of productivity to use of externally and internally derived inputs;
- avoiding the unnecessary use of external inputs;
- harnessing agro-ecological processes such as nutrient cycling, biological nitrogen fixation, allelopathy, predation and parasitism;
- minimizing the use of technologies or practices that have adverse impacts on the environment and human health;
- making productive use of human capital in the form of knowledge and capacity to adapt and innovate and social capital to resolve common landscape scale problems;
- quantifying and minimizing the impacts of system management on externalities such as greenhouse gas emissions, clean water availability, carbon sequestration, biodiversity and dispersal of pests, pathogens and weeds (Pretty et al., 2011).

WLE through its partners is already addressing wicked problems in a complex way. This includes the work through CIAT and the CGIAR Challenge Program on Water and Food looking at Payment for Environmental Service in South America. Here the focus is on changing laws as well as working out solutions through on the ground arrangements with different stakeholders such as indigenous communities, mining companies and large scale lowland farmers. Likewise, work on resource re-use and recovery focuses on developing business models which can be taken up by the private sector. That said more work is needed to support behaviour change and to develop social systems among concerned stakeholders and institutions to adopt a shift in land management practices towards increased resilience and sustainability of agricultural production systems. This could include research on incentive systems and capacity building (education and research).

2. The WLE Approach

2.1 Why a program on agro-ecosystems

The conventional approach to agricultural development has been to increase production through the creation of new and improved varieties of crops and livestock, and develop technologies that increase productivity through the provision of inputs that include fertilizers, agrochemicals, veterinary products and improved feeding systems. Whilst these approaches have resulted in significant increases in productivity and outputs they have also resulted in negative externalities, such as widespread water pollution and biodiversity loss.

Moreover, such approaches have often failed to have wide-spread impact because technical solutions have not been combined with social and institutional innovations needed to change behaviors and institutions. A more integrated approach is needed which recognizes the impacts of, and relationship between, agriculture and other development activities and that solutions are often political in nature. Understanding how agriculture works within ecosystems is critical for poverty alleviation and increasing equity. The poor, both men and women, tend to rely more directly on different ecosystem services such as forests, wetlands or rivers for their livelihoods, and have limited resources to reinvest. By neglecting the management of natural resources and the benefits they provide ensures that the basic needs of the rural poor are never fully addressed.

Now the CGIAR – the global partnership of organizations engaged in research for a food-secure future – is combining work from 11 of its centers worldwide and other partners in its ‘Research Program on Water, Land and Ecosystems’ (‘WLE’). WLE’s mandate is to work with partners toward improving the sustainability of agricultural development in Africa, Asia and Latin America – regions that are striving to meet burgeoning demands for food and water – while preserving fragile environments and ensuring the delivery of ecosystem services.

WLE is an ambitious 12-year CGIAR research program, unmatched in its scope and range of partners. It embodies innovative thinking on agriculture, the management of natural resources, and the alleviation of poverty to improve food security and environmental protection and innovative engagement with decision makers to effect positive change. It harnesses specialist skills to solve pressing problems in priority regions, and it processes data on natural resources to provide a truly global picture of the overall health of our ecosystem.

The Water, Land and Ecosystem program will provide applied research and capacity building on incentive and management systems across scales, knowledge and solutions to address this challenge and achieve the goal of sustainable intensification, which links to the four overall CGIAR system level outcomes (SLO), with the strategic proposition that SLO4 (sustainable management of natural resources) is a necessary pre-condition to attain SLOs 1 (reduction in rural poverty), 2 (food security) and 3 (improving nutrition and health).

2.2 Vision, goals, outcomes and impacts

Our Vision

A world in which agriculture thrives within vibrant ecosystems, and where communities have higher incomes, improved food security and the ability to continually improve their lives.

WLE Outcomes

There are four broad WLE outcomes we expect to achieve in the coming twelve years. To achieve these, specific outcomes will be delivered with the assistance of partners and development agencies (such as government decision makers, NGOs, businesses, farmer groups), for each of the focus regions that WLE works in as well as international public goods.

- Food security and livelihoods of male and female farmers in Sub-Saharan Africa are improved through expansion of small-scale irrigation and strategic improvements in rainfed agricultural systems which do not compromise ecosystem functions which underpin sustained development.
- Livelihoods of rural poor, particularly women, in Asia, are strengthened through improved irrigation and agricultural water management.
- The development of water, land, energy and ecosystems is maintained and enhanced through the equitable sharing of benefits and risks amongst different use and users across key river basins and landscapes.
- The concept of agriculture within vibrant ecosystems is adopted as a central tenet of the global discourse on sustainable development.

WLE delivers research outputs of broadly four kinds:

- Assessments of state of the systems and scenarios: Modeling of trends and socially-differentiated impacts of current, projected and optimal land and water resource scenarios and trade-offs.
- Recommendations to improve investments and practices: Recommended investment opportunities (e.g. practices, management interventions, technologies, business models, and institutional/governance arrangements) to catalyse sustainable intensification of agriculture, enhance ecosystem services, and positively benefit the poor and marginalized.
- Decision-support systems: Decision support tools that enable decision makers to assess synergies and trade-offs of WLE recommended investments opportunities (e.g. tools to assess water-energy-food, ecosystem services and other tradeoffs) and to optimize investments in technologies, policies, institutions, etc. in order to enhance water, food and environmental outcomes.
- Process instruments: WLE will establish or link with a range of multi-stakeholder platforms, regional and global agendas and networks to ensure research is relevant and

being utilized. The establishment or participation in such groupings is an important output unto itself.

Annex 1 provides an example of an impact pathway for the Volta region.

2.3 Comparative advantage: The Ecosystems perspective

WLE emphasizes the need to rethink agricultural development in the context of growing resource constraints and rising risks of abrupt changes and tipping points affecting water, land and ecosystems.

An ecosystems approach allows the program to view agricultural development from a perspective that considers endogenous and exogenous drivers of change and a range of different management objectives. For instance, ESS related information collected by WLE and its partners is being incorporated in developing models and decision support systems enabling stakeholders to use this information to better assess trade-offs and understand unintended impacts of planned interventions. WLE will work with development agencies to use this information in areas where governments, investors and NGOs are looking at ways to plan large-scale developments whilst having minimal undesirable impacts (i.e. agriculture concessions or hydropower).

It is also recognized that these agriculture systems are not isolated but affected by drivers of change, such as population growth, demographic change, economic pressure or climate change. Understanding the trade-offs of different interventions can save millions. For instance, the loss of ecosystem services is frequently overlooked or inadequately compensated and, as a result, poor people (who are the most reliant on the services) typically pay the price of development. Thus, information becomes an important tool by providing policy-makers with options and decision-support systems to understand the implications of various choices, and stakeholders' options to change current behaviors.

While other CGIAR Research Programs (CRPs) conduct research at the commodity, field and farm levels, researchers for the Water, Land and Ecosystems Program will work primarily at large scales (landscapes and basins), with an emphasis on interventions that support the natural resource base (see diagram below).

WLE will work closely with other natural resource management focused CRPs such as Forest and Trees and Climate Change and Agriculture for Food Security to map out changes at the landscape level and beyond. WLE will also work closely with commodity and systems CRPs that focus on the function of value chains and how they support livelihoods within a given area, because their sustainability depends upon the ability of ecosystems to provide the services needed to ensure sustainability. WLE will also link to the Policy, Institutions and Markets (CRP2) program to capitalize on research on market drivers, policies and institutional change for sustainable intensification.

Figure 1: How different CGIAR Research Programs relate

2.4 Our approach: putting the pieces of the puzzle together

WLE works in a rapidly changing environment. In order to stay abreast of new developments and to assist in shaping these, the unique features of WLE's programmatic approach are not contained within any single element but rather in how they are combined and prioritized, including:

- **Partnerships:**

WLE works in partnership with public, private and non-profit decision makers at global, regional and national levels to understand their needs for research to inform policies, practices, and investments. The program then harnesses the knowledge, experience and reach of its 13 strategic partners and hundreds of regional and national science partners to provide knowledge and innovative solutions that address the knowledge needs of development partners.

- **Working in focus regions for impact:**

WLE will engage with global, regional and national decision makers, development practitioners, and the private sector in focal regions across a continuum of development related constraints (high incidences of poverty, water scarcity, resource variability, demographic changes, gender inequity, large scale investments) for which our research can provide develop solutions (see section 2.5 for more details).

- **Engaging in policy processes and strengthening development investments at across scales by providing evidence based information, data and analysis**

WLE is unique in its focus on providing evidence based research and analysis to improve decision-making of different actors such as communities, government planners, investors and regional bodies. WLE's models and decision analysis systems helps these actors understand trade-offs and impacts of different decisions. Further, WLE is developing a unique approach to business modeling to provide decision-makers with better insights on the investments needed to successfully implement different solutions.

WLE recognizes that providing models and recommendations is not enough. In order to have impact, research must engage in development processes at different levels and not just 'hand-over information' if it expects its research to have impact. At the global and regional scales, we will support changes in the way key decision makers perceive, evaluate and support sustainable development in basins and landscapes. Above all, we wish to move towards a more positive development discourse by identifying development solutions to global problems of food and environmental security.

We will do research with and for new strategic partners allowing us to clearly show advantages e.g. for private sector engagement and returns on investment.

- **Prioritizing the needs of the poor, and especially women, within a gender context, for interventions**

WLE recognizes that only by developing a sound appreciation of the needs, priorities and interests of both men and women, will it be possible to provide sustainable interventions. Concomitant to this is the required understanding of the difference in between men and women in decision making surrounding issues of water, land and ecosystems. Both of these will form a basis for the work WLE does.

- **Use of theory of change to ensure impact**

WLE recognizes that theories of change and impact pathways are the glue that integrates a number of other processes (such as communication, monitoring and evaluation, learning and knowledge management) to ensure that our research moves to outcomes. Theories of change ensure that all these processes reinforce each other and are linking towards the changes that we seek in key stakeholder groups.

- **Competitive grants and funding**

In order to encourage innovation, WLE will develop a competitive grants fund. New opportunities and ideas emerge constantly and there is a need to find ways to encourage adaptive management. The competitive grants fund will allow WLE to fund new ideas and emerging partnerships that strengthen positive development impacts.

3. How we are organized for change

3.1 Program structure

The program includes five strategic research portfolios (SRPs) working in basins and regions in an integrated fashion to bring about change. These include: irrigation, rainfed systems, resource recovery and reuse (RRR), river basins and information. Each SRP is divided into a number of

"activity clusters" that provide more discrete intervention areas for the SRPs. Cross-cutting the SRPs are two themes: ecosystem services and resilience and gender, poverty and institutions.

As shown in the diagram, the different elements of the program interact in different ways to ensure wider impact from a programmatic perspective. The three main types of systems support vast numbers of people: irrigation systems, rainfed cropping and pastoral systems and systems that recover and reuse otherwise lost resources. These systems interact within river basins and landscapes.

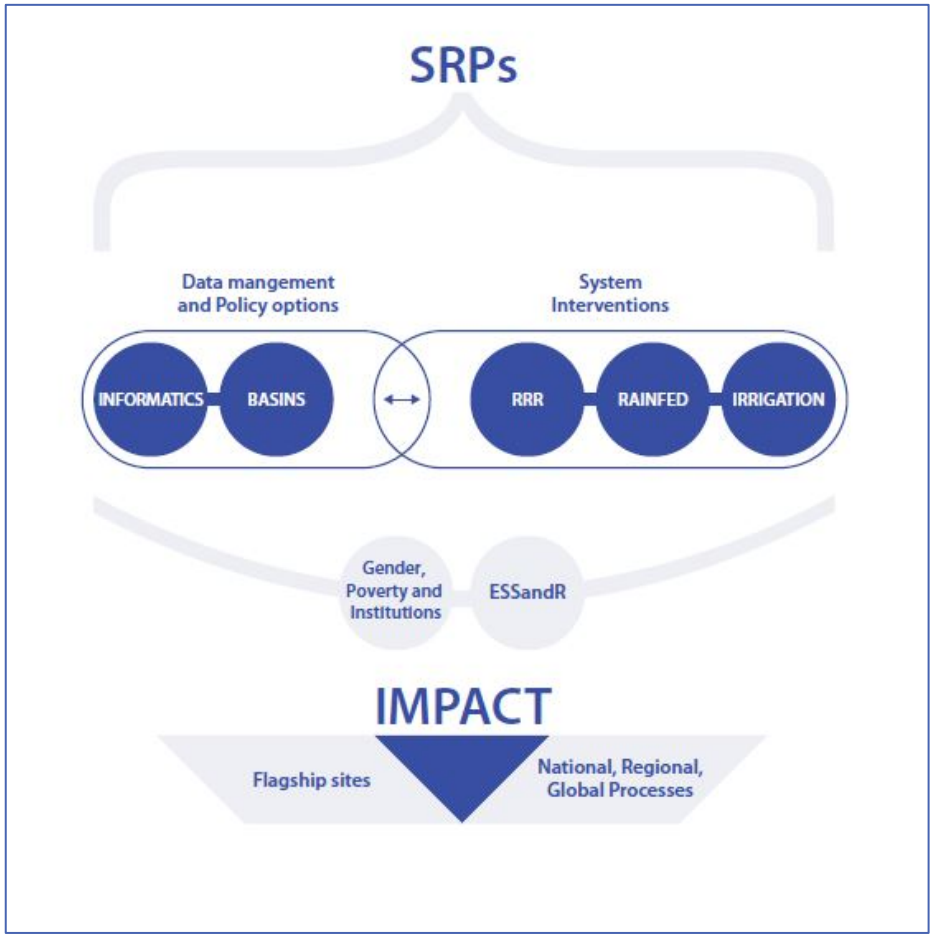

Figure 2: WLE Programmatic Structure

Key to figure: SRPs = Strategic Research Portfolios; ESSandR = Ecosystem Services and Resilience; Gender = Gender, Poverty and Institutions.

The focus on Ecosystem Services and Resilience (ESS&R) ensures that we start to understand how agriculture fits in with other natural services our environment provides. Unlike conventional ESS, WLE puts people first by focusing on how the poor benefit from ecosystems and how to manage nature to balance green growth, poverty alleviation, food security and the sustainability of natural resources. On the other hand, WLE integrates sustainability within development through practical solutions; for example, by understanding how different types of water storage can be used to benefit poor people by reducing their vulnerability to floods and drought and in the former taking advantage of these excesses by storing in natural above and below ground systems to be used during periods of drought.

The program develops information systems that aggregate social, biophysical and environmental data to generate knowledge and global insights, providing coherent information on development processes worldwide, that can address pressing environmental problems such as water scarcity, natural services and land degradation.

Another unique focus is on looking at multi-scalar processes and how agricultural systems fit within the broader environment. For example, developing irrigated land leads to changes both upstream and downstream from the irrigated area. Understanding these impacts at multiple scales opens up the possibility of managing the landscape for a range of benefits. These include:

- Integrated resource management solutions that deliver multiple ecosystem services (provisioning, regulating, cultural and supporting services)
- Modeling multiple ecosystem services and trade-offs at landscape scales to address multidimensional poverty issues in a more targeted manner.
- Incorporating “ecosystem services” into resource management decisions, using trade-off analysis and using spatial modeling tools.

To ensure that WLE research achieves impacts for enhanced natural resource management, poverty alleviation and food security will require that the program specifically examines the poverty, gender and institutional context and implications of interventions within the WLE framework. This implies gaining a better understanding and developing sound data approaches on the diverse needs, priorities and interests, and decision making process of both women and men, and possibly other impacts on women and other disadvantaged social groups. Policies, institutions and investments that increase women’s assets have proven to achieve greater impacts in all these areas. The objective of this is three-fold, moving gender issues from being gender responsive to transformative, from increased understanding and data available on the differential needs, to developing more inclusive decision making processes for equitable use and management of resources, to women having an increased share of resources, as defined by them. Some of the mechanisms we will use are:

- Analyzing data from a gender and equity perspective
- Understanding gender-specific barriers for adoption
- Developing gender-sensitive policies
    - Analyzing incentives for increased gender equity in land and water management

3.2 How WLE will work in its Focal Regions

WLE is a global program which concentrates its resources in six focal regions for enhanced impact. The map below depicts current investments in the program which are in some of the poorest regions of the world where there are pressing water-related problems. For instance, WLE works in sub-Saharan Africa where there are high levels of food insecurity and rainfall variability. Many of its activities in Southeast Asia focus on addressing water, food and energy-related issues, where hydropower needs to be balanced with other development priorities such as agriculture and fisheries.

WLE has an imperative to prioritize development outcomes in areas where needs and potential for desired impact are greatest. As reinforced by the experience of the CPWF, and of other CRPs that have already gone through such a prioritization process, development issues are most often regionalized. Our unique focal region approach identifies two-three impact pathways within each region where different SRPs and cross-cutting themes will work together in an integrated fashion to achieve higher impact (see Annex 1 for an example of the Volta Impact Pathway).

The regional prioritization of the program will be shaped in two phases (2013 and 2014). The following WLE Focal Regions are expected to be fully operational for 2015.

2013	2014
1. **Volta/Niger** 2. **Nile** 3. **Indus/Ganges**	1. **Mekong** 2. **Limpopo/Zambezi** 3. **Andes/Central America or** 4. **Syr Darya/Amu Darya**

These focal regions will be where WLE invests resources (financial and human) in a concerted effort to achieve impact. WLE recognizes achieving outcomes requires long-term thinking ,and therefore will invest for long-term engagement in these areas.

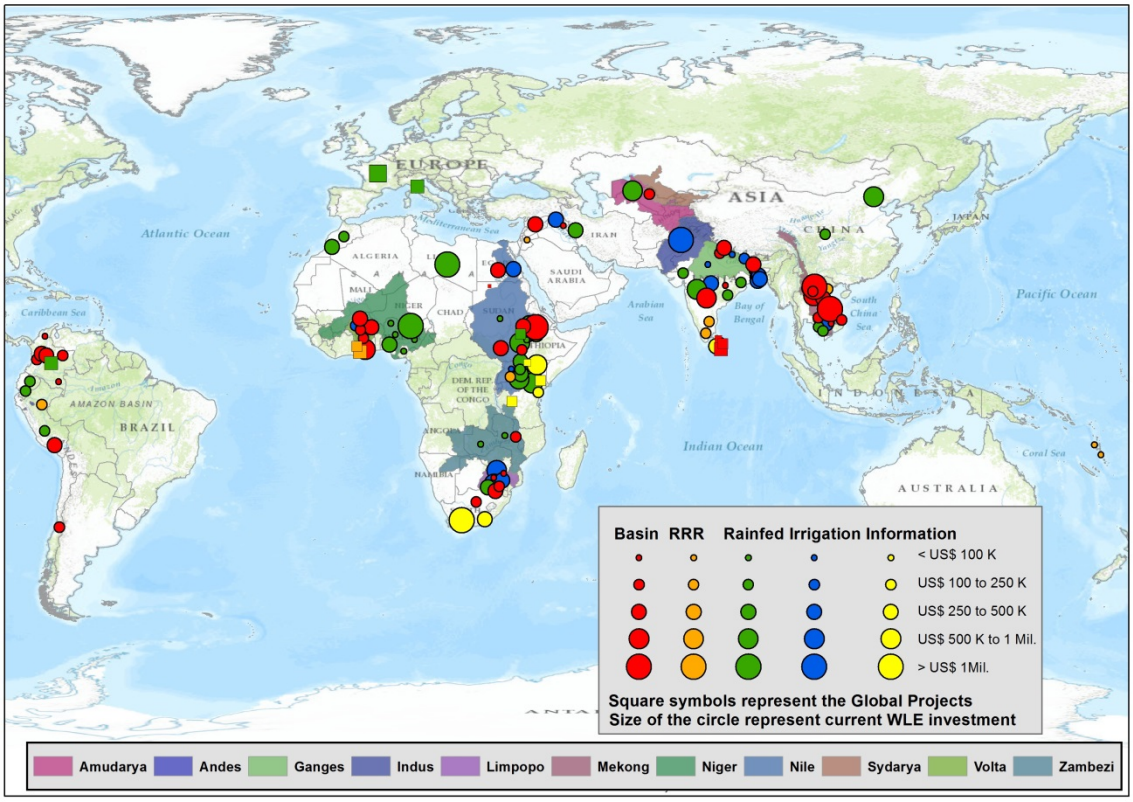

Figure 3: WLE's current investments in the region

3.3 Description of the Strategic Research Portfolios

For brevity a synopsis of each of the SRP's is presented below.

3.3.1 Irrigated Systems

Throughout sub-Saharan Africa and Asia, the rural poor mostly depend on rainfed agriculture. Wider adoption of irrigated agriculture could benefit smallholder farmers, who can potentially triple their food production and incomes through access to water. Irrigation at various levels of intensity has the potential to stabilize economies against rainfall variability, which threatens to become even more problematic due to climate change and increasing demands for water. Irrigated agriculture also delivers important ecosystem services (biodiversity in irrigated paddy systems in Asia, groundwater recharge). WLE will assess resource constraints in relation to irrigation and better understand how they affect (positively or negatively) other services.

Key activity areas

1. Irrigation in sub-Saharan Africa
2. Revitalizing public canal irrigation
3. Water management in the Eastern Gangetic Plain
4. Combating and convalescing irrigation induced salinity at field and regional scales.

The focus will be on Asia and sub-Saharan Africa. About 70% of the world's irrigated arable land is in Asia, consisting largely of canal systems supplemented by groundwater, but many are badly in need of revitalization and are extremely expensive to maintain. WLE recognizes these challenges have been around for a long time and will evaluate canal irrigation schemes in South and Central Asia, taking a 'systems approach' to water management. Research will consider alternative technologies (i.e. solar pumps, a range of agricultural water management approaches etc.) and explore ways to achieve sustainable groundwater management and ensure the livelihoods of the poor are improved.

Until now, large irrigation schemes have had a poor success rate in Africa: just 7 million hectares in Africa are irrigated by canals compared to 200 million in Asia. The key to revitalizing irrigation in Africa may be through public-private partnerships in the management of large schemes, along with a move towards smallholder irrigated agriculture. This could have huge benefits for food security and income generation allowing these communities to become vibrant and productive entities.

3.3.2 Rainfed Systems

The majority of the world's poorest people depend primarily on rainfed agriculture for their livelihoods and food security. Many rainfed farming landscapes are very fragile, affected by land degradation, climate risk, and poor infrastructure, contributing to extreme poverty and malnutrition. Smallholder rainfed systems are also under heavy pressure from current and increasing population density.

Key activity areas

1. Reducing land degradation in rainfed landscapes
2. Sustaining productive landscapes by increasing biodiversity
3. Reducing risk and tackling productivity and environmental challenges farming landscapes

These rainfed systems are undergoing rapid change due to a range of local, national and global drivers. For example, changes in local, regional and even global investment policies and trends have implications for national poverty reduction efforts as well as new challenges for resource

management. Climate change will have significant implications for the millions of smallholders who rely on rainfed agriculture in water-scarce areas.

The goal of this activity area is to achieve the sustainable intensification of agriculture in rainfed landscapes. It will work in areas where on-going land-use change threatens the environmental foundation upon which agriculture depends, and thus also the welfare of those who depend on the land. Our research will inform a new vision for rainfed landscapes, by providing evidence for how sustainable intensification and mitigating degradation can alleviate poverty and achieve social-ecological resilience. We will provide tools and methods for targeting interventions in landscapes that account for tradeoffs and synergies amongst ecosystem services and impacts on livelihoods. This research will design new incentives that will enable change in communities and in institutions to achieve better land management.

Our attention to change will look at multiple scales, from local to regional and include global drivers that 'land' in local places, to which local people have to adapt. Focus will be both on understanding social and institutional environments to design pathways for change, and the biophysical realities of changes, such as in ecosystem services. Thus this research portfolio will combine analysis of institutions, policy and livelihood portfolios with a focus on biophysical realities and understanding of ecosystem services.

3.3.3 Resource Recovery and Reuse (RRR)

Recognizing the impact of urbanization on resource flows in terms of quantities and quality, this SRP is addressing new approaches for recovering water, nutrients and energy from domestic and agro-industrial waste materials and wastewater, reducing the urban footprint and pollution, improving sanitation management and enhancing food security for millions of poor households in the rural-urban corridor in developing countries.

Key activity areas

1. Business opportunities for resource recovery and use
2. Safe wastewater and excreta used
3. Efficient water and land management in peri-urban areas.

The WLE resource recovery and reuse SRP focuses on three areas:

The first is introducing 'business thinking' into the sanitation sector and the use of appropriate technologies. Revenues from reuse can contribute to cost recovery in the sanitation chain through the productive use of waste borne nutrients, water and energy. WLE will be working with donors, municipalities, the private sector and business schools to promote successful models, and replicate them on the largest possible scale.

Implementing business models that can promote the absorption of 25% of the organic waste of urban South Asia and sub-Saharan Africa could, across both regions, benefit 23 million smallholders – supporting food security and reducing costs for millions of consumers.

The second is the support of national, regional and global guidelines for the safe use of wastewater and excreta in agriculture and aquaculture, and related capacity building..

The third activity will provide knowledge base, policy tools and investment recommendations that will assist authorities to improve adequacy, reliability, efficiency and equity in land and water resources management across the rural-urban interface with a specific focus on: Irrigated urban

and peri-urban farming; pro-poor rural-urban water allocations; and multi-stakeholder dialogues for urban water resource use planning.

This WLE activity seeks business opportunities but also aims to minimize the health risks associated with the use of waste products in agriculture. It will research low-cost treatment and other options for value addition and the changes in behavior needed for their adoption, and most importantly develop practical health risk reduction guidelines in close collaboration with UN agencies to train authorities in 100 countries.

3.3.4 River basins

River basins comprise a mosaic of ecosystems, including diverse components of land and water use. Basins provide a range of ecosystem services that are used to varying degrees of effectiveness by different groups with different results. They provide both provisioning (food, medicinal plants, energy) and regulating (carbon sequestration, air and water purification, crop pollination) ecosystem services. They are each unique, with different challenges and characteristics and with different systems of governance.

Key activity areas

1. Managing water resources variability and re-thinking storage
2. Resource allocation and sharing for the benefit of all
3. Water and energy for food
4. Water data and accounting in basins

The world's river basins have tremendous potential to sustain human and environmental needs over the next 40 years. The way we learn to develop, manage and share these resources is critical. An ecosystem services perspective would enable a different kind of research and policy approach to basins that respects their unique nature and the broad range of food, power and environmental functions they support. How people choose to manage river basins in the future, for multiple uses and across scales, while protecting vital ecosystem functions will make the difference between catastrophe and survival.

This SRP provides information for better decision-making on water allocation, benefit sharing and how to address issues of water variability. Efforts to improve water management can be deeply affected by fluctuations in water availability over time; these will only increase with climate change and other external drivers. Emphasis will be given to supporting policies and mechanisms that ensure equity in water rights, benefit-sharing and decision-making. This SRP revolves around four activity areas:

1. Rethinking different types of water storage (reservoirs, wetlands, farm ponds, etc.) to account for extremes in water availability such as floods and droughts. For instance, in the Mekong, there is the potential to find ways to improve storage of annual flood waters for dry-season use.

2. Sharing benefits from water management and allocation more effectively. This activity will not only provide information to decision-makers but also contribute to improved understanding of how different benefit-sharing mechanisms are being implemented. For instance, in the Andes partners are working with the environment ministry in Peru to develop and test different benefits sharing regimes.

3. Applying the water, food, energy nexus approach to identify and quantify linkages, tensions and trade-offs across these sectors using water.

4. Improving our ability to accurately predict how much water there is at any location so that decision-makers have better information for water-resource planning.

3.3.5 Information systems

Key activity areas

1. Connecting information to development decisions
2. Measuring agro-ecosystem health

Current and accurate information on land use and the environment is needed to underpin land and water planning and management. Yet the information available for many developing countries lacks substance; it is difficult to compare because it has been gathered using inconsistent collection methods; and it tends to focus on natural ecosystems rather than on agro-ecosystems. Inadequate information limits evidence-based planning and prevents reliable feedback on what works and why.

Information systems will support the other SRPs, as well as other consortium research programs, by developing and applying methods and metrics to help set priorities, target development interventions and evaluate the impact of the work.

For instance, by working with the irrigation SRP it will help to identify and improve return on investments in small-scale irrigation in sub-Saharan Africa. Likewise it will work with partners in the rainfed SRP to improve the design of integrated interventions that improve resilience to climatic and other variability.

Work will also focus on measuring agro-ecosystem health. Data products will support the resolution of major dilemmas facing decision-makers in the Mekong basin, for example. This will support stakeholders to make better-informed and more effective and efficient intervention and investment decisions.

4. Achieving impact

Trajectories of poverty and ecosystem health are significantly influenced by a multitude of decision makers at various scales – from individual farmers to government entities to multinational companies. Achieving sustainable improvements in management of water, land and ecosystems to benefit poor people requires that these decision makers make informed investments, actions and policies. WLE will improve the sustainability of agricultural development in Africa, Asia and Latin America by catalysing investments in evidence-based practices, policies, governance approaches at national and local levels and by changing the global discourse on agricultural development, environmental sustainability and poverty reduction.

WLE's approach to impact puts people - users of research results - at the heart of our research for development efforts. This guiding tenet is the unifying principle that brings together WLE international research centers, local research partners, and development agencies across sectors to jointly design research that delivers solutions that decision makers invest in to realize development goals.

WLE does not undertake development actions directly, but assumes responsibility for ensuring that research outputs lead to significant benefits for poor communities and the agro-ecosystems that poor people depend on. WLE's business processes and structures are designed to strengthen our knowledge of decision makers' research needs, provide knowledge of value to them, and optimize the conditions for the effective utilization of knowledge. This approach builds on WLE's comparative advantage of having / operating from local offices in Africa and Asia where we aim to realize our development impacts taking advantage of our in-depth

understanding of the needs and constraints of decision makers – from individual farmers, to medium-size businesses to regional level governance bodies. We draw on our local and international expertise and experience to provide knowledge and support for their decision making. In order to maximize returns on investments in research, WLE evaluates our research to impact performance to improve the work that we do. As a result of these efforts, improving sustainable intensification of agriculture will be achieved through information-driven design and strategies, not by chance.

WLE – together with international and local partners – implements the following integrated, multi-pronged strategy to create a foundation for impact success:

- **Market Analyses**
  WLE performs market analyses to understand development and policy formulation processes, and determine how markets influence decision making at different scales in different contexts, understand level and sources of knowledge of key decision makers, and to determine information, decision support, incentives and capacities required to enhance their decision-making. This baseline research responds to the development needs in each context and examines institutional, business, sociocultural, economic and other conditions that determine the value, acceptance and utilization of research-based development solutions. Through deep understanding of research "demand", WLE ensures that research is aligned to provide relevant solutions of value for users, which is a driving factor in achieving impact.
- **Design Research to Build Development Solutions**
  Based on market analyses, WLE designs and manages its research goals and research activities to align with research demand and development processes. In addition, WLE synthesizes the body of knowledge and provides expertise needed to create development solutions for identified research users. Through knowledge valorization, we will also determine what strategies are best suited to transfer the value from research results to society.
- **Support Implementation of Evidence-Based Development Solutions**
  To catalyze investments in evidence-based development solutions, WLE:

    a. Supports multi-stakeholder platforms, engages key decision makers at local, national, regional and global levels and provides them with tailored knowledge, decision support, and context-specific solutions to development challenges. The focus of these efforts is to bring multiple perspectives together on complex agriculture and ecosystem issues and to demonstrate to decision makers the costs and benefits of investing in solutions, strengthening incentives that improve social and financial returns on investments, and bringing innovations into use in development.
    b. Removing constraints that have limited the impact of research on sustainable agriculture in the past – including constraints associated with capacity, finance, information, and risks – is an important goal of WLE. WLE partners with organizations with relevant expertise to remove specific constraints to achieving envisioned impacts.
    c. To support the above engagement and capacity building support services, WLE will produce a range of 'evidence products' that synthesise and communicate a body of evidence that demonstrates the credibility, relevance and appropriateness of proposed solutions.

4.2 Communication and knowledge management

Communication of research findings has conventionally been seen as a by-product of research efforts. Research results are produced and disseminated. A poster might be made, a manual, a policy brief, or a glossy brochure for donors. Communication and knowledge management are an essential part of WLE as these practices will ensure that research moves to outcomes.

The range of practices within communication and knowledge management (KM) will support WLE in a number of ways. First it will help synthesize and distill key messages across the program and position WLE vis-à-vis other Consortium research programs. Second it will help establish a WLE identity that is inclusive and allows for partners participation. It will also help improve internal sharing of knowledge and information within WLE as well build capacity of researchers to communicate research findings. Finally, communication and knowledge management strategies will be directly linked to the outcome pathways identified by WLE and support efforts to engage and communicate research findings with various actors.

The main objectives of the engagement communication and knowledge management are to:

1. **A new discourse and engagement in global/regional fora**: promote continuous dialogue and interaction with diverse groups of stakeholders and communities of practice through face-to-face and virtual mechanisms (webinars, the agriculture and ecosystems blogs, workshops, as well as local, regional, and international events).

2. **Internal knowledge sharing**: Support partners in the program to take advantage of a range of tailored communication and knowledge sharing tools, approaches and methodologies to effectively share information and learning.

3. **Strategic Communication**: Inform key stakeholders beyond the program of WLE's focus, emerging results and insights so that they can use in their own work.

4. **Making information accessible**: Develop systems and tools to aggregate and harvest partner data and information related to WLE so that it is properly documented, archived and published to maximize its wide accessibility and re-use by others.

The Engagement, Communication and KM will leverage knowledge and expertise from IWMI and partners' own capacities and systems.

4.3 Partnerships for impact

Partnerships are at the heart of WLE as an initiative that brings together a diverse range of actors. There are three types of partnerships

1. Core partners: the 13 current partners that make up the consortium. They may be considered as co-investors.
2. Implementation and strategic partners: these are the national, regional and international partners that we engage with to ensure our research is relevant and being uptaken into wider development processes. These could be national government agencies, local research systems, communities, private investors, NGOs and financial instiutions and bi-lateral organization.
3. Donors and investor partners: we should view our donors and investors as key partners in the research as they can easily act as boundary partners and have influence in the areas they work.

Core partners have been engaged in a variety of ways and their inputs assured through participation in the Management Committee. Implementation and strategic partners will be engaged in research within focal regions and other work and we will seek to promote.

WLE will ensure that a substantial percentage of all research projects are led by national and regional partners as we recognize that it is essential to ensure meaningful participation of national and regional partners in order to achieve impact. In addition, competitive grants will be used to allow for a wider range of partners to participate in research.

4.4 Poverty, gender and institutions

Achieving long term and sustainable impact will not be possible without a clear strategy on understanding the dynamics of poverty and gender, and on involving and evolving institutions to allow for more equitable governance. To date impact is often limited due to the assumptions made on the link between interventions and their ability to reduce poverty. WLE will, therefore, invest in understanding poverty within the context of water, land and ecosystems, better. It will identify the main issues straddling the three themes as related to poverty, and will identify areas where it can have an impact through technical interventions, policy development or community engagement.

On gender, WLE appreciates that there is much rhetoric on engendering research and interventions, but often limited impact has been achieved. As part of the strategy under gender, WLE will have three clear objectives, building from gender responsive to gender transformative:

- Increasing the opportunities of both men and women to have productive roles in developing vibrant and sustainable communities
- Enhancing the abilities of men and women to engage in policy level (at all levels) and decision making on water, land and ecosystems
- Ultimately, improving women share of resources, as defined by them

The approach to reach these objectives is through mainstreaming and by providing gender leadership. The integration will be done by systematically setting up processes to allow for maximum input on gender within the project cycle to ensure its integration within the activities and projects. An important aspect will be to ensure systematic monitoring of the impacts of projects on the livelihoods of men and women, since interventions are known to have negative impacts on women and their work load. This gender responsive work will be done through working within the SRPs, by ensuring gender disaggregated data is collected, analysis of data from a gender and equity perspective is done, by understanding gender-specific barriers for equitable use and decision making in water, land and ecosystems, through developing gender-sensitive policies and gender–specific interventions, and by analyzing and enhancing incentives for increased gender equity in land and water management.

Providing gender leadership will be done through identifying a series of research questions and research areas that will guide the achievement of the objectives, both within the program and also within the SRPs. In other words, strategic and innovative research on gender issues within the WLE mandate that will help change perceptions and behaviour.

Three levels of outputs are expected:

- Increased understanding and data on gender and water, land and ecosystems
- Improved processes for ensuring equitable interventions and institutional arrangements
- Identified and implemented activities to enhance the well-being of men and women dependent on water, land and ecosystems

4.5 Monitoring and Learning

WLE is developing its monitoring, evaluation and learning strategy to assist program managers, researchers and stakeholders to monitor and evaluate its performance, to learn from observations and intermediate results, to align Program objectives and impact pathways and to increase its accountability to stakeholders. The principles of this strategy are that monitoring, evaluation and learning are driven by demand and measured by outcomes. The strategy intends to support dispersed and diverse teams to catalyze positive change. The strategy is therefore light, dynamic and learning-oriented, and will be flexible and aligned to existing monitoring, evaluation and learning systems in other CRPs where opportune and relevant. This will avoid duplication and reduce the workload for individual scientists who are involved in other CRPs besides Water, Land and Ecosystems.

The strategy will be guided by Theories of Change, which describe the vision of how the Program is expected to work and bring about developmental change. Theories of change determine where the development 'journey' will lead to and specify the anticipated development outcomes. They can be expressed in different ways and at several scales. Water, Land and Ecosystems has developed a series of theories of change and impact pathways at various levels, which are linked to the CGIAR system-level outcomes. Impact pathways provide the 'route map' and indicate who or what are the levers of change, the immediate users of research or development outputs and how their interaction is expected to lead to uptake and, ultimately, impact. Impacts are the positive and negative, primary and secondary long-term effects produced by a development intervention. They often occur many years after the end of the project that contributed to them and may thus be difficult to attribute to a particular intervention.

5. WLE Operational Structure

5.1 Program Delivery

Each of WLE's activities fits into one of five Strategic Research Portfolios (SRP)s;

- SRP1 – Irrigation Systems
- SRP2 – Rainfed Systems
- SRP3 - Resource Recovery and Re-use (RRR)
- SRP4 – River Basins
- SRP5 – Information Systems

Cross-cutting Working Groups (WG) on Ecosystem Services and Resilience (ESS&R) and Gender Poverty and Institutions (GPI) seek to enhance research across the whole program. WLE Partners map their individual research activities into activity 'clusters' within each SRP. Activity planning, budgeting and reporting at partner level is done on an annual basis.

5.2 Governance

Water Land and Ecosystems is a collaborative program in which 11 CGIAR Centers and a large number of external partners participate. The governance and management of WLE aims to strike the right balance between establishing clear and rigorous processes that ensure efficient and transparent delivery of the Program, while maintaining the flexibility to address emerging issues and minimize duplication with existing structures.

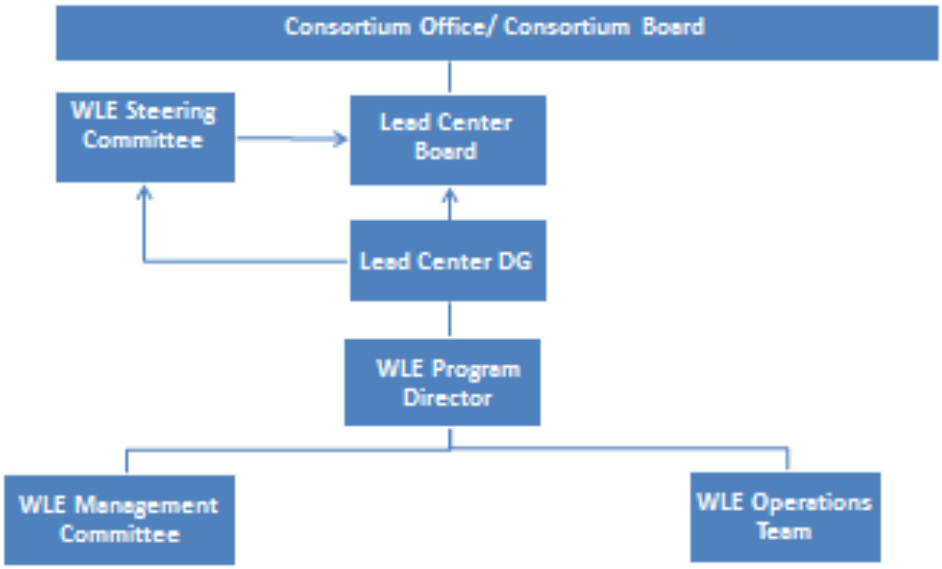

Figure 3: WLE Governance Structure

Four main bodies make up the governance structure of Water, Land and Ecosystems:

- **Lead Center (IWMI)**

IWMI is contractually accountable to the CGIAR Consortium Board for Program execution, delivery and use of Funding Council funds. IWMI enters into agreements with partners leading WLE activities and, together with its Board of Trustees, is responsible for fiduciary oversight, financial management and overall performance of the Program consistent with the guidelines of the Consortium Board and the Independent Science and Partnerships Council. IWMI hosts the WLE Operations Team.

- **Steering Committee (SC)**

Accountable to the IWMI Board, the SC comprises WLE partner representatives and independent members. It provides independent advice on scientific direction, quality of science and strategies for partnership and uptake, as well as strategic oversight for the Program as a whole.

- **Management Committee (MC)**

The MC executes planning and strategic management for the delivery of WLE, making recommendations to the Steering Committee and Board, via the Director General IWMI when appropriate, concerning decisions on WLE's science agenda, strategy, and governance and financial issues. Led by the Program Director, the MC consists of the leaders of the five Strategic Research Portfolios (SRPs) and the two working groups (WGs). The WLE operations team acts as a resource for the MC and supports implementing decisions and recommending changes.

- **Operations Team**

The Operations Team is responsible for the day-to-day management and coordination of the Program, as well as internal and external communications. The Operations Team consists of a small group of full- and part-time staff dedicated to the program, led by the Program Director and supported by IWMI.

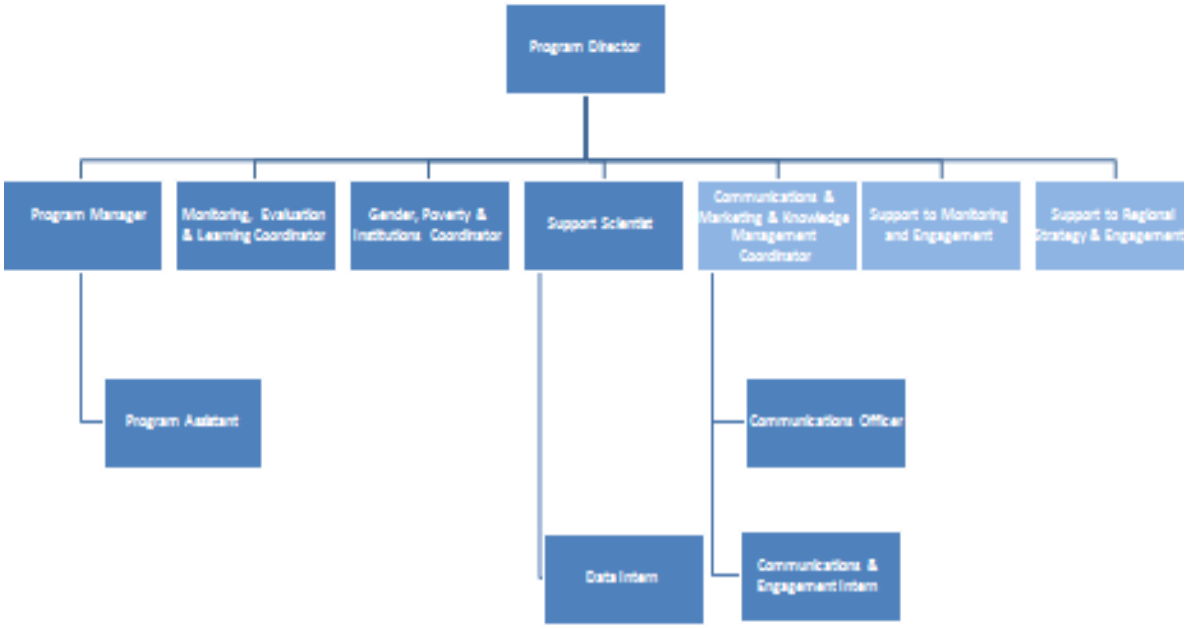

Figure 5: WLE Operations team

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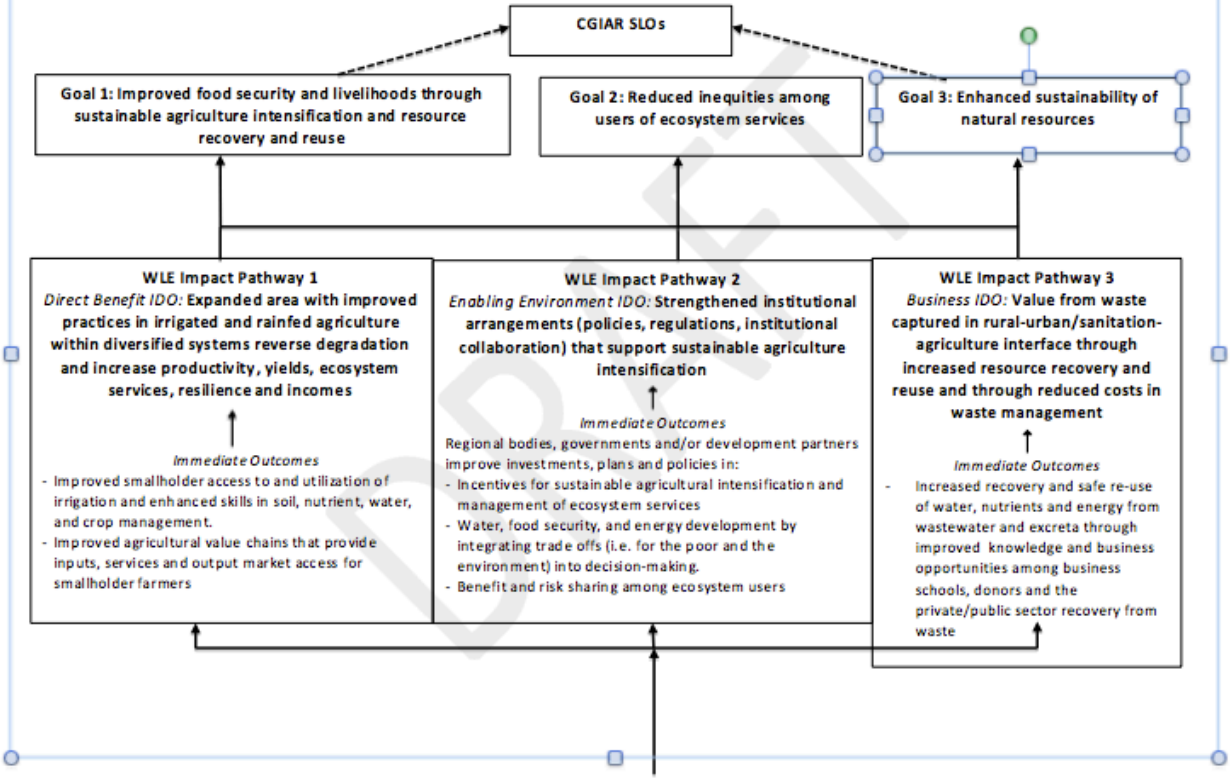
Annexes

A. A CRP Results Strategy Framework for the Volta Basin

Figure 2: A CRP Results Strategy Framework for the Volta Basin



B. WLE Outputs

WLE Outputs

1. Assessments of the state of the system and scenarios:
   a. Identification of key hotspots for loss of ecosystem services, spatial variability in soil fertility and land degradation, and variability in water resources in time and space.
   b. Assessment of natural and built water storage infrastructure and groundwater availability in large aquifers at basin scale and establishment of ecological thresholds for groundwater use.
   c. Trends, causes, and socially-differentiated impacts (in particular, on the poor and on women) of current and projected land and water resource usage on food production, nutrition, livelihood security, and ecosystem services, including national or basin-level implications of various development scenarios.
   d. Health and environmental risk assessment of resource recovery and reuse and options for risk mitigation.
2. Catalysing the Potential:
   a. Recommended practices, management interventions, technologies, business models, and institutional/governance arrangements to support sustainable intensification of agriculture at scale, inclusive of pathways to mitigate land degradation, potential for irrigation; demonstration of technical performance of underground water storage and use solutions and wetlands; factors affecting farmers' choices; policy and institutional analysis at multiple scales; enhanced understanding of how to capitalize on benefits of floods and droughts while mitigating their negative consequences. Potential for catalysing these recommendations, including enabling factors and incentive systems (including economic incentives) that support sustainable land management.
   b. Design of resource recovery and reuse options for risk mitigation of health and environmental risks.
   c. New methods of agricultural and natural resources information delivery and data collection to /from farmers and communities (e.g. mobile technology).
3. Documentation:
   a. Documented investment opportunities for decision makers, investors (e.g. economics of land degradation), NGOs, etc. to catalyse recommended practices, technologies, business models, management interventions, and institutional/governance arrangements for sustainable intensification of agriculture at scale that enhance ecosystem services and positively benefit the poor and marginalized. Includes business models for resource recovery and reuse, and investment plans to enable replication of business models across the Volta,
   b. Decision support tools for decision makers to assess synergies and trade-offs of above development investments.
   c. Resource recovery and reuse guidelines on safety options and regulations drafted for Ghana.
   d. Catalogues of promising resource recovery and reuse business cases and models for nutrient, water and energy.
   e. Improved input data provided to basin scale hydro-economic models.
4. Capacity Building
   a. National scientists, universities and development organizations trained in measurement systems to support intervention decisions.
   b. Capacity building requirements to plan, manage and maintain local irrigation.
5. Tools, Methods and Frameworks:
   a. Tools to assess and analyse trade-offs of technologies, policies, institutions and investments in relation to landscape integrity, biodiversity, and ecosystem services to increase benefits for enhanced water, food and environmental outcomes.
   b. Tools for ecosystem services monitoring in landscapes.
   c. Methods for participatory landscape and environmental planning.
   d. Tools and approaches for managing floods and droughts conjunctively in a river basin.
   e. Improved availability of various water data, methods and protocols describing surface and ground water resources and processes.
   f. Improved availability of various soil data, methods and protocols, describing major soil constraints and their spatial variability.
   g. Contribute to global soil and water resources monitoring metrics.
   h. Protocol for soil health monitoring in the World Bank Living Standards Measurement Study
6. Engagement: Engagement with actors at various scales (national, regional and international conventions, campaigns, meetings, innovation platforms to jointly develop pathways towards sustainable agricultural intensification. Volta Basin Authority; RUAF; relevant water management committees; Hydropower companies etc.

Narrative

Our WLE impact pathways in the Volta aim to lay the foundation for our longer term engagement in the basin and capitalize on the opportunities and challenges that present themselves within a highly likely future scenario, but we will explore alternative scenarios too. Together with a forecasted significant increase in population, the ratio of rural to urban populations in the basin has been forecasted to change dramatically from 2.3 now to 0.5 in 2050, so that by 2050 each rural dweller must provide food for almost two urban dwellers. Informal urban and peri-urban irrigation, mostly devoted to vegetable production, is rapidly expanding. Production will change according to the changes in urban diets and the demand for rice, maize and animal proteins. The transformation of agro-industrial and urban waste into organic manure to satisfy the needs of peri-urban agriculture is currently being pursued by Burkina Faso's sustainable agriculture development program. In Ghana activities involving a range of commodities including cash crops, livestock, indigenous commodities and value addition are being promoted through the value chain approach. This includes the development of rural infrastructure and support to urban and peri-urban agriculture. The current escalation in food market prices presents an opportunity for a higher level of commercialization by smallholders within the context of eco-efficient agricultural production systems.

WLE Impact Pathway 1 responds to the direct benefit of improved practices in irrigated and rainfed agriculture in the basin that delivers increased ecosystem services and enhances resilience in these systems. WLE encompasses a broad and integrated view of food security. Long-term food security requires sustainable land and water management as well as increased incomes. Rainfed agriculture is the activity of the majority of the poor rural population and reducing risk and dependency on rainfed agriculture at a landscape level will be the main focus for our contribution to the SLOs of improved food security, reduced rural poverty and sustainable management of natural resources. Food production is especially vulnerable to rainfall variability in the north and central parts of the basin. We will work through relevant boundary partners on improving dry season irrigation in the central part of the basin, through making better use of shallow groundwater irrigation where groundwater is underutilized and through improved management of rainwater and small reservoirs. We will aim to establish public-private partnerships as a key prerequisite for improved agricultural value chains that provide inputs, services and output market access for smallholder farmers.

WLE Impact Pathway 2 contributes to the SLO of reduced rural poverty. Governments in the basin have improved infrastructure to assist farmers who produce cash crops because of their importance for export earnings. Most of these investments however are not accompanied by incentives, capacity building and support for sustainable production. If we can encourage governments to integrate support for sustainable agricultural production, implementing similar policies for food crops could help increased production to avoid food crises. Institutional and policy changes are critically important to promote adoption of desirable agricultural and water management practices. The main links between rural poverty and institutions in the Volta Basin have been identified as access to credit, to markets, to land and to water. WLE Impact pathway 2 will create the enabling environment for improved investment plans and policies that support sustainable agriculture intensification. We will bring together relevant partners from government, NGOs, private sector and micro finance institutions to provide innovative financial products and services that stimulate development of small agro-industries to transform the local production for national markets and for export. Such products and services could include credit for equipment, supported by flood- and drought insurance to smaller farms. We will align our efforts with

governments' agriculture investment plans established under CAADP, and add value by focusing on ecosystem services upfront, as a prerequisite for sustainable agricultural intensification.

WLE Impact pathway 3 will identify business opportunities to pursue increased recovery and safe re-use of water, nutrients and energy from wastewater and excreta, in collaboration with relevant partners in the public and private sectors. This impact pathway links to our direct benefit pathway and contributes particularly to the SLO on sustainable management of natural resources, but also to the SLO on improved nutrition and health. Recognized causes of poverty in the basin are related to the lack of access to potable water, and diarrhea from unsafe domestic water (close to 50% of households use poor-quality water in both in Ghana and Burkina Faso), which have important consequences for health and manpower and have strong economic impacts at both household and basin scales. Through impact pathway 3 we will pursue improved quality of domestic water, and opportunities to turn waste captured in the rural-urban/sanitation-agriculture interface into valuable re-usable resources such as fertilizer and mulch to improve soil conditions in degraded agricultural landscapes.

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