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RICE Flagship project 3:

Sustainable farming systems

Rationale and scope

Some 400 million of the world's poor are associated with rice-based farming systems, and improving their livelihoods is one of the top priorities of RICE. These poor farmers provide surplus food to feed the increasing numbers of urban residents, many of whom are also poor and spend a large proportion of their income to buy rice. Hence, improved livelihoods of smallholder farmers should go hand-in-hand with securing the supply of safe, nutritious, and affordable rice to poor consumers. This combination broadens the scope of RICE to include large farms such as those found in the Southern Cone of Latin America, which make an important contribution to the global rice supply.

With increasing scarcity and degradation of natural resources, exacerbated by the effects of climate change, sustainable and ecological intensification is a key to increasing farm productivity at the rate needed to feed an increasing population. As the production of rice contributes to the emission of greenhouse gases (GHGs), sustainable intensification should include options to reduce such emissions.

Although gender roles and responsibilities are dynamic and can change over time depending on emerging factors such as shifts from subsistence to commercialized rice production, increasing mechanization, male out-migration, and other driving forces, female farmers play important roles in production. As family labor, women are often involved in rice farming activities that are mostly performed manually such as sowing, transplanting, weeding, harvesting, and threshing. However, women generally face difficulties performing these roles because of their lack of access to technical knowledge and technologies that can reduce their drudgery and labor bottlenecks, and provide additional income. Women also have household and care responsibilities. Reducing women's time in farm activities by enhancing their access to technologies will improve women's well-being by allowing them sufficient time for leisure or to engage in other income-generating activities. Smallholder women farmers are affected by the consequences of climate variability and other shocks with very little means to cope or adapt. Finally, women and children may suffer from malnutrition due to lack of access to and information about nutritious diets.

RICE considers farm diversification – through the introduction of nonrice crops (including fruits, vegetables, pulses, legumes), or the inclusion of trees, livestock or fish – as a major avenue to improving farmers' livelihoods and nutritional diversification. Hence, Flagship Project (FP) 3 will develop and deliver diversified farming systems and improved crop management technologies to sustainably intensify rice-based farming systems, while minimizing their environmental footprint and adapting them to climate change. Modifying the production characteristics for the rice crop is often the lynch pin change required to enable change across the entire system - eg the use of short duration rice varieties, or getting fertilizer and water management in the rice crop, is critical to enabling the success of the following crop and indeed the farming system. Crop and farm diversification will offer women increased income-generating opportunities and improved nutrition security. New mechanization options are expected to increase women's labor productivity and reduce their drudgery. This will free women's time that can be used for enhancing their income through other on- or off-farm activities. Consequently, women will gain greater control over income that they can invest for their families' well-being, including maternal health, children's education, and food and nutrition security.

FP3 develops its approaches, technologies, and farming systems in five RICE mega-rice-growing environments: mega-deltas and coastal zones, irrigated systems, rainfed lowlands, uplands, and inland valleys (see Table 3 for details). Through its place-bound mode of operation, FP3 is the main entry point for site integration with other CRPs. FP3 comprises three Cluster of Activities (CoAs) that make up a cycle from research to impact. Systems approaches will guide the research activities. Using a strong gender focus, CoA3.1 analyzes existing farming systems and identifies intervention points for innovations. Results are fed into CoAs 3.2 and 3.3 that develop and test prototype sustainable intensification and diversification options for rice production and harvest operations (postharvest operations are covered by FP2 [Upgrading rice value chains]). Participatory testing and delivery of prototype options with farmers, partners, and intermediate users at key action sites in target environments will provide the critical feedback and reflective learning in the process of technology development.

Objectives and targets

FP3 will develop and deliver improved crop management technologies and harvest practices, and intensified and diversified farming systems to (1) improve male and female farmers' and other value chain actors' livelihoods, (2) increase the sustainability and reduce the environmental footprint of rice-based farming systems and rice value chains, and (3) improve the nutritional status of malnourished, predominantly rice consumers (particularly women and children).

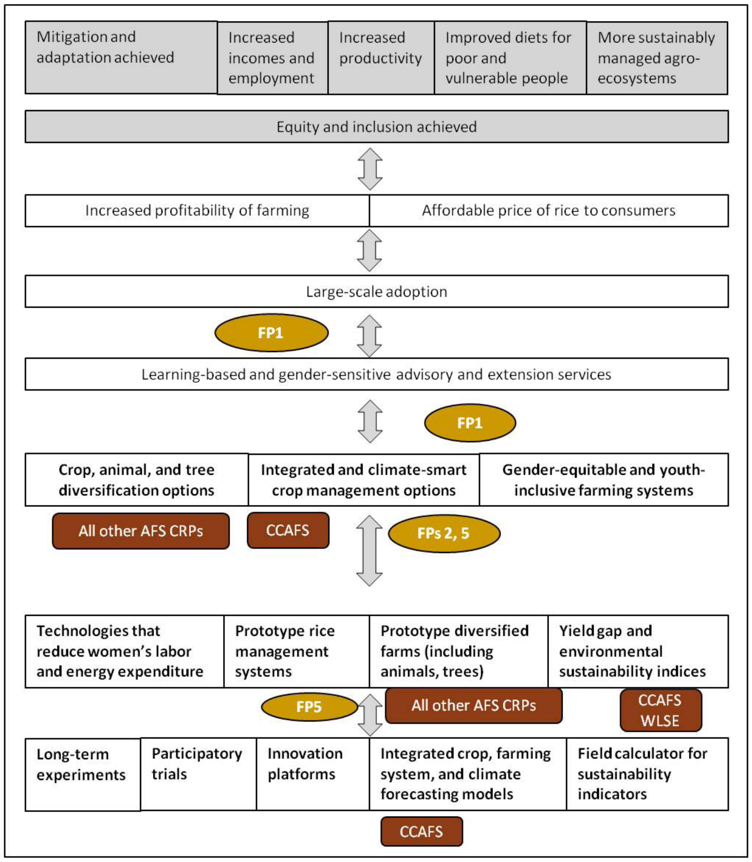
FP3 will deliver the following research outcomes to selected sub-IDOs, IDOs, SLOs, and cross-cutting issues of the SRF (see also the performance indicators matrix):

Among RICE target countries, FP3 focuses on actions sites in Côte d'Ivoire, Madagascar, Nigeria, Senegal, and Tanzania (in Africa); and Bangladesh, India, Indonesia, Myanmar, the Philippines, and Vietnam (in Asia). These countries were selected based on potential impact from rice research, country and partners' support, and donor interest. Five of these countries (Nigeria, Tanzania, Bangladesh, India, and Vietnam) were selected by the CGIAR Consortium for concerted site integration across CRPs.

Impact pathway and theory of change

Fig. 3.1 presents the impact pathway and theory of change, with risks and associated enabling actions of FP3. The three CoAs ensure that a pipeline of products and services (crop management technologies, novel cropping and farming systems, and mechanization equipment) is developed that benefits male and female farmers and other value-chain actors at the key action sites of RICE. Adoption of these products and services should enhance farmers' and other value-chain actors' livelihoods, gender equity, and the sustainability of natural resources and ecosystem services. Risks for poor farmers' adoption of products and services include lack of market incentives, limited access to credit and input suppliers, high expense of equipment for individual farmers, weak manufacturers and workshops for machineries, limited dissemination of products by scaling partners, supportive policies not in place, and major trade-offs among productivity, livelihood, and the environment (Fig. 3.1). Enabling actions to realize the benefits may include partnership development, capacity development, policy advocacy, engagement with market actors, facilitating linkages to finance services, business model development in collaboration with other FPs, and development of appropriate products and services in this FP (see enabling actions in Fig. 3.1). The development of products and services will be underpinned by needs and opportunity assessments and results

FP3 research outcome	Sub-IDO	IDO	SLO or cross-cutting issue
Improved management practices that reduce yield gap by 10-15% developed and disseminated at eight action sites (Nigeria, Senegal, Tanzania, Madagascar, Vietnam, Indonesia, Bangladesh, Myanmar)	Closed yield gaps through improved agronomic and animal husbandry practices	Increased productivity	Reduced poverty Improved food and nutrition security for health
Improved management practices that increase input use efficiency by 5% developed and disseminated at eight action sites (Nigeria, Senegal, Tanzania, Madagascar, Vietnam, Indonesia, Bangladesh, Myanmar)	More efficient use of inputs Enhanced conservation of habitats and resources More productive and equitable management of natural resources	Increased incomes and employment Natural capital enhanced and protected, especially from climate change Enhanced benefits from ecosystem goods and services	Reduced poverty Improved natural resource systems and ecosystem services
Options to diversity rice farms with other crops, animals, or trees developed and disseminated at six action sites (Cote d'Ivoire, Madagascar, Tanzania, India, Bangladesh, Myanmar) (together with other CRPs)	Increased livelihood opportunities	Increased income and employment	Reduced poverty
Diversified on-farm diets sourced through diversified farming systems at four action sites (Cote d'Ivoire, Madagascar, Bangladesh, Myanmar) (together with other CRPs)	Increased access to diverse nutrient rich food	Improved diets for poor and vulnerable people	Improved food and nutrition security for health
Improved rice management practices that reduce GHG by 5% disseminated at three action sites (Bangladesh, Philippines, Vietnam)	Reduced net GHG emissions from agriculture, forests and others forms of land use	More sustainably managed agroecosystems Mitigation and adaptation achieved	Improved natural resource systems and ecosystem services Climate change
Results of completed farming systems analyses used to focus development activities on key opportunities for adapting to climate risks at eight action sites (Nigeria, Senegal, Tanzania, Madagascar, Vietnam, Indonesia, Bangladesh, Myanmar)	Enhanced capacity to deal with climate risks and extremes	Mitigation and adaptation achieved	Climate change
Value chain actors including farmers and service providers using new mechanization options designed to increase women's labor productivity at seven action sites (Nigeria, Senegal, Tanzania, Vietnam, Indonesia, Bangladesh, Myanmar)	Technologies that reduce women's labor and energy expenditure developed and disseminated	Equity and inclusion	Gender and youth
Increased capacity for innovation on sustainable farming systems in partner research organizations	Increased capacity for innovation in partner research organizations	National partners and beneficiaries enabled	Capacity development



Risks	Enabling actions
Market incentives not in place	Market incentives assessed
Input supply and value chain actors, especially women and youth, do not become involved	Engaging market actors Business models development, involving women and youth
No credit access, especially by women and youth	Business models development, involving women and youth
Supportive policies not in place	Policy advocacy
Manufacturers/workshops for machineries not in place	Capacity development Policy advocacy
Extension workers and development partners do not disseminate products; are insufficiently aware of gender inequities	Involvement of partners in technology development; capacity development of partners; demonstrated benefits; gender awareness raising
No effective scaling-out mechanisms/tools	Out-scaling mechanisms/tools developed
Low adoption rate by farmers, including women	Products are Introduced to well-targeted domains and farmers Products are gender sensitive Understanding of farmers' preference and adoption constraints
Major trade-offs among productivity, livelihood, and the environment	Development and measurement of environmental sustainability
Technologies do not work, do not address women's needs	Proper technology setting; gender-differentiated needs assessment

Fig. 3.1. Impact pathway (left) and theory of change (right) of FPI. Grey boxes are IDOs, ovals (with FP x) refer to links with other FPs, and the dark boxes refer to links with other CRPs (see Annex 14.2 for abbreviations).

from market surveys, technology targeting, gender and youth analyses, and ex-ante impact assessments from FPs 1 and 2. Assessments will involve social scientists to help provide in-depth understanding of farmers' demand, labor, food and nutrition security, and risk constraints; mechanization in household decisions; and gender dimensions that are critical for designing products and services. Multistakeholder innovation platforms (linked with FP1 [Accelerating impact and equity]), in which public and private sectors with strong inclusion of women and youth will be involved, will be used to identify opportunities for achieving common goals.

A main feature of improving the enabling environment for development outcomes is the highly participatory and gender-inclusive way in which products and services will be developed, tested, adapted, and disseminated through multistakeholder innovation platforms and learning alliancesFeedback loops will be maintained throughout the impact pathway and result in site-specific versions that are continuously updated through incorporation of reflective learning.

To avoid poor adoption rate by female farmers and to provide new income-generating opportunities for them, special attention will be paid to gender equity and women's empowerment through the development and dissemination of gender-sensitive technologies and know-how that particularly respond to women's constraints, needs, and preferences, and through targeted inclusion of women in capacity development. Enabling actions in RICE such as training, development of scaling-out mechanisms, multistakeholder platforms that can strengthen linkages among value-chain actors, financial services, business model development, and market incentives, will improve women's access to resources, technologies, and know-how, which will contribute to increased productivity, reduced labor input, and increased food and nutrition security.

Increasing productivity and production leads to increased marketable surplus, thus enabling women to have a greater income and increased purchasing power to buy quality food, ensuring their roles in guarding household food security and health, especially of young children. They may also have more time to invest in other income-generating activities and for collecting water and sanitation practices, which will lead to improved health outcomes. Obviously, care must be taken with the introduction of labor-saving technologies that women workers are not deprived of their means of income and that alternative use of their time really constitutes an improvement in welfare.

Together with FP1, FP3 will develop training and dissemination materials such as videos, posters, leaflets, manuals, and training curricula for enhancing large-scale adoption. RICE recognizes that nearly all farmers are connected to markets and input suppliers through many intricate value chains. Hence, FP3 will maintain a strong link with FP2 to ensure that solutions respond to market demand, new market opportunities are exploited, links to input suppliers and service providers are strengthened, new entrepreneurial opportunities are exploited, and access to credit is facilitated. Links with FPs 1 and 2 will enable supportive policies to be designed and put in place that allow innovative farmers and other value-chain actors, including the private sector, to engage in, and benefit from, new market incentives.

Scaling-out and large-scale adoption will be supported by FP1 to strengthen the various technical, financial, and capacity development-related service providers. In collaboration with FP2, business models for the provision of agricultural advisory and machinery services and the delivery of equipment will be developed and piloted to support this process. These service providers will be enabled to provide better, demand-driven services based on the identified upgrading needs.

2.3.1.4 Science quality

FP3 will build on the approach of GRiSP to promote integrated research for developing demand-driven technologies with consideration of farmers' perspectives, including gender issues. In GRiSP, agronomy research focused on rice technologies at the plot/field level such as nutrient, water, or pest management options, with little consideration for the whole farming system that includes other crops, livestock, fish, or trees for improving whole-farm productivity, income, and diet diversity. Social learning is integrated in some agronomy work in Asian rice systems, but more effort is required. Development of new technologies and farming systems requires novel transdisciplinary research and partnership approaches in FP3, and will be based on needs and opportunity assessments, market surveys, technology targeting, gender and youth analyses, and ex-ante impact assessments from FPs 1 and 2. These assessments will be taken with involvement of social scientists (FPs 1 and 2), which will help provide in-depth understanding of farmers' demand, labor, and risk constraints; mechanization in household decisions; and gender dimensions that are critical for designing technologies. Technologies will be co-designed with farmers and other value-chain actors through innovation platforms and learning alliances and will be intensively evaluated for their efficacy and potential for poverty reduction so that the technologies will be readily adopted.

FP3 will use and develop systems analysis approaches throughout the product pipeline. Integrated farming systems approaches will be supported by the development and use of multidisciplinary and participatory diagnostics, site analyses, and technology assessments; and through the use of such tools as simulation analysis (e.g., ORYZA2000 for rice, APSIM and DSSAT for crop rotations) and decision-support systems (e.g., Crop Manager, RiceAdvice, WeRise—integrated seasonal weather forecasting and associated crop management advice, and PRACT—a tool for designing conservation agriculture systems). Development and delivery of decision-support tools will be major achievements in FPs 3 and 6. FP3 builds on GRiSP tools and will upgrade these based on farmers' and users' feedback, and critical assessment of these tools.

Socioeconomic and biophysical considerations will be integrated and trade-offs or win-win situations using alternative technologies and farming systems will be made explicit. Objective assessments of these trade-offs will be enabled through further development of the Field Calculator that simultaneously assesses economic and biophysical aspects of alternative management options. New metrics for socioeconomic and environmental sustainability will be designed and scaled-up together with the Sustainable Rice Platform and WLE.

RICE considers crop and farm diversification as a major avenue to improving farmers' livelihoods and will evaluate other staple crops (maize, wheat, and potatoes), pulses, vegetables, fish, livestock, and trees as diversification options in rice-based farming systems in collaboration with other agri-food system CRPs as well as other partners such as AVRDC. Its focus will not only be at field level, but also at farm and/or community level, especially for land and water management. Whole-farm productivity, income, and diet diversity as well as environmental sustainability will be assessed to make sure that there is no major trade-off among them.

The leader of FP3 is experienced in agronomy and has leadership skills obtained in both GRiSP and AfricaRice research-for-development projects and programs. The FP3 core team consists of senior scientists with a wide range of expertise (soil management, pest management, water management, cropping systems, crop models, climate change, and mechanization). Additional skills on needs and opportunity assessments, technology targeting, gender analyses, and participatory delivery will be drawn from collaboration with FPs 1 and 2.

GRiSP Theme 3 (equivalent to FP3) performed well in terms of scientific publications, with 18 of the top 50 most-cited publications in GRiSP since 2011 being on agronomy and crop management. The RICE FP3 will continue to emphasize high-quality journal papers and, as per Independent Evaluation Agreement (IEA) review recommendation, FP3 senior scientists will mentor junior colleagues, especially those at the lower end of the H-index scale and in Africa. To ensure quality of publications in peer-review journals and to reduce publications with no or very low impact factors, FP3 management will carefully monitor publication records annually and share publication guidelines among FP3 partners. Also, FP3 management will encourage stronger research collaboration among RICE core partners and with partners in ARIs for further improving the overall quality of the scientific output through jointly authored, high-quality publications (see also section on Partnerships). FP3 management will strengthen interdisciplinary research in collaboration with management of the other RICE FPs. Special attention will be paid to joint research in social science and gender aspects. Finally, in FP3, joint PhD scholarships will be pursued with ARIs such as Wageningen University that have strength in farming systems analyses and agricultural innovation systems. Two science partners—University of Leeds and NIAES—will strengthen climate-related research through use of state-of-the-art crop-climate modeling and novel micro-climate assessment methodologies. AVDRC will be a key partner for rice-vegetable systems.

Lessons learnt and unintended consequences

In GRiSP, much of the location-specific work on improved crop management was organized around hubs, or key action sites, and carried out in close partnership with national programs. The selection of technologies for adaptive testing and dissemination should be based on participatory diagnostics, but, as the IEA review of GRiSP identified, "too many resources were allocated to routine baseline descriptive data collection to characterize sites, with little analysis to understand household decision making on technology and natural resource management. This was partly due to donor-driven development projects too eager to see quick results (uptake and impact) on the ground. Also, insufficient resources were invested to understand opportunities and constraints of women in rice farming and value chains in order to better address the effectiveness and equity impacts of GRiSP research and technology delivery". Hence, in RICE, FP3 includes a specific CoA (3.1) to conduct multidisciplinary, participatory diagnostics and in-depth site analyses on issues of gender, nutrition security, risk, labor markets, farmers' needs and opportunities, and mechanization in household decisions.

Also, as suggested by the IEA GRiSP reviewers, FP3 will invest more resources (especially W1 and W2) in exploratory and upstream research and less in downstream delivery projects, which will become more appropriate for GRiSP scaling-out partners (through FP1). Another lesson learned is that too many of GRiSP R&D activities remained disciplinary in nature. FP3 will focus its work on specific action sites where, through multistakeholder platforms and participatory approaches, it will join hands with other FPs to develop interdisciplinary and holistic solutions that fit site-specific contexts.

FP3 will develop and deliver a wide range of technologies to promote gender equity, close yield gaps, improve productivity, enhance food and nutrition security, reduce production risks, adapt to climate change, increase farmers' livelihoods, and reduce degradation of natural resources and ecosystems. To account for potential trade-offs and develop win-win situations, various measures of both socioeconomic and environmental sustainability will be designed and collected. FP3 participates in the Sustainable Rice Platform in which multidimensional sustainability criteria are developed and mainstreamed in rice production and rice value chains. FP3 will also serves as the link point with WLE's ESA flagship project that will develop scalable sustainability indicators for RICE interventions, building on 2015 GRISP/WLE collaboration on assessing trade-offs in rice production systems.

Particular attention will be paid to potential unintended consequences for women when new technologies are introduced. For example, labor-saving technologies such as mechanized crop establishment may alleviate the plight of women by removing the need for backbreaking manual transplanting, but it may also deprive them of their jobs and hence their income. However, women might gain additional benefits from alternative value-adding opportunities or contract service provision. FP3 will closely monitor—and find ways to remedy—negative impacts and foster positive outcomes in close collaboration with FP1. Through its hands-on collaboration with local partners in innovation platforms and learning alliances, FP3 will closely monitor any other unintended consequences of its R&D activities.

Clusters of activity (CoA)

3.1. Farming systems analysis

Farming systems analysis will be the entry point for identifying opportunities for diversification and intensification for improving farmers' livelihoods (e.g., crop rotation, opportunities for livestock or fish, and improved crop management). CoA3.1 uses diagnostic surveys, participatory needs assessment, and simulation analysis tools (e.g., ORYZA2000 for rice, and APSIM and DSSAT for crop rotation). Analyses will encompass environmental, socioeconomic, and biophysical aspects such as environmental sustainability, resilience and capacity to adapt to shocks, and current and future climate risk. In collaboration with CCAFS, FP3 will assess future climate risk using the climate change scenarios and climate impact methodologies that are developed in CCAFS. CoA3.1 will build on information generated by FP1 through its foresight analyses and ex-ante and ex-post impact assessments. Linked with FP1, the analyses made in this CoA will also include gender issues to guide the development of R&D frameworks to deliver technologies designed to increase women's labor productivity, reduce their drudgery, and improve their nutrition security.

Through the process of site integration, CoA3.1 will organize joint workshops with other CRPs that have a significant presence in similar geographic areas to develop a common understanding of needs and opportunities for collaboration efforts. Such activities will foster ideas for collective action that will be further teased out in joint next steps (e.g., joint analysis using existing data, joint experiments, thematic workshops, and sharing facilities) and formulations of joint grant proposals. Joint PhD scholarships will be pursued with advanced research universities that have strength in farming systems analyses. Some of these PhD scholarships will be co-funded with other CRPs. As female agronomists are very few in sub-Saharan Africa and Asia, female candidates will be given priority.

In collaboration with the Sustainable Rice Platform, CoA 3.1 will develop, validate, and scale-up multidimensional sustainability indicators, building on the socioeconomic and biophysical sustainability criteria and field calculator developed in GRiSP. The indicators developed in this CoA will be used by CoAs 3.2 and 3.3.

3.2. Intensification and mechanization

Innovative technologies to improve rice farming will be designed based on the analyses from CoA3.1, as well as on yield gap assessments, process-based knowledge derived from ongoing long-term rice trials (>50 years in Asia and >20 years in Africa), and gender analyses (together with FP1). CoA3.1 starts with technologies developed in GRiSP (e.g., Crop Manager, RiceAdvice, alternate wetting and drying, and weeder), and novel technologies as they emerge from the pipeline.

Options for mechanization will be developed in response to labor shortages and to improve labor productivity and agricultural income. Examples are mechanical transplanters, direct-seeding equipment, mechanical weeders, and harvesting machinery (combined harvester-thresher). Attention will be paid to options that free women from backbreaking activities such as transplanting and weeding. Where women remain involved in such activities, mechanization will increase their productivity and income and CoA3.2 will actively support them with appropriate training. However, where the introduction of mechanization introduces the risk that women are deprived of their source of income, CoA3.2 will facilitate the development of alternative job opportunities. Together with FP1, CoA3.2 will link with partner organizations that foster women's development such as NGOs and women's self-help groups. CoA3.2 will also develop or upgrade ICT tools, on-farm advisory services, and machinery options that could be attractive to youth who want to start a rice business or extension service.

Component technologies such as options for improved management of soils, water, and pests; mechanization options; and new varieties (link with FP5 [New rice varieties]) will be grouped into integrated management practices, which will be co-developed and tested with farmers, with a strong inclusion of women and youth and other stakeholders organized in multistakeholder platforms at key action sites. Experiences of farmers and local partners will provide critical feedback to the process of technology development and lead to reflective learning and adaptation of impact pathways and theories of change (jointly with FP1). Together with FP1, experimental results will be combined with simulation tools to identify target domains that are suitable for adoption of the selected technologies.

Further, CoA3.2 will develop specific technologies to reduce GHG emissions from rice fields at key action sites and assess GHG emissions under improved technologies such as adapted tillage, water-saving technologies (e.g., alternate wetting and drying), straw and residue management with composting and charring, and fertilization strategies. Indicators developed in CoA3.1 will help assess synergies or trade-offs among other dimensions of sustainability. This CoA is a co-investment with the CCAFS CRP through sharing of staff, resources, and experimental sites. Jointly with CCAFS, climate-smart agricultural practices will be defined, fine-tuned, and scaled-up in rice production.

3.3. Farm diversification

In collaboration with other AFS CRPs and with centers such as AVRDC, other staple crops (maize, wheat, potatoes), pulses, vegetables, fruits, fish, livestock, and trees will be evaluated as diversification options in rice-based farming systems. The opportunity of farm diversification to diversify on-farm diets will be an important focus. The hypothesis that the on-farm availability of diverse food items will enhance dietary diversity among farmers and rural communities will be tested through dietary surveys. Novel systems options will be co-developed and tested with farmers, with strong inclusion of women and youth and other stakeholders organized in multistakeholder platforms at key action sites. The development of prototype systems will be based on the analyses of CoA3.1, novel technologies from CoA3.2, experiences from long-term rice-based cropping system trials, and in-depth understanding of local cropping/farming systems, farmers' demands, diets, labor and risk constraints, household decision mechanisms, and critical gender dimensions. Mechanization dimensions will expand from a rice focus in CoA3.2 to whole farm operations and farming system optimization. Examples are the use of machinery for multiple crops, and the opportunities that mechanization of one crop offers for changes in whole farm cropping patterns (see below).

Diversified cropping systems may take many forms depending on local conditions. For example, in parts of Bangladesh where water saving is required, crops that use less irrigation than boro rice, such as wheat, maize, and sunflower, are being introduced. The introduction of early-maturing rice varieties in two-rice crop systems has been shown to give farmers an extra month between seasons, allowing a third crop such as maize or mustard that can provide farmers with an extra US$ 600–700/ha (CSISA 2014). Double- or triple-cropped systems combining stress-tolerant rice and maize varieties with new breeds of fish have been shown to double the production of both rice and fish (CSISA 2014). Rice-lentil-mungbean systems produce rice-equivalent yield of 41% more than two-rice (aman-boro) crop systems, and are five times more profitable (Sirajul Islam et al 2015).

Newly-introduced systems create many new connections and networks into the rice-based system, each requiring its own (sub)set of interventions such as market research and postharvest and distribution activities, in order to optimize benefits to producers and consumers. CoA3.3 assesses the consequences of the introduction of new systems on livelihoods, labor productivity, diet diversity, and gender equity and empowerment parameters. The interactions between the crops, trees, or animals (livestock and fish) and the generalized rice-based value chain are envisaged as interconnecting value chains, such that the performance of any one crop/tree/animal affects the performance of the whole. While complex systems and their interactions are beyond the scope of RICE, opportunities for their analyses will be explored with other agri-food system CRPs and PIM through the process of site integration. The aim is to jointly develop a coherent approach to address complex webs of agri-food systems.

Partnerships

The CGIAR centers have strong partnerships with regional organizations and NARES, and have long experience in collaborative R&D on the topics of FP3. In Africa, AfricaRice leads research networks on the Africa-wide Rice Agronomy Task Force and the Africa-wide Rice Mechanization Task Force. Through these networks, technologies are introduced, validated, and disseminated. In Asia, IRRI leads cross-country partnerships through research consortia such as the Consortium for Unfavorable Rice Environments (CURE) and the Irrigated Rice Research Consortium (IRRC). In Latin America and the Caribbean, CIAT does not engage in agronomy research itself, but facilitates cross-country knowledge sharing and transfer through the Latin American Fund for Irrigated Rice (FLAR).

International public goods (IPGs) include simulation analysis tools, decision-support systems (e.g., Crop Manager, RiceAdvice, and Field Calculator), options for diversified farming systems, improved crop management technologies and machinery, and indicators for environmental sustainability. Generic IPGs will be adapted and developed into site-specific technologies and practices that fit local contexts.

The CGIAR centers and their partners have developed innovative research areas in GRiSP, which provide a solid foundation for RICE. Comparative advantages of CGIAR centers compared to other R&D providers are their international mandate, their extensive and diverse partner networks, the unique long-term and strategic NRM studies that are in place (e.g., IRRI long-term experiment ongoing since 1961; nutrient management studies with omission plots with national partners, 1995–2015), the close association of germplasm development and NRM, and their ability to adopt, validate, and transfer technologies across countries.

Climate change

Rice is among the most vulnerable crops to changing climates because of its importance in low-lying production areas such as mega-deltas and coastal zones. Women rice farmers are generally more threatened than their male counterparts by climate change, having far less capacity than males to cope or adapt (Mehar, 2014). Rice-farming areas are also substantial producers of the GHG methane, and climate-smart management practices are needed for both adaptation and mitigation along the rice value chain. FP3 will develop integrated management practices combining climate-smart varieties (from FP5) with climate-smart management technologies (e.g., water, nutrient, and residue management). Scaling-out of climate-smart technologies will be done with FP1 and in strong collaboration with CCAFS. Weather forecasting will be combined with climate-smart management practices into climate-informed advisories.

Some major partners and their roles are:

Discovery	Proof of concept	Scaling out
To enhance the quality of its science, FP3 will particularly expand partnerships with ARIs and universities (IEA review recommendation #2, IEA report, p xvi) such as CSIRO, Wageningen University, University of Leeds, AVRDC, and NIAES. CSIRO and Wageningen University will specifically strengthen RICE in systems analysis such as crop simulation models and farming systems analysis	NARES (e.g., PhilRice, VAAS, ICAR, BRRI, AIAT, NCRI, ISRA, and FOFIFA), development agencies (e.g., AGRA, CoARI, GIZ, SNV, and Syngenta Foundation), local universities (e.g., UPLB, Yezin Agricultural University in Myanmar, and Royal University of Agriculture in Cambodia), private companies (e.g., OCP), NGOs (e.g., CRS, BRAC, and Don Bosco), and value-chain stakeholders (farmers, processors, agri-business, exporters, and importers) are partners at the pilot study level. FP3 will undertake joint R&D activities such as surveys, participatory technology testing, and development of innovation platforms and learning alliances at action sites.	Regional organizations (e.g., ECOWAS), NARES (e.g., BRRI, VAAS, ICAR, ICRR, AIAT, and WAAPP), Latin American Fund for Irrigated Rice (FLAR), national organizations (e.g., SAED), development agencies (e.g., AGRA, CoARI, GIZ, and Syngenta Foundation), NGOs (e.g., CRS and BRAC), private companies (e.g., Hanigha Nigeria Limited), Notore Chemical Industries Plc, and value-chain stakeholders (farmers, processors, agri-business, and exporters) are partners for scaling-up, which will also involve other value-chain actors' organizations and business communities (e.g., input suppliers and markets).

For reducing GHG emissions, specific management and technologies such as improved water management options, technologies to reduce the emissions and pollution from open field burning, and more energy-efficient machines will be developed and delivered in collaboration with CCAFS.

Gender

Based on demand and needs from women in rice farming (in collaboration with FP1), and in collaboration with them, FP3 will develop and deliver integrated management options and sustainable farming systems designed to increase productivity, income, and diet diversity of women farmers. Options that can reduce/eliminate women's drudgery, reduce health risks, and free their time will be a special focus, including mechanical transplanters, direct-seeding equipment, mechanical weeders and/or the use of herbicides, harvesting machinery (combine harvester-thresher), and mechanical threshers. On-farm participatory testing will explicitly involve women farmers to ensure that technology development addresses their specific needs and concerns.

To avoid biased adoption by male and female farmers and to reduce the gender gap, FP3 will collaborate with FP1 and with the CGIAR gender network in PIM to enhance gender-equitable access to its developed products and services, gender-inclusive rural extension and advisory systems, other services including financial services, and agricultural training programs. As the introduction of mechanization might displace women in certain farm operations and deprive them of current incomes, FP3 facilitates the introduction and expansion of new income-generating opportunities. Mechanization can also provide new value-adding options for youth, and therefore can renew interest among youth for a career in agriculture. In collaboration with FP2, FP3 will ensure that business models for mechanization activities are gender inclusive and will provide appropriate capacity development, e.g., on the operational and financial aspects of business models to women. Finally, FP3 researchers and their partners (public and private sector, NARES, NGOs, etc.) will be sensitized by gender specialists in RICE to the gender aspects of their work. FP3 scientists will improve their understanding of gender roles and cultural contexts, and will engage women farmers and other women actors along the rice value chain for technology testing and dissemination.

Capacity development

Five of the nine elements of the CGIAR Capacity Development Framework (CapDev) are specifically addressed in FP3. In the element "Developing future research leaders through fellowships," FP3, together with FP1, will have a scholarship program for PhD research, especially for women. A clear focus in Africa is to develop capacity in systems analysis, including crop simulation modeling and farming systems analysis. For the element "Organizational development," FP3 will focus on enhancing NARES research and research management capacity, and capacity development of partners and extension systems for scaling-out technologies.

"Capacity needs assessment and intervention strategy design" will focus on creating an enabling environment and improving the capacity of national partners in developing curricula for academic and skills training, in particular for mechanization. These activities will target organizational and institutional changes such as assisting the joint use of technologies, service provision, and institutional changes required. Individual capacity development will focus on participatory and on-the-job training of partners from the public and private sector as well as service providers. Women will be given priority. Through the multistakeholder approach using learning alliances, FP3 will also engage in "Design and delivery of innovative learning materials and approaches" in close cooperation with FP1. FP3 will also work with FP1 on "Gender-sensitive approaches for capacity development," in particular for mechanization interventions.

2.3.1.11 Intellectual asset and open access management

FP3 follows the RICE policies and strategies on intellectual asset management, open access, and data management in line with the CGIAR Principles on the Management of Intellectual Assets and their Implementation Guidelines, and with the CGIAR Open Access and Data Management Policy and its Implementation Guidelines. FP3 intellectual assets/research data include agronomic data and databases; data analysis tools; computer and other IT software such as simulation models and advisory systems; crop management options; blueprints for machinery (in rice production); video, audio, and images; peer-reviewed journal articles; reports and other papers; and books and book chapters. Data will be made accessible through various websites, e.g., AfricaRice Data Repository and Dataverse. Agronomic knowledge, information on management practices, training materials, and dissemination products will be made available at Rice Knowledge Bank, RiceHub, Rice videos Africa, and Rice videos Asia. The rice model ORYZA2000 is fully documented, maintained, and downloadable with tutorials. Data are made available within 12 months after curation and quality control or 6 months after journal publication of analyses. Personal data collected with respect to farmers or other stakeholders will be processed fairly and lawfully and, in particular, shall not be made public.

Flagship Project management

FP3 is led by Kazuki Saito from AfricaRice. Each CoA is co-led by a team of senior scientists (focal persons) consisting of one or more representatives from each center. FP3 leader Kazuki Saito will coordinate activities in FP3 across the participating centers and institutes. AfricaRice and IRRI will work on all the CoAs. CIAT will facilitate knowledge sharing with and within Latin America and the Caribbean in conjunction with FP1. Cirad will contribute to CoA 3.3. JIRCAS will contribute to CoA 3.2. Cirad and JIRCAS will focus on target countries in sub-Saharan Africa. David Johnson (IRRI) will coordinate all CoAs in Asia. Patrice Autfray (Cirad) and Satoshi Tobita (JIRCAS) will co-lead CoAs 3.3 and 3.2 in Africa, respectively, and Kazuki Saito (AfricaRice) will lead the other CoAs in Africa. These senior staff (focal points) will be responsible for planning, monitoring, and evaluating activities across CoAs within each center or institute. The FP3 leader and focal points will organize workshops using the FP3 leader's coordination budget. Also, they will facilitate communication across the participating centers and institutes to enhance information and knowledge sharing. Reiner Wassmann is focal point for CCAFS in IRRI and will also facilitate collaboration between CCAFS and RICE.