Smart-Valleys Project Phase 2 Final Technical Report (2014-2019)

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Executive summary

A Smart-Valleys approach is a farmers' participatory approach to develop inland valleys for lowland rice. The approach was developed by Africa Rice Center (AfricaRice) in SMART-IV Phase 1 funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF), Japan. In the Phase 1 project targeting Benin and Togo, the Smart-Valleys approach was evaluated and validated in the demonstration sites. Thanks to the continuous financial support of MAFF, the Smart-Valleys project started in October 2014 with the target countries of Benin, Togo, Sierra Leone and Liberia as Phase 2 of the SMART-IV.

The Smart-Valleys project (October 2014–September 2019) aimed to improve the livelihood and food security of rice producers by augmenting and securing rice production in inland valleys through improved land and water management and improved agronomic practices and mechanization. The specific objectives were:

- To improve inland valley rice production of smallholder farmers through area expansion and increased productivity in the target countries, which are expanded from Phase 1
- To achieve augmented and stable yields through improved site-specific agronomic practices and mechanization
- To support and facilitate the further diffusion of the Smart-Valleys development approach and improved agronomic tools and equipment through capacity building and technical support

To achieve the objectives, five activities were generated and implemented with NARS and other partners. They were:

1. Expanding inland valley rice areas
2. Improving and stabilizing rice yields
3. Strengthening post-harvest activity
4. Impact assessment
5. Assuring sustainable project implementation and accelerating adoption of the technologies beyond the project

In the new project countries, Sierra Leone and Liberia, demonstration sites were developed and lowlands were reclaimed with the Smart-Valleys approach. In addition to the developed sites, no-project farmers adopted the approach and they reclaimed lowlands. In Benin and Togo, no new demonstration site was developed by the project but some spillover effects where farmers and NGOs reclaimed lowlands by Smart-Valleys approach were observed.

In all countries, trainings in the Smart-Valleys approach, technologies to improve rice yield—use of RiceAdvice providing site-specific fertilizer recommendations, fabrication of mechanical weeders, good agricultural practices and adoption of Participatory Learning & Action Research (PLAR)—and post-harvest technologies based on the needs of farmers were intensively conducted.

Due to the Ebola crisis happened in Guinea, Sierra Leone and Liberia in 2013–2016, change of the project coordinator and staff turnover, the implementation of the project delayed, especially in Sierra Leone and Liberia. AfricaRice requested MAFF for no-cost extension up to December 2019 and almost all outputs expected were achieved.

The following is major achievements in Benin and Togo:

- Farmers near the old demonstration sites in Phase 1 developed the area of 325 ha

- A total area including lowlands developed by NGOs and farmers' groups became 1030.9 ha
- 576 individuals—national agricultural research partners, technicians, extension officers and farmers—were trained for the methodology of the Smart-Valleys approach
- 1036 individuals—technicians, local craftsmen and farmers—were trained in various technologies to improve rice yield
- 27 farmers were trained in improved parboiling technologies
- Yield of the Smart-Valleys adopters was 2.05 t/ha, while that of the non-adopters was 1.67 t/ha
- Income of a Smart-Valleys adopter was 315.56 US$/ha, while that of a non-adopter was 97.51 US$/ha

The following is major achievements in Sierra Leone and Liberia:

- 39 demonstration sites were developed and the lowland rice area of 55.2 ha was newly developed in the demonstration sites
- A total area developed by the Smart-Valleys approach including spillover effects by non-project farmers was 179.3 ha in Sierra Leone. In Liberia, this survey, which was part of the impact assessment study, has not yet been conducted but will be made by other funding sources
- 1590 individuals—national agricultural research partners, technicians, extension officers and farmers—were trained for the methodology of the Smart-Valleys approach
- 3395 individuals—technicians, local craftsmen and farmers—were trained in various technologies to improve rice yield
- 48 farmers were trained in improved parboiling technologies
- Yield of the Smart-Valleys adopters was 4.02 t/ha, while that of the non-adopters was 1.62 t/ha
- Income of a Smart-Valleys adopter was 2017.29 US$/ha, while that of a non-adopter was 860.39 US$/ha

Contents

1. Introduction

1.1. Importance of inland valleys to achieve rice self-sufficiency in sub-Sahara Africa

Rice production of the 23 CARD member countries, which cover major rice production countries in Africa, became almost double from 2008 to 2018. However the consumption increased more in that period; therefore a rice self-sufficiency rate decreased from 63% (2008) to 59% (2018) (USDA Statistics). Necessity of continuous and further intervention by R4D for rice in Africa is clear and CARD Phase 2 aiming double rice production from 2018 to 2030 has started.

The doubled rice production in Africa from 2008 to 2018 was mostly due to land expansion rather than yield increase. Furthermore, van Oort et al. (2015) shows that even under the assumption that yield increases 80%--this cannot be realistic—land expansion in lowland is indispensable to achieve rice self-sufficiency in eight African countries in 2025 (https://doi.org/10.1016/j.gfs.2015.01.002). Improvement of water management in existing lowland rice areas, which is the key of the improvement of yield, and expansion of lowland with some water control are both crucial to increase rice production.

For the land expansion, lowland has higher productivity—higher yield and possibly continuous cultivation without a fallow period—for rice than upland so that sustainable development of lowland is crucial. In Africa, fortunately, there still be a huge amount of unexploited lowland, e.g. only 10–25% of the total inland valleys area (Rodenburg et al. 2014: https://doi.org/10.1016/j.agsy.2013.09.004) accounting for 85 million ha. The Smart-Valleys, a participatory lowland development approach, developed by AfricaRice in the SMART-IV Phase 1 funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF), Japan could be a technology responding to the necessity in this regard.

1.2. Achievements of SMART-IV Phase 1 (2009–2014)

The Phase 1 project—from October 2009 to September 2014—targeted Benin and Togo. The Smart-Valleys approach was introduced into the demonstration sites selected with capacity strengthening for trainers and leading farmers. Spillover effects that farmers groups and NGOs around the demonstration sites voluntarily adopted the approach. In Phase 1, the following key achievements were obtained:

- 9 Smart-Valleys trainings were organized
- 87 technicians were trained in the Smart-Valleys approach
- 47 lead-farmers were trained
- 28 Smart-Valleys demonstration sites as a total in 6 zones were developed
- After project ending 139 Smart-Valleys sites were operational
- Average yields increased from 1.5–2 to on average 3.5–4 tons/ha
- The area developed using Smart-Valleys was 205 ha in Benin 135 ha in Togo
- In total 1,486 farmers cultivated rice of which 55% were female farmers

Smart-Valleys led to greater water storage in the fields and less field run-off through bunding and drainage facilities. The agricultural risks for farmers, such as drought, flooding and loss of fertilizers, are reduced and they invest more in agricultural equipment and agricultural inputs, such as fertilizers and good seeds, and they produce for the local and regional markets. In addition, the project investigated three rice technologies: 1) RiceAdvice tool; 2) mechanic weeders; 3) contract farming.

2. Implementation of the project

2.1. Description of the project

In this section, the project and its implementation are outlined. For more detailed description. “Project proposal” (Appendix 1) and “Smart-Valleys project principles 2014–2019” (Appendix 2) can be referred.

Goal and objectives

The goal of the Smart-Valleys project (2014–2019) was to improve the livelihood and food security of rice producers by augmenting and securing rice production in inland valleys through improved land and water management and improved agronomic practices and mechanization.
The specific objectives were:

- To improve inland valley rice production of smallholder farmers through area expansion and increased productivity in the target countries, which are expanded from Phase 1
- To achieve augmented and stable yields through improved site-specific agronomic practices and mechanization
- To support and facilitate the further diffusion of the Smart-Valleys development approach and improved agronomic tools and equipment through capacity building and technical support

Target countries and partners

Benin, Togo, Sierra Leone and Liberia are target countries. The experiences and achievements from the Phase 1 Project in Benin and Togo will benefit the project. In these two countries, AfricaRice did not lead new demonstration sites development. New technologies and mechanization equipment were tested and evaluated with rice farmers in the demonstration sites. Since new target countries, Sierra Leone and Liberia, receive much higher rainfall than the phase 1 countries, the Smart-valleys approach was needed to be evaluated first then implemented.

AfricaRice was a project implementing institution. In each country the project was implemented in close collaboration with the national partners:

Country	Acronym	Institute
Benin	CBF	Inland Valley Unit of the Rural Engineer Division of the Ministry of Agriculture
Togo	ITRA	Agronomy Research Institute of Togo
Sierra Leone	SLARI	Sierra Leone Agricultural research Institute
Liberia	CARI	Central Agricultural research Institute

Other organizations that benefit from the project through capacity building and technical support—no funded partners—are as follows:

Country	Acronym	Organization
Benin, Togo	ETD	NGO Entreprises Territoires et Développement
Benin	CIRAPIP	NGO Recherche et l'Action pour la Promotion des Initiatives Paysannes
Togo	WiLDAF	NGO Women in Law and Development in Africa
Togo	GRED	NGO Groupe de Recherche-action pour l'Education au Développement
Togo	PADAT	MINISTRY: Projet d'Appui au Développement Agricole du Togo
Liberia	WFP	INTERNATIONAL: World Food Program of the United Nations
Sierra Leone	WFP	INTERNATIONAL: World Food Program of the United Nations

Project activities and expected outputs

The project had activities in five areas and some sub-areas under the area. They are:

A1: Expanding inland valley rice areas

- A1-1: Development of Smart-Valleys demonstration sites in Sierra Leone and Liberia
- A1-2: Development of the Smart-Valleys training package
- A1-3: Smart-Valleys capacity building for new trainers, technicians and leader-farmers

A2: Improving and stabilizing rice yields

- A2-1: Development and validation of sustainable site-specific nutrient management tools
- A2-2: Evaluation and introduction of adapted labor-saving small machineries
- A2-3: Introduction of Good Agricultural Practices (GAP) and Participatory Learning & Action Research (PLAR)

A3: Strengthening post-harvest activity

- A3-1: Capacity building of farmers regarding post-harvest activity

A4: Impact assessment

- A4-1: Impact assessment on livelihood of rice farmers

A5: Assuring sustainable project implementation and accelerating adoption of the technologies beyond the project

- A5-1: Diffusion of rice technologies and enabling environment
- A5-2: Support fund-raising to support scaling out of rice technologies and continuation of activities
- A5-3: Creating visibility for the project and the research for development approach

Each activity had expected outputs, which are summarized in the following table:

ACTIVITY		Togo and Benin	Sierra Leone and Liberia
A1	A1-1	N/A	5 demonstration sites are operational in each country
	A1-2	Training package is available in French, and four local languages. Multiplied to 100 copies	Training package is available in English, and two local languages. Multiplied to 50 copies
	A1-3	10 technicians are trained as Smart-Valleys instructors	4 technicians are trained as Smart-Valleys instructors
		40 extension officers and 40 leader farmers are trained in Smart-Valleys approach	10 extension officers and 10 leader farmers are trained in Smart-Valleys approach
		At least 300 farmers receive on-the-job training in Smart-Valleys approach	At least 100 farmers receive on-the-job training in Smart-Valleys approach
A2	A2-1	RiceAdvice tool is validated in 4 zones.	Sustainable nutrient management method is identified and validated in 2 zones
		12 field technicians are trained in the use of RiceAdvice and provide fertilizer advice to 120 rice farmers	10 field technicians are trained in the sustainable nutrient management method and provide training to 100 rice farmers
	A2-2	Farmer preference for mechanic weeders in inland valleys rice system is assessed in 4 zones	Farmer preference for mechanic weeders in inland valleys rice system is assessed in 2 zones
		30 local craftsmen are trained in the production and maintenance of mechanic weeders	10 local craftsmen are trained in the production and maintenance of mechanic weeders
	A2-3	120 farmers receive GAP training	40 farmers receive GAP training
		30 field technicians are trained in PLAR	10 field technicians are trained in PLAR
		PLAR is implemented with farmers in 6 zones and on-farm agronomic practices are improved	PLAR is implemented with farmers in 2 zones and on-farm agronomic practices are improved
A3	A3-1	Postharvest technology needs are identified in 4 zones and 24 farmers are trained in use of postharvest technology	Postharvest technology needs are identified in 2 zones and 6 farmers are trained in use of postharvest technology
A4	A4-1	Impact assessment on farmer livelihoods performed using 2013 WFP baseline study	Impact assessment on farmer livelihoods performed using 2011 baseline study
A5	A5-1	Governments of Togo and Benin incorporate AfricaRice rice technologies in national policies and projects. Development organizations and NGO's have adopted AfricaRice rice technologies	50 delegates from the (agricultural) development sector participate in Rice Innovations Forum. Development organizations and NGO's have adopted AfricaRice rice technologies
	A5-2	At least 10 proposals are developed or supported that aim rice development and	At least 5 proposals are developed or supported that aim rice development and

	that integrate AfricaRice scalable technologies	that integrate AfricaRice scalable technologies
A5-3	Results are presented in popular journals like Rice Today	Project is broadcasted on national television in Liberia and Sierra Leone
	Newspaper articles are prepared and published	Newspaper articles are prepared and published
	Project briefs are prepared and shared with donors and fund council of CGIAR	Project briefs are prepared and shared with donors and fund council of CGIAR

2.2. Delay of the project implementation and no-cost extension

The implementation of the Smart-Valleys project encountered several difficulties that caused some delays in obtaining the outputs that were projected. The Ebola crisis in Guinea, Sierra Leone and Liberia (2013–2016) caused delay in the project implementation of Sierra Leone and Liberia in Year 1 and Year 2. Some staff turnovers including the change of the coordinator (from Sander Zwart to Roland Issaka in March 2017) also affected the project implementation.

In Year 3 and Year 4, the delay of the implementation was mostly resolved. However, the two activities—dissemination of the instruction video in Liberia and Sierra Leone and impact assessment in Liberia and Sierra Leone—could not be completed. Therefore, AfricaRice requested MAFF no-cost extension of three months (from 1 October to 31 December 2019) and the request was kindly approved.

2.3. Mid-term evaluation

A mid-term evaluation was conducted by Dr. Moro Buri in 14–28 February 2018. After the review of the project document and past reports, Dr, Buri visited all project countries with the project coordinator. Field visits were made to Kpele Tutu (Togo), Zoungou (Benin), Bamoi (Sierra Leone) and SKT town (Liberia) where discussions were held with beneficiary farmers, technicians and opinion leaders.

Expected progresses in Benin and Togo, who could receive benefits of Phase 1, were observed. Farmers in the two countries were conversant with improved technologies in land development, water management and good agricultural practice (GAP) under the Smart-Valleys approach. Delays in Sierra Leone and Liberia were also identified. Due to late start in Liberia and Sierra Leone as a result of the Ebola crisis, famers are still to imbibe improved land development, water management and GAP technologies.

The reviewer provided AfricaRice recommendations to the project (See “Mid-term, evaluation report” in Appendix 3). AfricaRice continued the project implementation taking the recommendations into account.

2.4. Final evaluation

The final evaluation was also made by Dr. Moro Buri from 24 October to 6 November 2019. Basically the same methodology was taken with the mid-term evaluation.

The review was positive in general and the following is an observation: “Most planned activities have been well executed and project outputs achieved particularly under A1, A2 and A3. Farmers seem to be making progress in terms of improved land development, water management and nutrient management at all sites visited. Rice yields have significantly increased and land under rice cultivation increased at all project

sites yields have significantly increased since inception of project. This could reflect in increased income, as marketing seems to be favorable at all countries and may result in improved living conditions. Out-scaling has been seen in greater areas in Togo and Benin but gradually picking up in Liberia and Sierra Leone. However, not much has been achieved under A5 basically on adoption studies and incorporation of technology into national policy formulations. Impact studies (A4) have been done in Togo and Benin but still on-going in Liberia and Sierra Leone."

The reviewer also stated major challenges remaining—i.e. "As presented during interaction with some farmers, storage facilities, quality management of milled rice continue to pose challenges in Togo and Benin. In Sierra Leone and Liberia, backstopping activities to support farmers adopting the Smart Valleys approach are still critically necessary. Support activities on land development, GAP application and site specific nutrient management technologies are critical key challenges that may require further assistance if the gains made are to be sustained."

The report is enclosed as Appendix 4.

3. Achievements

3.1. Status of achievements against the project outputs expected (2014–2019)

Most expected outputs have been achieved. Some outputs in Activity 5—Assuring sustainable project implementation and adoption of technologies—have not been fully achieved, especially in Sierra Leone and Liberia. Achievements in the four countries are summarized in the following two tables (one for Benin and Togo and the other for Sierra Leone and Liberia). In Sub-sections 3.2, 3.3, 3.4 and 3.5, more detailed explanations on the achievements are provided.

Togo and Benin Project output (2014-2019)		Status	Achievements
A1: Expanding inland valley rice areas with the Smart-valleys approach			
A1-1	N/A	N/A	A spillover effect has begun in both Togo and Benin since 2014. In Togo, working at 40 sites located within 3 regions and involving a total of 301 farmers (62 females), a total area of 120 ha has been developed, while in Benin, over 205 ha across 50 sites have also been developed.
A1-2	Training package is available in French, and four local languages. Multiplied to 100 copies.	Achieved	An instruction manual developed in French and multiplied to 100 copies. 30 copies of manual distributed to partners in Benin and 30 copies of manual distributed to partners in Togo. An educational video developed in French, and translated to two local languages in Benin (Fon and Yoruba) and two local languages in Togo (Ewe and Yoruba). 100 copies of the video made for each local language and distributed to partners.
A1-3	10 technicians are trained as Smart-Valleys instructors.	Achieved	10 technicians (5 from each country) selected by national partners trained as Smart-Valleys instructors.
	40 extension officers and 40 leader farmers are trained in the Smart-Valleys approach.	Achieved	47 extension officers and 40 lead farmers were trained in the Smart-Valleys approach.
	At least 300 farmers receive on-the-job training in the Smart-Valleys approach	Achieved	A total of 479 farmers (300 in Togo and 179 in Benin) received on-the-job training in the Smart-Valleys approach.
A2: Improving and stabilizing rice yields through improved agronomic practices and mechanization			
A2-1	RiceAdvice tool is validated in 4 zones.	Achieved	RiceAdvice has been validated in 2 regions in both countries. Validation has been done in Cove and Zogbodome in Benin. In Togo validation was done at Plateaux and central regions.
	12 field technicians are trained in the use of RiceAdvice and provide fertilizer advice to 120 rice farmers.	Achieved	28 technicians have been trained in the use of the RiceAdvice and provided site specific-fertilizer advice to more than 215 farmers.

A2-2	Farmer preference for mechanic weeders in inland valleys rice system is assessed in 4 zones.	Achieved	Farmers' preference assessed in 2 zones (one zone in Benin and another in Togo) and involved 40 farmers.
	30 Local craftsmen are trained in the production and maintenance of mechanic weeders.	Achieved	30 local craftsmen trained in the production and maintenance of weeders in both countries. In Benin, 12 local craftsmen were given special training to fabricate two types of weeders that farmers preferred most.
A2-3	120 farmers receive GAP training.	Achieved	479 farmers have received training on GAP.
	30 field technicians are trained in PLAR.	Achieved	47 field technicians have been trained in both countries.
	PLAR is implemented with farmers in 6 zones and on-farm agronomic practices are improved.	Achieved	Over 400 farmers spread across 6 zones from both countries have been engaged in PLAR activities resulting in significant yield increases (5–6 t/ha in Benin and 3.5–5.0 t/ha in Togo).
A3: Reducing post-harvest yield losses through the introduction of locally adapted technologies			
A3-1	Postharvest technology needs are identified in 4 zones and 24 farmers are trained in use of postharvest technology.	Achieved	2 workshops involving 67 participants organized to identify farmers' needs in post-harvest. 27 farmers (15 in Benin and 12 in Togo) trained in improved parboiling techniques.
A4: Impact assessment on livelihood of rice farmers			
A4-1	Impact assessment on farmer livelihoods performed using the 2013 baseline study.	Achieved	See the text of Sub-section 3.4.
A5: Assuring sustainable project implementation and adoption of technologies			
A5-1	Governments of Togo and Benin incorporate AfricaRice rice technologies in national policies and projects. Development organizations and NGO's have adopted AfricaRice rice technologies.	Achieved	Meetings in both countries with the Ministries of Agriculture to help draft inland valley policies in into national policies in both countries. 9 NGOs in Togo and 2 NGOs in Benin have adopted the Smart-Valleys approach. The Smart Valley approach has been incorporated into two strategic documents of the Ministry of Agriculture, Livestock and fisheries of Benin: National Strategies for Lowlands and National Strategies for Irrigation.
A5-2	At least 10 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable technologies.	Partially achieved	Five proposals were developed and submitted. Out of the 5 proposals, two were approved for funding by the German Development Co-operation. One project is CSA-Burkina and it is aimed at increasing the resilience of Burkina farmers to

			climate change, with a focus on Smart-Valleys approach in the rainfed lowland environment. The other project, ETES-Rice, has been implemented in Benin and Togo and is now completed.
A5-3	Results are presented in popular journals like Rice Today.	Achieved	Four publications produced in journals by team from Benin. One publication is in Rice Today and the others are in other journals.
	Newspaper articles are prepared and published.	Achieved	Presentation on the Smart-Valleys approach aired on Radio France. Results have been published on mail online In Benin, “Smart-Valley brings rice bounty”. Smart-Valleys approach was presented at the COP 22 Climate Change Conference held in Marrakech, Morocco in 2016 and was selected as an example of the adaptation of African farmers to climate change and variability. Scientific publication by Arouna and Akpa in 2019.
	Project briefs are prepared and shared with donors and fund council of CGIAR.	Achieved	Results published on CGIAR website title “In Benin, Smart Valleys bring rice bounty”.

Sierra Leone and Liberia			
Project output (2014-2019)		**Status**	**Achievements**
A1: Expanding inland valley rice areas with the Smart-valleys approach			
A1-1	5 demonstration sites are operational in each country.	Achieved	A total of 21 demonstration sites spread across four counties have been established in Liberia involving 600 farmers (244 females) on 35.2 ha. In Sierra Leone, 18 sites spread across 4 chiefdoms have been established involving over 900 farmers on more than 20.4 ha.
A1-2	Training package is available in English, and two local languages. Multiplied to 50 copies.	Achieved	An instruction manual developed in English and multiplied to 100 copies. 50 copies of manual distributed to partners in Liberia and 50 copies of manual distributed to partners in Sierra Leone. An educational video developed in English, and translated to local languages in two local languages in Liberia (Mino and Kpelleh). 30 copies of the video made for each local language and distributed to partners.
A1-3	4 technicians are trained as Smart-Valleys instructors.	Achieved	33 technicians (15 from Sierra Leone and 18 from Liberia) trained as Smart-Valleys instructors.
	10 extension officers and 10 leader farmers are trained in the Smart-Valleys approach.	Achieved	25 extension officers and 32 lead-farmers were trained in the Smart-Valleys approach.
	At least 100 farmers receive on-the-job training in the Smart-Valleys approach.	Achieved	A total of 1,500 farmers (600 in Sierra Leone and 900 farmers in Liberia) trained in the Smart-Valleys approach.
A2: Improving and stabilizing rice yields through improved agronomic practices and mechanization			
A2-1	Sustainable nutrient management method is identified and validated in 2 zones.	Achieved	In Liberia, yield improvement validated with two improved rice varieties (IR841 & NERICA-L19). In Sierra Leone, yield improvement with urea deep placement and yield loss reduction due to iron toxicity with the use of rice husk validated.
	10 field technicians are trained in the sustainable nutrient management method and provide training to 100 rice farmers.	Achieved	13 field technicians (5 from Sierra Leone and 8 from Liberia) trained in sustainable nutrient management. 350 farmers (150 from Sierra Leone and 200 in Liberia) trained.

A2-2	Farmers' preferences for mechanic weeders in inland valley rice systems are assessed in 2 zones.	Achieved	Farmers' preference assessed in 10 sites (7 in Sierra Leone and 3 in Liberia).
	10 local craftsmen are trained in the production and maintenance of mechanic weeders.	Partially achieved	In Liberia, 2 craftsmen trained in the production and maintenance of mechanical weeders.
A2-3	40 farmers receive GAP training.	Achieved	More than 1,500 farmers (900 from Sierra Leone and 600 from Liberia) received training on GAP.
	10 field technicians are trained in PLAR.	Achieved	In Sierra Leone, 5 technicians and in Liberia, 10 technicians have been trained in PLAR.
	PLAR is implemented with farmers in 2 zones and on-farm agronomic practices are improved.	Achieved	PLAR has been implemented in 2 chiefdoms in Sierra Leone and in 3 counties in Liberia.
A3: Reducing post-harvest yield losses through the introduction of locally adapted technologies			
A3-1	Postharvest technology needs are identified in 2 zones and 6 farmers are trained in use of postharvest technology.	Achieved	Farmers' needs in post-harvest assessed in 2 zones. 48 farmers (19 in Sierra Leone and 29 in Liberia) trained in improved parboiling techniques.
A4: Impact assessment on livelihood of rice farmers			
A4-1	Impact assessment on farmer livelihoods performed using the 2013 WFP baseline study.	Almost achieved	See the text of Section 3.4. The adoption area of the Smart-Valleys in Liberia is a remaining task, which will be determined using other funding sources.
A5: Assuring sustainable project implementation and adoption of technologies			
A5-1	50 delegates from the (agricultural) development sector participate in Rice Innovations Forum. Development organizations and NGO's have adopted AfricaRice rice technologies.	Partially achieved	A rice innovation forum organized in November 2018 in Sierra Leone. Over 80 persons including personnel from the Ministry of Agriculture, policy makers, scientists, project farmers and some NGOs participated. In Liberia a rice innovation forum was organized in September 2019. Over 100 people from the Ministry of Agriculture, Scientists, NGOs, Project farmers and other interested farmers attended.
A5-2	At least 5 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable technologies.	Not achieved	In Liberia, development of a proposal almost completed

A5-3	Project is broadcasted on national television in Liberia and Sierra Leone.	Partially achieved	In Liberia, project activities have been broadcast on county radio (Radio Gbanga) and on national television.
	Newspaper articles are prepared and published.	Achieved	In Liberia Project activities was published in National Newspaper the Observer. https://www.liberianobserver.com/news/smart-valleys-rice-project-flourishes-in-gbartala/

3.2. Land expansion by the Smart-Valleys approach

The results are summarized in the tables in Sub-section 3.1.

In Sierra Leone and Liberia, the Smart-Valleys approach was introduced through the development of demonstration sites. In total, 21 demonstration sites covering 35.2 ha were established across 4 counties in Liberia involving 600 farmers. In Sierra Leone, 18 demonstration sites covering 20 ha were established across 4 chiefdoms involving 900 farmers.

In Benin and Togo, the inland valley rice development approach of the SMART-IV project (2009–2014) consisted of the establishment of Smart-Valleys demonstration sites and the provision of adequate training to field technicians and lead-farmers. In the framework of the implementation of the SMART-Valleys project, no new demonstration sites was developed in Benin and Togo. However, the out-scaling of the Smart-Valleys approach was witnessed, mainly through spillover effects. Beneficiary farmers of the SMART-IV project (Phase 1) extended the Smart-Valleys area in their sites. Neighborhood farmers who visited the Smart-Valleys sites replicated the approach in their fields. About 325 ha of new inland valley areas were developed with the Smart-Valleys approach across 90 sites by about 2000–3000 farmers.

In Sierra Leone and Liberia, the collected information on the developed area and number of farmers adopting the Smart-Valleys approach is from the demonstration sites. Spillover effects to non-project farmers have not been captured in that result. The impact assessment study has revealed that wider areas and more farmers have adopted the approach (see Sub-section 3.4). On the other hand, in Benin and Togo, figures came from spillover effects by farmers in and near the sites developed in Phase 1. Areas developed by NOGs and other groups could not be seized. The impact assessment study has depicted larger figures in the adoption of the Smart-Valleys approach (see Sub-section 3.4).

3.3. Capacity buildings

Capacity building for the Smart-Valleys approach (Activity 1)

The results are summarized in the tables in Sub-section 3.1.

A training package consisting of an instruction manual and an educational video was developed to support the scaling of the Smart-Valleys approach. The instruction manual was developed in French and English. The educational video was developed in French and English and has been translated into two local languages in Benin (Fon and Yoruba), two local languages in Togo (Ewe and Kabie), and two local languages in Liberia (Mino and Kpelleh). In each language, one hundred copies of the instruction manual and 100 copies of the educational video were made. In Benin and Togo, 60 copies of the French version of the manual and 100 copies of the videos in French and local languages were distributed to project partners. In Sierra Leone and Liberia, 100 copies of the English version of the manual and 30 copies of the educational video in each of the two local languages were distributed to project partners.

In Benin and Togo, ten technicians (5 from each country) selected by national partners were trained in the use of the Smart-Valleys manual. Trainees and technicians were further sensitized to serve as instructors in scaling out the Smart-Valleys approach among farmers. A Smart-Valleys diffusion scheme has been developed for both countries. In total, 47 extension officers, 40 lead farmers, and 479 farmers were trained in the Smart-Valleys approach in both countries.

In Liberia and Sierra Leone, 33 technicians have been trained as Smart-Valleys instructors. The capacity of trainees was built on basic land development procedures, water management, GAP and post-harvest technologies. Twenty-five extension officers and 32 lead farmers have been trained in the

Smart-Valleys approach. Participants were trained in land development and water management. At each site, a trained technician and a lead farmer provided the necessary support and training to farmers. A total of 1,500 farmers received on-the-job training in the Smart-Valleys approach. In all project countries, technicians, extension officers, lead-farmers and farmers were taken through the various steps of the Smart-Valleys approach from land development (site selection, field layout, bunding, leveling, puddling), through water management (weir construction, canals, drains) and GAP (nursery establishment, row transplanting, nutrient management, weed management, and pest/diseases management).

Yield increase and stabilization (Activity 2)

The results are summarized in the tables in Sub-section 3.1.

Sustainable site-specific nutrient management tools considered in this project were RiceAdvice—Android-based applications working on smartphones and tablets—in Benin and Togo and optimum nutrient management technologies such as improved rice varieties, deep urea placement, and use of rice husk to reduce yield loss due to iron toxicity in Sierra Leone and Liberia.

In Benin and Togo, RiceAdvice has been validated in two regions in each country. Validation was done in Cove and Zogbodome in Benin and Plateaux and the Central region in Togo. Twenty-eight technicians have been trained on the use of RiceAdvice and provided field specific fertilizer recommendations to over 215 farmers.

In Sierra Leone and Liberia, field experiments have been conducted for validating rice yield improvement using improved varieties and the urea deep placement method. The use of rice husk to mitigate iron toxicity was also evaluated in farmers' fields. All technologies had a positive effect on rice yield leading to a yield increase to 3.5–7.0 t/ha. Training was provided to more than 350 farmers in the urea deep placement method and use of rice husk for yield increase in inland valleys.

Different types of mechanical weeders were evaluated through participatory testing in the project countries. In Benin and Togo, the evaluation was conducted in 2 zones (one zone in Benin and another in Togo) and involved 40 farmers. In Sierra Leone and Liberia, the evaluation was conducted at 10 sites.

Training was provided to local manufacturers to fabricate and maintain selected weeders locally. In Benin and Togo, 30 local craftsmen were trained in the production and maintenance of weeders. In Benin, 12 local craftsmen were given special training to fabricate two types of weeders that farmers preferred most. In Liberia, 2 local craftsmen have been trained in collaboration with the SAPEC Project.

A training was provided to farmers in Good Agricultural Practices (GAP) in all project countries. GAP included good practices for land preparation, crop establishment, fertilizer application, weed control, and water management. GAP training was provided to 479 farmers in Benin and Togo and more than 1,500 farmers in Sierra Leone and Liberia.

To strengthen the skills of field technicians, a training was provided on Participatory Learning & Action Research (PLAR) in all project countries. PLAR is a farmer education approach, based on adults in groups of 20 to 25 farmers, making use of the experiences of the group members. The PLAR approach covers the whole cropping season, and the activities follow the development stages of the rice crop and the cropping season calendar. In the PLAR approach, field technicians encourage farmers to analyze their practices, discover problems, and seek solutions to solve them. PLAR does not seek to find the best solutions from a scientific point of view, but those which are the most practical, applicable, and adapted to specific local situations. In Benin and Togo, 47 technicians were trained in

PLAR and in Sierra Leone and Liberia, 15 technicians were trained in PLAR. PLAR has been implemented with over 400 farmers across 6 zones in Benin and Togo and in 5 zones in Liberia and Sierra Leone. This has resulted in farmers' yield increase to 5–6 t/ha in Benin and 3.5–5.0 t/ha in Togo.

Post-harvest (Activity 3)

The results are summarized in the tables in Sub-section 3.1.

Workshops were held to identify appropriate post-harvest technology based on needs farmers' assessment. A training need in improved parboiling technique was expressed by farmers. In Benin and Togo, 27 farmers from 7 zones were trained in improved parboiling techniques and 48 farmers from two zones were trained in improved parboiling techniques in Sierra Leone and Liberia.

3.4. Impact assessment

Methodologies adopted in the impact assessment study are stated in Appendix 5. Part of the results which are determinants for the adoption of the Smart-Valley approach in Benin, Togo, Sierra Leone and Liberia are also mentioned in Appendix 5 since the analysis of these results could be too much in detail.

Adoption of the Smart-Valleys approach

All fields under the Smart-Valley approach were tracked using GPS in order to obtain the actual area of the fields, their locations and map.

In Benin and Togo, the Smart-Valleys approach was adopted by 1486 rice farmers (668 male and 818 female) with the developed area of 233 ha (101 ha in Benin and 132 ha in Togo) in 2014. In 2019, the total area tracked for the Smart-Valley was 1030.94 ha as a total in Benin and Togo and the approach was adopted by 6110 rice farmers (2116 male and 3994 female). The impact study better saw the picture of the adopters of the Smart-Valleys approach and lands expanded by them, compared to the results shown in the tables of Sub-section 3.1, which capture only spillover effects around the old sites in Phase 1. The results of the impact assessment study include expanded areas by NGOs and farmers' groups.

In Sierra Leone, the total area tracked for smart-valley was 179.3 ha and it was adopted by 460 rice farmers (282 male and 178 female) in 2019. The area adopting the Smart-Valleys includes spillover effects beyond the demonstration sites. In Liberia, the figure of the total adoption including spillover effects is yet to be collected or calculated. A survey on the adoption area of Liberia will be conducted using other funding sources such as CCAFS (see Section 4).

Impacts of the Smart-Valleys approach on yield, household income and food consumption score

On average, the adoption of the Smart-Valleys approach increased rice yield by 0.38 t/ha in Benin and Togo and 2.41 t/ha in Liberia and Sierra Leone. Farmer's income was increased by 218.05 US$/ha in Benin and Togo and by 1,156.9 US$/ha in Liberia and Sierra Leone due to the adoption of the Smart-Valleys approach. As a consequence of the higher farmer's income resulting in purchasing power, food consumption score—an index for food and nutritional security of smallholder farmers developed by WFP (2009)—of the Smart-Valleys adopter was higher by 9.05 in Benin and Togo and 3.80 in Sierra Leone and Liberia than that of the non-adopter of the Smart-Valleys approach, indicating a potential positive effect of the adoption of Smart-Valleys on food security at the household level.

The following table summarizes the comparisons of rice yield, a farmer's income and a food consumption score between the adopters of the Smart-Valleys and non-adopters:

	Rice yield (t/ha)			Income (US$/ha)			Food consumption score		
	Adopter	Non-adopter	LATE	Adopter	Non-adopter	LATE	Adopter	Non-adopter	LATE
Benin & Togo	2.05	1.67	0.92***	315.56	97.51	243.05***	71.07	62.02	10.46***
Sierra Leone & Liberia	4.02	1.62	1.32***	2017.29	860.39	439.65***	62.37	58.57	4.12***

LATE: Local Average Treatment Effect (this is the average impact for the subpopulation of potential adopters to assess the impact on five outcomes: yield, income and food security).
***: Significant at < 1%.

3.5. Assuring technology adoption

The results are summarized in the tables in 3.1.

In Benin and Togo, meetings were held with the Ministries of Agriculture to help draft inland valley policies into national policies. The Smart-Valleys approach was incorporated into two strategic documents of the Ministry of Agriculture, Livestock and fisheries of Benin. These documents are the National Strategies for Lowlands and National Strategies for Irrigation. In addition, 9 NGOs in Togo and 2 NGOs in Benin have adopted the Smart-Valleys approach.

In Sierra Leone, some agricultural-based NGOs have been trained on the Smart-Valleys approach and the technology is being adopted. A rice innovation forum was organized in November 2018. Over 80 people including staff from the Ministry of Agriculture, policy makers, scientists, project farmers and some NGOs participated. In Liberia, a rice innovation forum was organized in September 2019. Over 100 people from the Ministry of Agriculture, Scientists, NGOs, Project farmers and farmers participated.

In Benin and Togo, five proposals were developed and submitted. Out of the 5 proposals, two were approved for funding by the German Development Cooperation (GIZ). One project is CSA-Burkina and it is aimed at increasing the resilience of Burkina farmers to climate change, with a focus on Smart-Valleys approach in the rainfed lowland environment. The other project is ETES-Rice and it is aimed at developing an operational framework for equitable scaling of the Smart-Valleys approach.

In Benin and Togo, 4 publications produced in journals by team from Benin. One publication is in Rice Today and the others are in other journals. Journalists were invited in Benin to prepare articles to presentation and one of such was a presentation on climate smart-Valley approach aired on Radio France. Results have been published on mail online In Benin, “Smart-Valley brings rice bounty”. Smart-Valleys approach was presented at the COP 22 Climate Change Conference held in Marrakech, Morocco in 2016 and was selected as an example of the adaptation of African farmers to climate change and variability. Results published on CGIAR website title “In Benin, Smart Valleys bring rice bounty”. Results were also published in international journals (Arouna and Akpa, 2019).

In Liberia, project activities have been broadcast on county radio (Radio Gbanga) and on national television. Project activities were published in National newspaper (The Observer)

4. Other projects where the Smart-Valleys approach is used

The Smart-Valleys approach has been included in several projects as a promising innovation for lowland development. CSI-Burkina Faso (Burkina Faso) and ETES-Rice (Benin and Togo) funded by GIZ and CIPA (Côte d'Ivoire and Ghana) funded by the International Fund for Agricultural Development (IFAD) are examples.

The Smart-Valleys approach is included in a list of the innovations in FP3 of RICE CRP as an innovation in the advanced stage, i.e. "adopted by the next users".

CCAFS CRP will budget AfricaRice for an impact study on the Smart-Valleys in West Africa in 2020. A larger scale impact assessment will become possible.

5. Acknowledgement

AfricaRice expresses its sincere thanks to the Ministry of Agriculture, Forestry and Fisheries (MAFF), Japan for financial supports to the project. Because of the long standing support, AfricaRice could have been conducted R4D to exploit inland valleys which possess high potential for rice production in Africa for 10 years. The technology—the Smart-Valleys approach—will be expanded by farmers beyond the project.

Appendix 1:

5-year project plan

SMART-VALLEYS

2014-2019

AfricaRice

Achievements of the SMART-IV project (2009-2014)

The SMART-IV project started in October 2009 and ended 5 years later in September 2014. The goal was to improve the livelihood of the rural poor by reducing imports of rice through augmenting the production of the inland valleys in SSA. This was to be achieved by the introduction of the so-called *Sawah* system in Benin and Togo to improve rice yields. *Sawah* is the Asian way of rice production that includes bunding, land levelling and puddling in order to achieve full water control and continuous flooded conditions in the fields. It is usually found in irrigated systems or in areas with high rainfall.

This system was tested in year 1 and 2 of the project. However, two major limitations were found that rendered the introduction and diffusion of such a system difficult in the target countries. Firstly, there are only limited inland valleys that have sufficient water supply to achieve full water control. Secondly, the water requirements are very large and it could potentially destabilize the hydrologic conditions in an inland valley. Moreover, the *Sawah* system for rice cultivation is labor intensive.

In year three it was therefore decided to abandon the *Sawah* system development approach and a new system was developed which was later baptized as the "Smart-valley approach". This system is participatory during all steps of implementation, including the design of a system, it is low-cost and it can be easily replicated by farmers. It requires less water resources and it can be applied for rainfed as well irrigated conditions.

From year 3 onwards demonstration sites were developed using the Smart-valley approach. In Benin and Togo together over 60 inland valleys were developed as demonstration sites. Yields were easily doubled from 1.5-2 ton/ha in traditional systems to 3.5-4 ton/ha in the development sites. Hundreds of farmers received on-the-job training, whereas field technicians from extension services, NGO's working in agricultural development, and leader farmers received trainings in 1) Sites selection and validation, 2) participatory development of a site, and 3) site maintenance.

AfricaRice and the national partners are developing a Smart-valleys training package that consists of:

1. a training guide for trainers
2. a field guide for technicians
3. educational video

Adoption of the Smart-valley approach by project non-participating farmers' groups and NGOs was observed at small scale in year 4. However, large-scale adoption became visible in the fifth year of the project. The diffusion of the methodology was taken place in many different manners:

1. Trained rice farmers a) expand the existing demonstration sites without outside support, or b) they move to other inland valleys and develop new rice systems.
2. Trained field technicians from extension services and national partners (ITRA, CBF) provide technical support to new rice farmers that express their interest to develop their inland valleys.
3. Trained field technicians from NGO's working in agricultural development develop inland valleys using the Smart-valleys approach
4. Lead farmers trained in the SMART-IV project provide technical support to other rice farmers that request support to develop an inland valley.
5. Farmers copy the Smart-valley approach to develop their inland valley for rice production without technical support from technicians or farmers trained in the SMART-IV project.

Adopting farmers indicated that the Smart-valley approach has major advantages over their traditional way of rice cultivation. Increased water retention in their rice fields helped to overcome dry spells reduced their risk of loss of investments in seed, fertilizers and pesticides. The higher yields resulted in a significant increase in revenue.

	Major achievements of the SMART-IV project (2009-2014)
1	**A participatory development approach, *Smart-valleys*, has been developed, tested and validated in Benin and Togo and is currently documented in a training package to facilitate diffusion.**
2	**Over 60 demonstration sites have been successfully developed in Togo and Benin, and average yields doubled to 3.5 to 4 ton/ha under rainfed conditions.**
3	**Rice area expansion through large-scale adoption of the *Smart-valley* approach is observed in year 5 in both Benin and Togo.**

Goal and objectives SMART-VALLEYS project (2014-2019)

The goal of the proposed SMART-VALLEYS project (2014-2019) is to improve the livelihood and food security of rice producers by augmenting and securing rice production in inland valleys through improved land and water management and improved agronomic practices and mechanization.

The specific objectives of the project are:

1. To improve inland valley rice production of smallholder farmers through area expansion and increased productivity in the target countries, which are expanded from phase 1;
2. To achieve augmented and stable yields through improved site-specific agronomic practices and mechanization; and
3. To support and facilitate the further diffusion of the *Smart-valley* development approach and improved agronomic tools and equipment through capacity building and technical support.

Target countries

The SMART-VALLEYS project will continue SMART-IV project activities in Togo and Benin and it will expand to Sierra Leone and Liberia.

1. Benin
2. Togo
3. Sierra Leone
4. Liberia

The SMART-VALLEYS project will benefit from the experiences and achievements from the SMART-IV project in Benin and Togo. New technologies and mechanization equipment will be tested and evaluated with rice farmers in the demonstration sites. The *Smart-valley* development approach will be implemented and evaluated—the evaluation is needed since Sierra Leone and Liberia receive much higher rainfall than the phase 1 countries. Then the approach will be adapted in Sierra Leone and Liberia where necessary.

Project structure and partners

The Africa Rice Center (AfricaRice) is the project implementing institution. In each country the project will be implemented in close collaboration with national partners (Table 1). Other organizations that benefit from the project through capacity building and technical support are project partners (

Table 2). The organizations listed are current project partners, but organizations can become new project partners. Project partners do not receive direct funding from the project, but they will participate in trainings and they will receive technical backstopping. Existing partnerships will be strengthened and deepened.

Table 1: National coordinating institutes

Country	Acronym	Institute
Benin	CBF	Inland Valley Unit of the Rural Engineer Division of the Ministry of Agriculture
Togo	ITRA	Agronomy Research Institute of Togo
Sierra Leone	SLARI	Sierra Leone Agricultural research Institute
Liberia	CARI	Central Agricultural research Institute

Table 2: Project partners (non-funded)

Country	Acronym	Organization
Benin, Togo	ETD	NGO Entreprises Territoires et Développement
Benin	CIRAPIP	NGO Recherche et l'Action pour la Promotion des Initiatives Paysannes
Togo	WiLDAF	NGO Women in Law and Development in Africa
Togo	GRED	NGO Groupe de Recherche-action pour l'Education au Développement
Togo	PADAT	MINISTRY Projet d'Appui au Développement Agricole du Togo
Liberia	WFP	INTERNATIONAL World Food Program of the United Nations
Sierra Leone	WFP	INTERNATIONAL World Food Program of the United Nations

Project activities

The project will operate in three fields of activities following the specific objects of the project. Additionally, an impact assessment will be implemented using the 2011 baseline study of the SMART-IV project. The activities are summarized as follows:

A1. Expanding inland valley rice areas with the *Smart-valleys* approach;

A2. Improving and stabilizing rice yields through improved agronomic practices and mechanization;

A3. Reducing post-harvest yield losses through the introduction of locally adapted technologies;
A4. Impact assessment on livelihood of rice farmers; and
A5. Assuring sustainable project implementation and accelerating adoption of the technologies beyond the project.

These activities will take place in all four countries, but, given the budget restrictions and the experiences and achievements obtained from the SMART-IV project, at different scales.

Expanding inland valley rice areas

In Benin and Togo the inland valley rice development approach of the SMART-IV project consisted of the establishment of *Smart-valley* demonstration sites and the provision of adequate training to field technicians and lead-farmers. This has led to large-scale adoption observed in both countries. Three activities will be conducted:

A1-1. Development of *Smart-valleys* demonstration sites in Sierra Leone and Liberia

Ten demonstration sites will be developed in Sierra Leone and ten in Liberia. The regions that will be selected are likely Bong Mines in Liberia and the district between Porto Loko and Makeni in Sierra Leone. These are identical to the intervention regions of the WFP Food for Work program, thus facilitating the scaling out of the approach.

No new demonstration sites will be developed in Benin and Togo. All activities in Benin and Togo will focus on the strengthening of the existing demonstration sites, and facilitating further scaling-out through capacity building activities.

A1-2. Development of the *Smart-valleys* training package

During the SMART-IV project the contours of the *Smart-valleys* training package has been developed. It will consist of:

1. **Trainers guide**, providing the curriculum and different training modules.
2. **Field guide**, outlining the 5 steps for successful implementation of the Smart-valleys approach
3. **Educational video**, to support the implementation of the Smart-valleys approach in the steps of sensitization of farmers, system design, and implementation.

The educational video has been finalized and is currently available in French and English[1]. During the SMART-VALLEYS project it will be translated in four local languages of Benin and Togo and 1 in Sierra Leone and Liberia each.

The trainers guide and field guide will be finalized in year 1 of the project. It will be available in French and English. It will be distributed to participants of trainings and development agencies.

A1-3. *Smart-valleys* capacity building for new trainers, technicians and leader-farmers

The current curriculum consists of three trainings events:

1. Site selection and validation
2. Participatory design and implementation of rice-based systems
3. Site maintenance

[1] The video is available at Dailymotion.com:
http://www.dailymotion.com/video/x1wfnet_smart-valleys-version-entiere-fr_school

In Benin and Togo these trainings have been provided to leader farmers and to field technicians of the national partners (CBF and ITRA), national extension services (ICAT and CARDER), field technicians of NGO's (ETD, GRED, WiLDAF) and a national project (PADAT).

The quality of the training materials will be enhanced and formalized in the Smart-valleys training package (A1-2).

Benin and Togo
The project will continue providing training to lead-farmers and technicians of NGO's and extension services. Collaboration will be established with other NGO's.

New instructors/trainers for the Smart-valleys approach will be trained to speed up the dissemination of the Smart-valleys approach.

Sierra Leone and Liberia
Field technicians, leader farmers and farmers will be trained. Collaboration will be established with development NGOs as well as with the Food for Work project of WFP. Lead-farmers will be selected from the new demonstration sites. New trainers for the Smart-valleys approach will be trained.

Improving and stabilizing rice yields

To reduce yield variability, new agricultural practices and machinery will be introduced. Technical skills of extension officers will be strengthened through providing training using the Participatory Learning & Action Research (PLAR) approach.

A2-1. Development and validation of sustainable site-specific nutrient management tools

Benin and Togo
Rice Advice[2] will be validated in the demonstration zones using the results of Nutrient Omission Trials conducted during the SMART-IV project. Local officers will be trained how to use of Rice Advice and to provide fertilizer recommendations to rice farmers.

Sierra Leone and Liberia
Sustainable nutrient management methods will be identified and validated considering the local and site-specific conditions. Optimum nutrient management methods will be developed with and introduced to rice farmers.

A2-2. Evaluation and introduction of adapted labor-saving small machineries

In Benin, Togo, Sierra Leone and Liberia, different types of mechanical weeders will be evaluated though participatory testing. Training will be provided to craftsmen to fabricate and maintain selected weeders locally. Feasibility of importing small machineries (e.g. reapers) will be assessed. If feasibility will be confirmed, small machineries will be provided to trained farmers.

A2-3. Introduction of Good Agricultural Practices and Participatory Learning & Action Research

In Benin, Togo, Sierra Leone and Liberia, a basket of good agricultural practices (GAP) is being tested in the Rice Research and Development Hubs. These practices together with effective practices

[2] *Rice Advice* is a decision support tool developed by AfricaRice that can be used by lead-farmers, extension services and development partners to optimize soil fertility through site-specific fertilizer recommendations and crop management decisions.

identified in other projects (e.g. JICA project in Sierra Leone) will be introduced to the demonstration sites of the SMART-VALLEYS project. To strengthen local officers' extension skill, training on Participatory Learning & Action Research (PLAR) will be provided.

Strengthening post-harvest activity

A3-1. Capacity building of farmers regarding post-harvest activity

In Benin, Togo, Sierra Leone and Liberia, workshops will be held to identify appropriate post-harvest technology based on needs assessment for farmers in the demonstration sites. Post-harvest rice technologies available at AfricaRice through the Task Force on 'Rice Processing and Value Addition Task' such as an energy efficient parboiler or locally produced rice thresher will be introduced and farmers will be trained.

To implement these activities, collaboration with relevant development organizations including government and non-government organizations is actively promoted, and develop and install these systems in a sustainable manner even after the project terminated.

Impact assessment

A5-1. Impact assessment on livelihood of rice farmers

Benin and Togo

A comprehensive baseline study has been conducted in 2011. A new survey is planned for year 4 of the SMART-VALLEYS project. An analysis of the project's impact will be assessed in year 5 (2018-19).

Sierra Leone and Liberia

WFP has conducted a baseline study in the pre-selected areas in Sierra Leone and Liberia. This study will be used and additional data will be collected if required. A new survey is planned for year 4 of the SMART-VALLEYS project. An analysis of the project's impact will be assessed in year 5 (2018-19).

Assuring sustainable project implementation and accelerating adoption of the technologies beyond the project

The SMART-VALLEYS project is considered a pilot activity for the delivery of the research assets of the Africa Rice Center and its partners for the lowland and inland valley rice cultivation areas. The project therefore contributes to the Development Strategy 2011-2020 of the Africa Rice Center, which includes the development of Rice Sector Development Hubs in the member states, and to contribute the Strategic Research Framework of CGIAR. The project can only partially implement activities and it should function as a catalyzer for new projects to assure continuation and where possible expansion of the project activities after project ending.

Activities in the project will focus on capacity building, but also on scaling out of the technologies through cost-efficient diffusion pathways, active support to NGO's and government bodies in fund raising, supporting policies for inland valley development, and by creating visibility for project activities at different levels (governments, research community, CGIAR, fund council, GRiSP, etc.).

A5-1. Diffusion of rice technologies and enabling environment

Development NGO's, farmer groups, government organizations, extension services, etc. will be exposed to and supported to incorporate AfricaRice rice technologies, including the *Smart-valleys* approach, in development projects related to rice. Rice Innovation Forums will be organized in Liberia

and Sierra Leone to raise awareness among national policy and decision makers about the Smart-valleys approach and other innovations in the rice value chain.

Support will be provided to governments of Benin and Togo to develop national policies for sustainable rice development using rice technologies develop by AfricaRice and partners.

A5-2. Support fund-raising to support scaling out of rice technologies and continuation of activities

SMART-VALLEYS is a pilot project and collaboration is required, not only based on role-sharing, but also based on cost-sharing. Therefore, new development proposals will be developed in collaboration with development partners. Opportunities, such as call for proposals or national development projects, will be analysed and proposals will be developed with national partners.

A5-3. Creating visibility for the project and the research for development approach

The achievements of the project and the operational research for development approach will be actively promoted through popular articles, newspaper articles, television broadcasts, exchange visits of government officials, presentations for donor and the CGIAR, etc.

Project outputs

The table below provides the outputs per group of countries and per activity as defined in the previous section.

ACTIVITY		Togo and Benin	Sierra Leone and Liberia
A1	A1-1	-	5 demonstration sites are operational in each country.
	A1-2	Training package is available in French, and four local languages. Multiplied to 100 copies.	Training package is available in English, and two local languages. Multiplied to 50 copies.
	A1-3	10 technicians are trained as Smart-valleys instructors	4 technicians are trained as Smart-valleys instructors
		40 extension officers and 40 leader farmers are trained in Smart-valleys approach	10 extension officers and 10 leader farmers are trained in Smart-valleys approach
		At least 300 farmers receive on-the-job training in Smart-valleys approach	At least 100 farmers receive on-the-job training in Smart-valleys approach
A2	A2-1	RiceAdvice tool is validated in 4 zones.	Sustainable nutrient management method is identified and validated in 2 zones.
		12 field technicians are trained in the use of RiceAdvice and provide fertilizer advice to 120 rice farmers.	10 Field technicians are trained in the sustainable nutrient management method and provide training to 100 rice farmers.
	A2-2	Farmer preference for mechanic weeders in inland valleys rice system is assessed in 4 zones.	Farmer preference for mechanic weeders in inland valleys rice system is assessed in 2 zones.
		30 Local craftsmen are trained in the production and maintenance of mechanic weeders.	10 Local craftsmen are trained in the production and maintenance of mechanic weeders.
	A2-3	120 farmers receive GAP training.	40 farmers receive GAP training.
		30 field technicians are trained in PLAR	10 field technicians are trained in PLAR
		PLAR is implemented with farmers in 6 zones and on-farm agronomic practices are improved.	PLAR is implemented with farmers in 2 zones and on-farm agronomic practices are improved.
A3	A3-1	Postharvest technology needs are identified in 4 zones and 24 farmers are trained in use of postharvest technology	Postharvest technology needs are identified in 2 zones and 6 farmers are trained in use of postharvest technology
A4	A4-1	Impact assessment on farmer livelihoods performed using 2013 WFP baseline study.	Impact assessment on farmer livelihoods performed using 2011 baseline study.
A5	A5-1	Governments of Togo and Benin incorporate AfricaRice rice technologies in national policies and projects. Development organizations and NGO's have adopted AfricaRice rice technologies.	50 delegates from the (agricultural) development sector participate in Rice Innovations Forum. Development organizations and NGO's have adopted AfricaRice rice technologies.
	A5-2	At least 10 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable technologies	At least 5 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable technologies

A5-3	Results are presented in popular journals like RiceTime	Project is broadcasted on national television in Liberia and Sierra Leone
	Newspaper articles are prepared and published	Newspaper articles are prepared and published
	Project briefs are prepared and shared with donors and fund council of CGIAR.	

Project outcomes

Expected outcomes SMART-VALLEYS project for Benin, Togo, Sierra Leone, Liberia	
EO1	Farmers have developed inland valleys around the demonstration sites using the *Smart-valleys* approach and good agricultural practices and mechanization are adopted.
EO2	Farmers reduce rice losses and improve rice value through adoption of improved post-harvest technologies, such as the selection of harvest period and the use of threshers.
EO3	Rice farmers have improved their livelihoods through good agricultural practices, improved land and water management and post-harvest technology.
EO4	Field technicians and leader-farmers train and technically support rice farmers to develop inland valleys and use GAP and mechanization.
EO5	Local craftsmen produce and maintain locally adapted equipment for rice cultivation, such as mechanical weeders, and equipment becomes locally available on the market.
EO6	National government organizations and development NGO's incorporate the *Smart-valley* approach, GAP and mechanization in (new) projects and policies to promote further scaling out.
EO7	A comprehensive impact assessment study is performed to show changes in livelihood due to the project's interventions.

Project Evaluation

1. Self-evaluation of the project's outputs will be conducted at 3rd (2016–2017) year for the mid-term evaluation.
2. Self-evaluation of the project's outputs and outcomes will be conducted at 5th (2018–2019) year for the final evaluation.

Detail of the 5-year project plan may be amended based on the mid-term evaluation and self-review of activities occurring every year. Amendments will be made in close consultation with the donor.

- end -

Appendix 2:

SMART-VALLEYS
Project principles
2014-2019

Name of Project
SMART-VALLEYS

Project Period
2014 – 2019 (year lasts from 1 October to 30 September of the following year).

Project Principles
1. In order to execute the project, the Africa Rice Center (AfricaRice) will:

a) Establish a separate Trust Fund for the receipt and administration of the project fund from the Government of Japan. The Trust Fund will be used exclusively to meet the cost of the project, including project support costs equivalent to 14.2% of the expenditure for the project;
b) Consult with the Government of Japan on the details of the project plan prior to finalization;
c) Administer the Trust Fund in accordance with its financial regulations and rules;
d) Maintain a separate account for the Trust Fund, making all receipts and expenditures accountable; and
e) Employ its best efforts to ensure that expenditure for the implementation of the project will not exceed the aggregated amount of the contribution by the Government of Japan and any interests accruing.

2. Creating Trust Fund account:

a) Any interests accruing on the Fund will be credited to the Trust Fund; and
b) All financial records made in connection with the Trust Fund will be expressed in United States Dollars. Expenditures in other currencies will be converted into United States Dollars at the rate of exchange established by AfricaRice at the beginning of each month. Any balance in the Trust Fund will also be expressed, in the final statement of accounts, in United States Dollars.

3. Other financial matters:

a) The Government of Japan will not provide any additional fund apart from the amount allocated to the project each project year; and
b) Any amount not spent for the project by AfricaRice from the Trust Fund is subject to the decision made by the Government of Japan.

4. The following reports will be submitted to the Government of Japan by AfricaRice:

a) The Annual Implementation Report by 31 December every year from 2014 to 2018, covering the applicable period of the Trust Fund. The Annual Implementation Report will include an Interim Financial Statement, covering the utilization of the Trust Fund; and
b) The Final Implementation Report by 31 December 2019, covering the whole period of the Trust Fund. The Final Implementation Report will include an Final Financial Statement, covering the utilization of the Trust Fund.
c) AfricaRice will provide project updates on the status any of the activities on a regular basis. The donor can request additional information at any time during the implementation of the project.

5. The following project evaluation will be scheduled and reported in a timely manner:

a) Ex-ante evaluation: set out concrete figures into the project plan developed after due consultation with the government of Japan and AfricaRice;
b) Mid-term evaluation: 28 months after the beginning of the project (schedule: April 2017); and
c) Terminal evaluation: 1 month before the completion of the project (schedule: August 2019).

6. Support by the expert:

Technical expert(s), preferentially Japanese national(s), for this project will be placed appropriately to manage and handle the project, and to communicate effectively with the Government of Japan.

7. Data and all the copyright and intellectual property rights will be vested with AfricaRice and the Government of Japan. Either party may use these outcomes.

Appendix 3:

MID-TERM REVIEW REPORT

SAWAH, MARKET ACCESS AND RICE TECHNOLOGIES FOR VALLEYS PROJECT (SMART- VALLEYS)

2014–2019

PRESENTED TO:

THE PROJECT COORDINATOR

(DR. ROLAND NUHU ISSAKA)

AFRICARICE, ABIDJAN COTE D'IVOIRE

REVIEWER:

DR. MOHAMMED MORO BURI,

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MARCH 2018.

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1 Executive Summary

The SMART-Valleys project is a Japanese funded project under the Ministry of Agriculture, Forestry and Fisheries (MAFF). It commenced in October 2014 and expected to be completed by September 2019. It is a lowland development project being executed by the Africa Rice Centre (AfricaRice) in collaboration with other partners. It is expected to benefit several countries including Togo, Benin, Liberia and Sierra Leone. The Project's overall goal is to improve the livelihood and food security of rice producers by augmenting and securing rice production in inland valleys through improved land and water management, improved agronomic practices and mechanization. The project is expected to produce five main outputs, through the execution of several activities based on set targets. The expected end results should include but not limited to the following: (i) Inland valley rice areas expanded with the SMART-Valley approach, (ii) Rice yields improved and stabilized through improved agronomic practices and mechanization, (iii) Post-harvest yield losses reduced through the introduction of locally adapted technologies, (iv) Impact assessment on livelihood of rice farmers conducted, and (v) Assured sustainable project implementation and accelerated adoption of technologies beyond the project.

During the mid-term review of the project (February 14–28, 2018), the following observations were made. The Project started at different times across countries. While activities commenced in 2014 in Togo and Benin, it was not until second half of 2016 that activities started in Liberia and Sierra Leone. As such, project implementation varies across countries. A progress has been made in the conduction of activities towards the realization of the project overall goal and objectives. Due to benefits from the SMART-IV Project Phase 1 (2009–2014), farmers in both Togo and Benin are now conversant with improved technologies in land development, water management and good agricultural practice (GAP) under the Smart-Valleys approach. Farmers should therefore be encouraged to assist in scaling out activities. However, due to late start in Liberia and Sierra Leone as a result of the Ebola crisis, famers are still to imbibe improved land development, water management and GAP technologies. Particular progress has been made in Togo and Benin; as spillover effects without direct commitment of AfricaRice to develop the sites, out-scaling has begun in both Togo and Benin since the end of Phase 1 in 2014—in Togo, working at 40 sites located within 3 regions and involving a total of 301 farmers (62 females) resulting a total area of 120 ha has been developed, while in Benin, over 205 ha across 50 sites has also been developed. Over 1000 farmers, working at many sites are adopting the Smart Valleys approach and rice yields being stabilized at 3–4 t ha^{-1} in both countries. Even though started a bit late in Liberia and Sierra Leone, the Smart Valleys approach to lowland development is gaining ground through the

active participation of farmers, technicians and scientists at ten (10) sites in each country currently. The capacity of 67 technicians has been built or being built through on-the-job training across all countries on the smart valley approach. The testing of light tools and light equipment particularly weeders has been completed in some countries but on-going in others. Current site specific nutrient management options being developed are very useful but should include the use of local, available and affordable materials to improve soil fertility and control of Fe toxicity in .Liberia and Sierra Leone**.** Challenges vary across countries. In both Togo and Benin, postharvest technology development and access to market are major. In both Liberia and Sierra Leone, major aspects of the smart valley approach, particularly land development and GAP should be concentrated on, while bringing on board postharvest needs at the appropriate time.

2 Introduction

The “Sawah”, Market Access and Rice Technologies for Valleys (Smart-Valleys) Project is supported by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan. It is the second phase of the SMART-IV Project that was implemented by AfricaRice in 2009 – 2014. It is a lowland development project being executed by Africa Rice in collaboration with other partners. Direct beneficiary countries of the Project include Togo, Benin, Sierra Leone and Liberia. It is to cover variable agro-ecological zones across all countries. It commenced in 2014 and is expected to be completed within a period of five years (2019). This report covers the period from Project inception to February 2018 in the various countries. The review considered activities on all the outputs A1–A5 as outlined in the Smart Valleys – Five Year Project Plan (2014–2019) (ref: Appendix 3).

3 Terms of Reference (ToR)

The consultant was to review the project under the following terms of reference:

(i) Review the project based on the five year implementation plan (2014–2019).

(ii) Collect information from annual reports, annual project implementation plans including project updates, and discuss progress of work and work-plans with project coordinator and project teams of the implementing countries.

(iii) Visit at least one site in each of the 4 countries to interact with farmers and country coordinators.

4 Project Goal

The overall goal of Smart-Valleys Project is to improve the livelihood and food security of rice producers by augmenting and securing rice production in inland valleys through improved land and water management, improved agronomic practices and mechanization.

5 Project Objectives

SMART-Valleys Project has the following specific objectives

To improve inland valley rice production of smallholder farmers through area expansion (extension of SMART IV)

(i) To achieve augmented and stable yields through improve site specific agronomic practices and mechanization

(ii) To support and facilitate further diffusion of the smart-iv development approach and improved agronomic tools and equipment through capacity building and technical support

6 Characteristics of the “Sawah” system

The “Sawah” system entails good agricultural practices such as construction of bunds around rice fields, and soil puddling and levelling of fields in combination with good water management. The system therefore can minimize the effect of water shortage, poor nutrition especially for nitrogen and phosphorous supply, neutralize acidity as well as alkalinity, and improve micronutrient supply for rice production.

7 Expected Project Coverage

The targeted countries of the SMART-Valleys Project are Togo, Benin, Sierra Leone and Liberia. Demonstration sites are to be established in suitable agro-ecological zones in Sierra Leone and Liberia and sites developed by the Smart-Valleys approach are expected to be expanded in Benin and Togo.

8 Expected Project Outputs

In order to achieve its objectives, the project was expected to conduct activities based on the following expected outputs/outcomes:

(i) Inland valley rice areas expanded with the Smart-valleys approach (A1).
(ii) Rice yields improved and stabilized through improved agronomic practices and mechanization (A2).
(iii) Post-harvest yield losses reduced through the introduction of locally adapted technologies (A3).
(iv) Impact assessment on livelihood of rice farmers conducted (A4).
(v) Assured sustainable project implementation and accelerated adoption of technologies beyond the project (A5).

9 Project Targets

In conducting or carrying out the above mentioned working activities, the following targets were set (cited from Smart Valleys–Five Year Project Plan 2014–2019):

Activity	Togo & Benin	Liberia & Sierra Leone
A1-1		5 demonstration sites are operational in each country
A1-2	Training package is available in French and four local languages	Training package is available in English and two local languages
A1-3	10 technicians are trained as SMART Valley instructors	4 technicians are trained as SMART Valley instructors
	40 extension officers and 40 lead farmers are trained in Smart valley approach	10 extension officers and 10 lead farmers are trained in Smart valley approach
	At least 300 farmers receive on-the-job training in Smart valley approach	At least 100 farmers receive on-the-job training in Smart valley approach
A2-1	Rice Advice tool is validated in 4 zones	Sustainable nutrient management method is identified and validated in two zones
	12 field technicians are trained in the use of Rice Advice and provide fertilizer advise to 120 rice farmers	10 field technicians are trained in the sustainable nutrient management method and provide training to 100 rice farmers
A2-2	Farmer preference for mechanical weeders in inland valley rice systems assessed in 4 zones	Farmer preference for mechanical weeders in inland valley rice systems assessed in 2 zones
	30 local craftsmen are trained in the production and maintenance of mechanical weeders	30 local craftsmen are trained in the production and maintenance of mechanical weeders
A2-3	120 farmers receive GAP training	120 farmers receive GAP training
	30 field technicians are trained in PLAR	10 field technicians are trained in PLAR
	PLAR is implemented with farmers in 6 zones and on-farm agronomic practices are improved	PLAR is implemented with farmers in 2 zones and on-farm agronomic practices are improved
A3-1	Postharvest technology needs are identified in 4 zones and 24 farmers are trained in use of postharvest technology	Postharvest technology needs are identified in 2 zones and 6 farmers are trained in use of postharvest technology
A4	Impact assessment on farmer livelihoods performed using 2013 WFP baseline study	Impact assessment on farmer livelihoods performed using 2011 WFP baseline study
A5-1	Governments of Togo and Benin incorporate AfricaRice technologies in national policies and projects	50 delegates from the agricultural development sector participate in Rice innovations Forum. Development organizations and NGOs have adopted AfricaRice rice technologies
A5-2	At least 10 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable technologies	At least 5 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable technologies
A5-3	Results are presented in popular journals	Project is broadcast on national television in Liberia and sierra Leone
	Newspaper articles are prepared and published	Newspaper articles are prepared and published
	Project briefs are prepared and shared with donors and fund council of CGIAR	Project briefs are prepared and shared with donors and fund council of CGIAR

10 Review Methodology

As outlined in the ToR, the consultant had the opportunity to read through (i) the five year project plan, (ii) project annual technical progress report (2016–2017), (iii) project achievements report for Togo and Benin (2014–2015), and (iv) Smart Valleys Implementation Plans for Year 1 to Year 3. The Consultant also had the opportunity to talk to the country project coordinators for Togo, Benin, Sierra Leone and Liberia. Field visits were made to Kpele Tutu (Togo), Zoungou (Benin), Bamoi (Sierra Leone) and SKT town (Liberia) where discussions were held with beneficiary farmers, technicians and opinion leaders. The field visits also provided an opportunity for physical observations of structures on the ground and on-going activities. Observations made from the field and as reported by country project coordinators, scientists, technicians and farmers. These observations were then weighed against expected targets or outputs. On the basis of such observations, recommendations were made.

11 Current Status of Project (Observations)

Interactions with project scientists, farmers and field observations indicate that progress has been made or is being made as evidenced by some on-going activities and outputs. The project started at different times in the four countries. It started in 2014–2015 in both Togo and Benin but only commenced in 2016–2017 in both Liberia and Sierra Leone. The late start of the project in both Liberia and Sierra Leone was attributed to the Ebola crisis. AfricaRice staff stationed in both countries had to be evacuated out of these countries for their safety in May/June 2014. It was not until March/April 2015 that such staff of Liberia returned to their duty post while those in Sierra Leone returned much later, when both countries were respectively declared Ebola free by World Health Organization (WHO). During this break period, no project activities could be conducted as movement into and out of both countries was not authorized and no meetings or any gatherings could be held. Project activities therefore started earlier and are more advanced in Togo and Benin over the other two countries.

Activities conducted (completed or on-going) under each project target under the respective outputs (Outputs 1–5) are shown in Table 1 below.

Output 1. Inland valley rice areas expanded with the Smart-Valleys approach

	Togo/Benin,	Liberia/Sierra Leone
A1-1	Without direct commitments by AfricaRice for site development, out-scaling has begun in both Togo and Benin since 2014. In Togo, working at 40 sites located within 3 regions and involving a total of 301 farmers (62 females), a total area of 120 ha has been developed, while in Benin, over 205 ha across 50 sites has also been developed.	*5 Demonstration sites are operational in each country* A total of 20 demonstration sites (10 in each country) have been established but one was abandoned in Sierra Leone due to land tenure issues. The remaining 19 sites are all operational. Twelve (12) ha of land have also been developed at these sites.
A1-2	*Training package is available in French and four local languages. Multiplied to 100 copies* 30 manuals in French have been distributed in Togo and another 30 manuals have been distributed in Benin. The video is available in French on CDs. The training package and the video needs to be translated into four local languages.	*Training package is available in English and two local languages. Multiplied to 100 copies* Manuals in English have been distributed in both countries for the use of technicians. Both Liberia and Sierra Leone received 50 manuals each. The video is available in English on CDs. The training package and the video needs to be translated into two local languages.
A1-3	*10 technicians trained as SMART Valley instructors* Ten technicians (5 from each country) selected by national partners have been provided training on the use of the manual. Trainees were further sensitized on to serve as instructors in scaling out the Smart valley approach among farmers. A Smart Valley training and diffusion scheme has been developed for both countries.	*5 technicians trained as SMART Valley instructors* Ten (10) technicians from each country have been given basic training in the smart valley approach. Capacity of trainees was built on basic land development procedures, water management and GAP.
	40 extension officers and 40 lead farmers are trained in Smart valley approach 47 extension officers and 40 lead farmers have been trained in the smart valley approach in Benin and Togo.	*10 extension officers and 10 lead farmers are trained in Smart valley approach* Twenty (20) technicians and twenty (20) lead farmers (10 in each country) are being given basic training in the Smart valley approach. Participants are being trained on land development, water management and GAP.

	At least 300 farmers receive on-the-job training in Smart valley approach A total of 479 farmers (300 in Togo and 179 in Benin) have been provided with on-the-job training in the smart valley approach in both countries.	*At least 100 farmers receive on-the-job training in Smart valley approach* A total of 537 farmers, comprising 265 (including 82 women) from Liberia and 272 (including 109 women) from Sierra Leone have been engaged. Farmers haven been taken through the basic steps of the Smart Valley approach through on-the-job training on land development (site selection, field layout, bunding, levelling, puddling), water management (weir construction, canals, drains), GAP (nursery establishment, row transplanting, nutrient management, weed control).

Output 2: Rice yields improved and stabilized through improved agronomic practices and mechanization

	Togo/Benin	**Liberia/Sierra Leone**
A2-1	*RiceAdvice tool is validated in 4 zones* Efforts were made in validating the RiceAdvice tool. 44 trials were established in Benin. Trials were established at Zoungo in Ouinhi and Bamey in Zangnanando. In Togo 27 trials were established in 2015 in 3 préfectures across 14 villages. However, most sites were affected by drought. Validation was therefore done in two zones (one zone in each country).	*Sustainable nutrient management methods are identified and validated in two zones* Field experiments are in progress in both countries towards developing sustainable nutrient management options for farmers. Preliminary results of these experiments are quite promising. Such results will need to be validated before being transferred to farmers. First harvesting has been done at all sites and yields haven been very good. In Liberia, two improved rice varieties (IR 841 & NERICA-L19) were used. Average yield for IR 841 was 3.0t ha^{-1} while NERICA-L 19 gave 3.5 t ha^{-1}. In Sierra Leone, average rice yields of 2.8 t ha^{-1} are encouraging.
	12 field technicians are trained in the use of RiceAdvice and provide fertilizer advice to 120 rice farmers 28 technicians have been trained in the use of the RiceAdvice and 111 farmers have been provided with fertilizer advice using the RiceAdvice in both countries.	*10 field technicians are trained in the sustainable nutrient management methods and provide training to 100 rice farmers.* Field experiments on the development of sustainable nutrient management methods are in progress with the full participation of 20 technicians (10 technicians from each country). Training for 537 farmers will commence soon after results have been validated.
A2-2	*Farmer preference for mechanical weeders in inland valleys rice systems assessed in 4 zones*	*Farmer preference for mechanical weeders in inland valleys rice systems assessed in 2 zones*

	Weeders have been tested and evaluated in 2 zones using 40 farmers. Weeders were later distributed to the 40 farmers	Weeders currently being tested at 3 sites in Sierra Leone. Activity is yet to start in Liberia
	30 local craftsmen are trained in the production and maintenance of mechanical weeders 30 local craftsmen have been trained in the production and maintenance of weeders in both countries. In Benin, 12 local craftsmen were given special training to fabricate two types of weeders mostly preferred by farmers.	*10 local craftsmen are trained in the production and maintenance of mechanical weeders* In collaboration with the SAPEC project, 2 local craftsmen have been trained in Liberia. Training in Sierra Leone is yet to commence.
A2-3	*120 farmers receive GAP training* 479 farmers have received GAP training and scaling out activities is in progress across both countries.	*40 farmers receive GAP training* Plans are far ahead to start in the fourth year in both countries.
	30 field technicians are trained in PLAR 47 field technicians have been trained in both countries.	*10 field technicians are trained in PLAR* 20 field technicians are available and training will soon commence for both countries.
	PLAR is implemented with farmers in 6 zones and on-farm agronomic practices are improved Over 400 farmers spread across 6 zones from both countries have been engaged in PLAR activities resulting in significant yield increases. Farmers in Benin currently obtain average rice yields of 4 t ha^{-1} while that of Togo is 3.5 t ha^{-1}.	*PLAR is implemented with farmers in 2 zones and on-farm agronomic practices are improved.* Activity planned to start in 2018 at two sites in Sierra Leone and one site in Liberia.

Output 3. Post-harvest yield losses reduced through the introduction of locally adapted technologies

	Togo/Benin	Liberia/Sierra Leone
	Postharvest technology needs are identified in 4 zones and 24 farmers are trained in use of postharvest technology Two workshops involving 67 participants have been organized with the objective of promoting the smart valley approach and identifying the postharvest needs of farmers for Glazoue and Zoungo in Atogbo, and for Ahicon and Kaffa in Ouinhi. Major	*Postharvest technology needs are identified in 2 zones and 6 farmers are trained in use of postharvest technology.* The postharvest technology needs of the two countries have been assessed. They basically include threshing, drying, storage, milling structures, equipment, quality management and access to market.

	needs identified include access to market, improved equipment and quality management.	Training on improved parboiling technologies has been provided to selected farmers in Sierra Leone.

Output 4: Impact assessment on livelihood of rice farmers conducted

	Togo/Benin	Liberia/Sierra Leone
	Impact assessment on farmer livelihoods performed using 2013 WFP baseline study Baseline surveys have been conducted in both countries in 2014. A monitoring survey covering area developed using smart valley approach has also been conducted in both countries in 2014. An impact assessment has been done in Benin in 2015 and results published. An impact assessment is yet to be done in Togo. A panel data was also collected in Benin in 2016. The methodology adopted for impact assessment has been tested and validated in Benin. It was successful and will be replicated in the other countries (Togo, Liberia and Sierra Leone).	*Impact assessment on farmer livelihoods performed using 2011 WFP baseline study* Baseline survey has been conducted in Sierra Leone in 2017 and this will be used as basis for impact assessment for the country and not the 2011 WFP base line study as stated above. This is because the 2011 WFP study did not include current sites under the smart valley project. A baseline survey will be conducted in Liberia in 2018.

Output 5: Assured sustainable project implementation and accelerated adoption of technologies beyond the project.

	Togo/Benin	Liberia/Sierra Leone
A5-1	*Governments of Togo and Benin incorporate AfricaRice technologies in national policies and projects. Development Organizations and NGOs have adopt AfricaRice rice technologies* Meetings have been held in both countries with the Ministries of Agriculture to help draft inland valley policies in into national policies in both countries. In addition, two NGOs each in both Togo and Benin have adopted the Smart valley approach. The Smart Valley approach has been incorporated into in two strategic documents of the Ministry of Agriculture, Livestock and fisheries of Benin. These documents are the National Strategies for Lowlands and National Strategies for Irrigation.	*50 delegates from the agricultural development sector participate in Rice Innovations Forum. Development organizations and NGOs have adopted AfricaRice rice technologies* Some agricultural based NGOs in Sierra Leone have been trained on the smart valley approach and the technology is being adopted. No rice Innovations for a organized for both countries yet.
A5-2	*At least 10 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable*	*At least 5 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable technologies*

	technologies Two proposals were developed, submitted and accepted. For funding. One project was accepted by the German Development Co-operation and is being implemented in Burkina Faso. The project is CSA- Burkina and it is aimed at increasing the adaptive capacity of Burkina farmers in climate smart technologies, with a focus on smart valleys. The other project, ETES Project, is being implemented in both Togo and Benin and is currently on-going.	No proposals have been developed yet in the two countries.
A5-3	*Results are presented in popular journals like Rice Today* Four (4) publications produced in journals by team from Benin. One publication is in Rice Today and the others in other journals.	*Project is broadcast on national television in Liberia and Sierra Leone* Efforts are underway to get national television stations of both countries to cover smart valley activities and broadcast to the populace.
	Newspaper articles are prepared and published Journalists were invited in Benin to prepare articles to presentation and one of such was a presentation on climate smart valley approach aired on Radio France. Results have been published on mail online In Benin, smart valley brings rice bounty.	*Newspaper articles are prepared and published* Yet to be prepared.
	Project briefs are prepared and shared with donors and fund council of CGIAR Results published on CGIAR website title “In Benin, Smart Valleys bring rice bounty”.	*Project briefs are prepared and shared with donors and fund council of CGIAR* Yet to be prepared.

12 Major Challenges

In Togo and Benin, challenges are mainly on post-harvest technologies including marketing (improved equipment to minimize labor and improved market access) and quality management. In Sierra Leone and Liberia, land development and introduction of GAP including site specific nutrient management technologies are currently critical key challenges.

13 Important Note

In the Annual Implementation Plans for Year 1 and Year 2 of the project, reapers were supposed to be purchased. This is in contrast with the five year project plan which did not include any purchase of reapers. No reapers have been purchased as of February 2018.

14 Recommendations

(i) The foundation for Smart Valley Approach is the establishment of basic structures (land development and water management) that are necessary for the system to function effectively and efficiently, and these should be areas of focus for Liberia and Sierra Leone

(ii) Capacity building and backstopping should be enhanced for all countries to accelerate the adoption of technologies

(iii) Postharvest technology and marketing are major challenges for both Togo and Benin currently and therefore should be an area of focus for the two countries.

(iv) In developing effective and easily adopted nutrient management systems under GAP, consideration should be given to the use of local resources (soil organic amendments such chicken droppings, cattle/sheep/goats manure, rice straw, rice husk, compost, etc. based on availability for site specificity under nutrient management) particularly in Liberia and Sierra Leone.

(v) Since the postharvest needs of Liberia and Sierra Leone have already been identified, the project should begin to look at incorporating marketing mechanism/options into existing operations for an integrated adoption of technologies

(vi) Training for local artisans in their respective local communities on how to fabricate simple tools /equipment that are being promoted across countries under the smart valley approach should be intensified.

(vii) Both Liberia and Sierra Leone should be assisted to organize national rice fora involving all the key stakeholders in the rice value chain, NGOs and the Japanese Embassies in their respective countries. This may require additional funds since such Technological Fairs are generally expensive.

(viii) In the project document, both Togo and Benin were to develop 10 proposals while Liberia and Sierra Leone were expected to develop 5 proposals. This does not seem

feasible. It is recommended that the number be reduced to about five proposals for the whole sub-region since such proposals normally involve several countries.

(ix) Although purchasing reapers for Benin and Togo is not included in the output table of the Smart Valleys – Five Year Project Plan (2014 – 2019), its text mentions "Feasibility of importing small machineries (e.g. reapers) will be assessed. If feasibility will be confirmed, small machineries will be provided to trained farmers." This activity is stated in the tables of the Annual Implementation Plans for Year 1 and Year 2. The implementation may be considered.

15 References

1. Smart Valleys–Five Year Project Plan (2014 – 2019)
2. Smart Valleys Project: Achievements in Togo and Benin (2014 – 2015)
3. Smart Valleys: Annual Technical Progress Report (2016 – 2017)
4. Smart Valleys Annual Implementation Plans for Year 1 to Year 3.

16 Appendix 1: Project Personnel Contacted in Each Country (Name and email)

Name	Country	Email Address
Dr. Ayeva Tchatchibara	Togo	ayevababa@yahoo.fr
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Dr. Dennis Taylor	Liberia	denrtay@hotmail.com
Dr. R. N. Issaka	Liberia	r.issaka@cgiar.org

17 Appendix 2: AfricaRice Staff Present During Discussion at AfricaRice Abidjan on 5th March 2018

(i) Dr. Koichi Futakuchi, Program Leader, Sustainable Productivity Enhancement
(ii) Dr. Aminou Arouna, Impact Assessment Economist
(iii) Dr. Roland Nuhu Issaka, Project Coordinator

Appendix 4:

TERMINAL EVALUATION REPORT

SAWAH, MARKET ACCESS AND RICE TECHNOLOGIES FOR VALLEYS APPROACH PROJECT (SMART- VALLEYS)

2014–2019

Presented to:

The Project Coordinator
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November 2019.

CSIR-SRI/CR/BMM/2019/01

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Executive Summary

The SMART-VALLEYS project is a Japanese funded project under the Ministry of Agriculture, Forestry and Fisheries (MAFF). It commenced in October 2014 and is expected to be completed by September 2019. The goal of the proposed SMART-VALLEYS project (2014–2019) is to improve the livelihood and food security of rice producers by augmenting and securing rice production in inland valleys through improved land and water management and improved agronomic practices and mechanization. The specific objectives of the project are: (i) to improve inland valley rice production of smallholder farmers through area expansion and increased productivity in the target countries; (ii) to achieve augmented and stable yields through improved site-specific agronomic practices and mechanization; (iii) to support and facilitate the further diffusion of the *Smart-valleys* development approach and improved agronomic tools and equipment through capacity building and technical support. It is a lowland development project executed by the Africa Rice Centre (AfricaRice) in collaboration with other partners. Beneficiary countries include Togo, Benin, Liberia and Sierra Leone. The project is expected to produce five main outputs, through the execution of several activities based on set targets. The expected end results should include but not limited to the following: (i) Inland valley rice areas expanded with the Smert-Valleys approach; (ii) Rice yields improved and stabilized through improved agronomic practices and mechanization; (iii) Post-harvest yield losses reduced through the introduction of locally adapted technologies; (iv) Impact of project on livelihood of rice farmers assessed and documented; (v) Assured sustainable project implementation and accelerated adoption of technologies beyond the project through policy adoption by the beneficiary countries.

During this terminal evaluation which took place from 24 October to 6 November 2019, the following observations were made. The Project started at different times across countries. While activities commenced in 2014 in Togo and Benin, it was not until second half of 2016 that activities started in Liberia and Sierra Leone. As such, project implementation varied across countries. Significant gains have been made in the project activities. Due to the implementation of the SMART-IV Project Phase 1 (2009–2014), farmers in both Togo and Benin had the benefit of being introduced to improved technologies in land development, water management and good agricultural practices (GAP) under the Smart-Valleys approach. Hence current levels of farmers' adoption of the Smart Valleys approach are higher in these countries and out-scaling activities seem to be moving faster. However, project implementation started late in Liberia and Sierra Leone due to the Ebola crisis. This late start of the project caused the delayed implementation of the project activities. A significant progress has been made in Togo and Benin; spillover effects that neighboring farmers have adopted the Smart-Valleys approach without direct commitment of AfricaRice to develop the lands can be seen. Out-scaling is quite high in both Togo and Benin. About 2000–3000 farmers, working at many sites are adopting the Smart Valleys approach and rice yields have almost stabilized at 4.0–6.0 t ha^{-1} in both countries. However, regardless of the late start of the project in Liberia and Sierra Leone, significant gains have been made. In Liberia, over 600 farmers have been introduced to the Smart-valleys approach and over 35.5 hectares of land developed with paddy rice yields ranging from 3.5–7.0 t ha^{-1}. In Sierra Leone, over 900 farmers have been introduced to the Smart-valleys approach and farmers have obtained yield

of about 4.0 t ha^{-1} in over 20 hectares of land newly developed. The capacity of 67 technicians on the Smart-Valleys approach has been built through on-the-job training across all countries. The testing of light tools and light equipment particularly weeders has been completed in some countries. Site specific nutrient management options have been developed using local, available and affordable materials to improve soil fertility and control of Fe toxicity in Liberia and Sierra Leone**.** This will produce significant effects on rice yield in inland valleys these countries and be commendable. Validation of RiceAdvice including training of technicians for the use of RiceAdvice has been conducted in Togo and Benin. In spite of rich and evident achievements, specific challenges remain in the respective countries. For instance, backstopping activities supporting farmers to adopt the Smart-valleys approach are necessary in Liberia and Sierra Leone. This may be looked at under the project for a possible short duration extension or a new project with another funding source. In all countries, some work still has to be done under WP 5 (policy). Under WP 4 (impact assessment), work is currently on-going in Sierra Leone and Liberia. This has been completed in Benin and Togo.

Introduction

The “Sawah”, Market Access and Rice Technologies for Valleys (SMART-VALLEYS) project is financially supported by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan. It is supposed to build on the achievement of the SMART-IV Project that was implemented by AfricaRice in 2009–2014 in Togo and Benin and a possible extension to Liberia and Sierra Leone. It is a lowland development project being executed by AfricaRice in collaboration with partners in the respective countries. It covers variable agro-ecological zones across all project countries, Benin, Togo, Liberia and Sierra Leone. The project started in October 2014 and was expected to be completed at the end of September 2019. Due to the no-cost extension approved by the funder, the project termination is end of December 2019. This report covers the period from the project inception to early November 2019 in the four countries. The review considered the activities on all the outputs A1–A5 as outlined in the SMART-VALLEYS – Five Year Project Plan 2014–2019 (Appendix 2).

Terms of Reference (ToR)

The consultant was to review the project under the following terms of reference:

(iv) Review the project based on the five-year implementation plan 2014–2019

(v) Collect information from project annual and progress reports, annual project implementation plans including project updates, and discuss details of work done with project coordinator and project teams of the implementing countries

(vi) Visit at least one site in each of the four countries to interact with farmers, country project staff and conduct field observations

Project Goal

The goal of the SMART-VALLEYS project (2014-2019) is to improve the livelihood and food security of rice producers by augmenting and securing rice production in inland valleys through improved land and water management and improved agronomic practices and mechanization

Project Objectives

The specific objectives of the SMART VALLEYS project are:

4. To improve inland valley rice production of smallholder farmers through area expansion and increased productivity in the target countries, which are expanded from phase 1
5. To achieve augmented and stable yields through improved site-specific agronomic practices and mechanization

6. To support and facilitate the further diffusion of the Smart-Valleys development approach and improved agronomic tools and equipment through capacity building and technical support

Project Coverage

The SMART-VALLEYS project was to be a continuation of SMART-IV project activities in Togo and Benin and expanded to Sierra Leone and Liberia. The SMART-VALLEYS project will benefit from the experiences and achievements from the SMART-IV project in Benin and Togo (2009–2014). New technologies and mechanization equipment were be tested and evaluated with rice farmers at demonstration sites.

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Smart Valleys Approach Description

Due to the perceived large water requirements, limited number of inland valleys that have sufficient water supply to achieve full water control and supposed labour intensive nature of the *Sawah* system, the Smart-Valleys approach (modification of sawah system) was developed to minimize the effect of these challenges experienced during the initial stages of the SMART-IV project. By description the "Sawah" system is a package that includes improved land preparation methods such as bunding, puddling and levelling of rice fields and the adoption of good agricultural practices in combination with good water management. The system therefore can minimize the effect of water shortage, poor nutrition especially for nitrogen and phosphorous supply, neutralize acidity as well as alkalinity, and improve micronutrient supply for rice production. It is a package of activities that have to be adopted in integration if maximum paddy yields are to be obtained.

Project Activities

The project will operate in three fields of activities following the specific objectives of the project. Additionally, an impact assessment will be implemented using the 2011 baseline study of the SMART-IV project. The activities are summarized as follows:

A6. Expanding inland valley rice areas with the Smart-Valleys approach

A7. Improving and stabilizing rice yields through improved agronomic practices and mechanization

A8. Reducing post-harvest yield losses through the introduction of locally adapted technologies

A9. Impact assessment on livelihood of rice farmers

A10. Assuring sustainable project implementation and accelerating adoption of the technologies beyond the project

Expected Project Outputs/Outcomes

Based on the objectives of the project the following activities have been conducted with the following outputs/outcomes:

(vi) Inland valley rice areas expanded with the Smart-Valleys approach (A1)

(vii) Rice yields improved and stabilized through improved agronomic practices and mechanization (A2)

(viii) Post-harvest yield losses reduced through the introduction of locally adapted technologies (A3)

(ix) Impact assessment on livelihood of rice farmers conducted (A4)

(x) Assured sustainable project implementation and accelerated adoption of technologies beyond the project (A5)

Project Targets

In conducting or carrying out the above mentioned working activities under the Project, the following targets were set (cited from SMART VALLEYS–Five Year Project Plan 2014–2019):

Activity	Togo & Benin	Liberia & Sierra Leone
A1-1		5 demonstration sites are operational in each country
A1-2	Training package is available in French and four local languages	Training package is available in English and two local languages. Multiplied to 50 copies.
A1-3	10 technicians are trained as Smart-Valleys instructors	4 technicians are trained as Smart-Valleys instructors
	40 extension officers and 40 lead farmers are trained in Smart-Valleys approach	10 extension officers and 10 lead farmers are trained in Smart-Valleys approach
	At least 300 farmers receive on-the-job training in Smart Valleys approach	At least 100 farmers receive on-the-job training in Smart Valleys approach
A2-1	RiceAdvice tool is validated in four zones	Sustainable nutrient management method is identified and validated in two zones
	12 field technicians are trained in the use of RiceAdvice and provide fertilizer advise to 120 rice farmers	10 field technicians are trained in the sustainable nutrient management method and provide training to 100 rice farmers
A2-2	Farmer preference for mechanical weeders in inland valley rice systems assessed in four zones	Farmer preference for mechanical weeders in inland valley rice systems assessed in two zones
	30 local craftsmen are trained in the production and maintenance of mechanical weeders	10 local craftsmen are trained in the production and maintenance of mechanical weeders
A2-3	120 farmers receive GAP training	40 farmers receive GAP training
	30 field technicians are trained in PLAR	10 field technicians are trained in PLAR
	PLAR is implemented with farmers in six zones and on-farm agronomic practices are improved	PLAR is implemented with farmers in two zones and on-farm agronomic practices are improved
A3-1	Postharvest technology needs are identified in four zones and 24 farmers are trained in use of post-harvest technology	Postharvest technology needs are identified in two zones and 6 farmers are trained in use of post-harvest technology
A4	Impact assessment on farmer livelihoods performed using 2013 WFP baseline study	Impact assessment on farmer livelihoods performed using 2011 WFP baseline study
A5-1	Governments of Togo and Benin incorporate AfricaRice technologies in national policies and projects. Development organizations and NGO's have adopted AfricaRice rice technologies.	50 delegates from the agricultural development sector participate in Rice Innovations Forum. Development organizations and NGOs have adopted AfricaRice rice technologies
A5-2	At least 10 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable technologies	At least 5 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable technologies
A5-3	Results are presented in popular journals	Project is broadcast on national television in Liberia and Sierra Leone
	Newspaper articles are prepared and published	Newspaper articles are prepared and published
	Project briefs are prepared and shared with donors and fund council of CGIAR	Project briefs are prepared and shared with donors and fund council of CGIAR

Evaluation Methodology

As outlined in the ToR, the consultant had opportunity to read through the documents which had been submitted to the donor, i.e. (i) Five Year Project Plan 2014–2019; (ii) Annual Technical Reports Year 1, Year 2, Year 3 and Year 4; (iii) Achievements in Togo and Benin (Year 1–Year 4); (iv) Smart Valleys Implementation Plans for Year 1, Year 2, Year 3, Year 4 and Year 5. In addition, progress reports sent from some partners of the project countries to AfricaRice were available as inputs for the review. To facilitate the review, the project coordinator had prepared a table summarizing the achievements of Year 5 (October 2018–September 2019) in Togo and Benin and another table for Sierra Leone and Liberia (Appendix 3). The Consultant also had the opportunity to talk to the country project coordinators for Togo, Benin, Sierra Leone and Liberia. Field visits were made to Kpele Tutu and Abeva both in Togo, Glazoue – Attogbo in Benin, Katic and Longilol in Sierra Leone, and Thomases Farm (SKT town) and Jonny Cole village both located in Liberia. Field interaction and discussions were held with beneficiary farmers (both males and females), field technical officers and opinion leaders of all sites visited. The field visits also provided an opportunity for physical observations of structures on the ground and other activities that have been conducted. Field observations were made in addition to deduction from interactions with country project coordinators, scientists, technicians and farmers. Information provided in progress reports were also evaluated against field activities.

Project Implementation Status

Interactions with the project scientists, farmers and field observations indicate that the project has produced a number of gains or achievements. This is based on evidence on the ground based on outputs. The project started at different times in the four countries. It started in 2014–2015 in Togo and Benin but only commenced in 2016–2017 in Liberia and Sierra Leone. The late start of the project in both Liberia and Sierra Leone was attributed to the Ebola crisis. AfricaRice staff stationed in both countries had to be evacuated out of these countries for their safety in May/June 2014. It was not until March/April 2015 that such staff of Liberia returned to their duty post while those in Sierra Leone returned much later, when both countries were respectively declared Ebola free by World Health Organization (WHO). Even though the Project activities stared late in Liberia and Sierra Leone, planned outputs—more in some cases—have mostly been achieved in all countries evidenced by what is on the ground as achievements. In addition, while out-scaling is fast moving on in Togo and Benin as a spillover effect around the project sites, this effect is slowly but gradually picking up in Liberia and Sierra Leone.

As outlined earlier, major activities conducted under each project target resulting in the achievements of the various outputs (Outputs 1–5) is as detailed below.

WP 1. Inland valley rice areas expanded with the Smart-Valleys approach

	Togo and Benin,	Liberia and Sierra Leone	Comments
A1-1	*No direct commitment planned* Without direct commitments by AfricaRice for site development, out-scaling has begun in both Togo and Benin since 2014. In Togo, working at 40 sites located within 3 regions and involving a total of 301 farmers (62 females), a total area of 120 ha has been developed, while in Benin, over 205 ha across 50 sites have also been developed.	*5 Demonstration sites are operational in each country* A total of 21 demonstration sites spread across four counties have been established in Liberia involving 600 farmers (244 females). A total of 35.2 ha have been developed while scaling out activities are in progress. In Sierra Leone 18 sites spread across 4 chiefdoms have been established involving over 900 farmers. Over twenty (20) ha of land has been developed.	*Achieved in all countries*
A1-2	*Training package is available in French and four local languages. Multiplied to 100 copies* 30 manuals in French have been distributed in Togo and another 30 manuals have been distributed in Benin. The video is available in French on CDs. The companies to translate the educational videos into two local languages in both Togo and Benin have been selected under competitive procedures. The translation has been completed and videos being distributed to technicians and lead farmers.	*Training package is available in English and two local languages. Multiplied to 100 copies* Manuals in English have been distributed in both countries for the use of technicians. Both Liberia and Sierra Leone received 50 manuals each. The video is available in English on CDs. The video are currently being translated into two local languages in both countries.	*Achieved in Benin and Togo. By end of the project, the planed activities will be achieved in Liberia and Sierra Leone too*
A1-3	*10 technicians trained as Smart-Valley instructors* Ten technicians (5 from each country) selected by national partners have been provided training on the use of the manual. Trainees were further sensitized to serve as instructors in scaling out the Smart valleys approach among farmers. A Smart-Valley training and diffusion scheme has been developed for both countries.	*5 technicians trained as SMART Valley instructors* Fifteen (15) technicians from Sierra Leone and eighteen (18) technicians from Liberia have been given basic training as Smart-valley instructors. Capacity of trainees was built on basic land development procedures, water management, good agronomic practices (GAP) and post selected postharvest technologies.	*Achieved in all countries*
	40 extension officers and 40 lead farmers are trained in Smart-Valleys approach 47 extension officers and 40 lead farmers have been trained in the Smart-Valleys approach in Benin and Togo.	*10 extension officers and 10 lead farmers are trained in Smart-Valleys approach* In Sierra Leone ten (10) extension officers and fifteen (15) lead farmers have been trained in the Smart-Valleys approach. Participants were trained on land development, water management and GAP. At each site, a trained technician and a lead farmer	*Achieved in all countries*

		provided the necessary support and training to farmers. In Liberia, fifteen (15) extension officers and seventeen (17) lead farmers have been trained in the smart valley approach on same activities.	
	At least 300 farmers receive on-the-job training in Smart Valleys approach A total of 479 farmers (300 in Togo and 179 in Benin) have been provided with on-the-job training in the Smart-Valleys approach in both countries. In addition, field observations show that such trained farmers are deeply involved in the training of more farmers, but actual numbers could not be verified.	*At least 100 farmers receive on-the-job training in Smart valley approach* A total of 600 farmers including 244 females have received on-the-job training in Liberia while over 900 farmers including 550 females have been trained in Sierra Leone. Farmers were taken through the basic steps of the Smart-Valley approach through on-the-job training on land development (site selection, field layout, bunding, levelling, puddling), water management (weir construction, canals, drains), GAP (nursery establishment, row transplanting, nutrient management, weed management and pest/diseases management).	*Achieved in all countries*

WP 2: Rice yields improved and stabilized through improved agronomic practices and mechanization

	Togo and Benin	Liberia and Sierra Leone	Comments
A2-1	*RiceAdvice tool is validated in four zones* RiceAdvice has been validated in two regions in both countries. Validation has been done in Cove and Zogbodome in Benin. In Togo validation was done at Plateaux and central regions.	*Sustainable nutrient management methods are identified and validated in two zones* Field experiments have been conducted in both countries towards developing sustainable nutrient management options for farmers. Results of these experiments are good and have been validated. In Liberia, two improved rice varieties (IR 841 & NERICA-L19) were used. Average yields ranged from 3.5 -7.0 tons per hector. In Sierra Leone, average rice yields obtained were 4.0 tons per hector. Other activities conducted on nutrient management include urea deep placement, general fertilizer management, use of rice husk to minimize the effect of Fe toxicity and general promotion of organic fertilizer use to improve physical and chemical properties of soil.	*Achieved but should be updated periodically*
	12 field technicians are trained in the use of RiceAdvice and provide fertilizer advice to 120 rice farmers 28 technicians have been trained in the use of the RiceAdvice and have assisted in providing site specific fertilizer recommendations to over 215 farmers in Benin and Togo.	*10 field technicians are trained in the sustainable nutrient management methods and provide training to 100 rice farmers.* In Sierra Leone, five (5) field technicians have received training on sustainable nutrient management and 150 farmers have been trained while in Liberia eight (8) field technicians received the training and over 200 farmers benefitted.	*Achieved*

A2-2	*Farmer preference for mechanical weeders in inland valleys rice systems assessed in 4 zones* Weeders have been tested and evaluated in 2 zones (one zone in Benin and another in Togo) involving 40 farmers. Weeders to be tested and evaluated in two other zones for rapid expansion.	*Farmer preference for mechanical weeders in inland valleys rice systems assessed in 2 zones* Different weeders have been tested and demonstrated at seven (7) sites in Sierra Leone. In Liberia, SMART valley project in collaboration with SAPEC, have fabricated and tested weeders on three (3) different sites.	*Partially achieved and need to be further supported in Benin and Togo*
	30 local craftsmen are trained in the production and maintenance of mechanical weeders 30 local craftsmen have been trained in the production and maintenance of weeders in both countries. In Benin, 12 local craftsmen were given special training to fabricate two types of weeders that farmers preferred most.	*10 local craftsmen are trained in the production and maintenance of mechanical weeders* In Liberia, SMART Valleys in collaboration with the SAPEC Project have enhanced the capacity of two (2) craftsmen in the production of mechanical weeders.	*Partially achieved and need to be further supported in Liberia and Sierra Leone*
A2-3	*120 farmers receive GAP training* 479 farmers have received GAP training and scaling out activities are in progress across both countries.	*40 farmers receive GAP training* In Sierra Leone, over 900 farmers have received GAP training and in Liberia, over 600 farmers have received training on GAP.	*Achieved in all countries*
	30 field technicians are trained in PLAR 47 field technicians have been trained in both countries.	*10 field technicians are trained in PLAR* In Sierra Leone, 5 technicians and in Liberia, 10 technicians have been trained in PLAR.	*Achieved in all countries*
	PLAR is implemented with farmers in 6 zones and on-farm agronomic practices are improved Over 400 farmers spread across 6 zones from both countries have been engaged in PLAR activities resulting in significant yield increases. Farmers in Benin currently obtain average rice yields of 5-6 tons per hectare while that of Togo is 3.5 – 5.0 tons per hectare.	*PLAR is implemented with farmers in 2 zones and on-farm agronomic practices are improved.* PLAR has been implemented in two (2) chiefdoms (Gbintin, Lokomasama) in Sierra Leone while three (3) counties (Bong, Nimba, Magibi) have benefited from PLAR implementation in Liberia.	*Achieved in all countries*

WP 3. Post-harvest yield losses reduced through the introduction of locally adapted technologies

	Togo and Benin	Liberia and Sierra Leone	
	Postharvest technology needs are identified in 4 zones and 24 farmers are trained in use of postharvest technology Two workshops involving 67 participants have been organized to promote the smart valley approach and identify the postharvest	*Postharvest technology needs are identified in 2 zones and 6 farmers are trained in use of postharvest technology.* Three (3) farmers groups from one zone (Gbintin Chiefdom), involving 19 farmers (3 males, 16 females) have been trained on	*Achieved*

	needs of farmers. Fifteen farmers (6 males, 9 females) from three zones in Benin (Glazoue, Dassa-Zoume and Savalou) and twelve farmers (1 male, 11 female) from four zones in Togo (Plateaux, Centrale, Kara and Savanes) were trained in improved parboiling techniques.	improved parboiling techniques in Sierra Leone. In Liberia, four (4) farmers groups, from one zone (Bong) involving 29 farmers (5 males, 24 females) have been trained on improved parboiling techniques.	

WP 4: Impact assessment on livelihood of rice farmers conducted

	Togo and Benin	Liberia and Sierra Leone	
	Impact assessment on farmer livelihoods performed using 2013 WFP baseline study Baseline surveys have been conducted in both countries in 2014. A monitoring survey covering area developed using Smart-Valleys approach has also been conducted in both countries in 2014. An impact assessment has been done in Benin in 2015 and results published. A book chapter was published on the adoption and impact of Smart-valleys approach in Benin and Togo (Arouna and Akpa, 2019). Impact of smart valleys approach has been fully assessed in Benin and Togo.	*Impact assessment on farmer livelihoods performed using 2011 WFP baseline study* A baseline survey was conducted in 2016 in Sierra Leone with a total of 240 households. Using the same sample, the ex-post survey for impact assessment is currently going on in Sierra Leone. The impact assessment in Sierra Leone has started on 13th November and will be completed by 30th November 2019. In Liberia impact assessment will be done from 20th November to 6th December 2019.	*Achieved in Benin and Togo; On-going in Liberia and Sierra Leone*

WP 5: Assured sustainable project implementation and accelerated adoption of technologies beyond the project.

	Togo and Benin	Liberia and Sierra Leone	Comments
A5-1	*Governments of Togo and Benin incorporate AfricaRice technologies in national policies and projects. Development Organizations and NGOs have adopted AfricaRice rice technologies* Meetings have been held in both countries with the Ministries of Agriculture to help draft inland valley policies in into national policies in both countries. In addition, 9 NGOs in Togo and 2 NGOs in Benin have adopted the Smart-Valley approach. The Smart Valley approach has been incorporated into two strategic documents of the Ministry of Agriculture, Livestock and fisheries of Benin. These documents are the National Strategies for Lowlands and National Strategies for Irrigation.	*50 delegates from the agricultural development sector participate in Rice Innovations Forum. Development organizations and NGOs have adopted AfricaRice rice technologies* Some agricultural-based NGOs in Sierra Leone have been trained on the Smart-Valleys approach and the technology is being adopted. A rice innovation forum was organized in November 2018 in Sierra Leone. Over 80 persons including personnel from the Ministry of Agriculture, policy makers, scientists, project farmers and some NGOs participated. In Liberia a rice innovation forum was organized in September 2019. Over 100 people from the Ministry of Agriculture, Scientists, NGOs, Project farmers and other interested farmers attended.	*Partially achieved and project sponsors and AfricaRice may wish to take it up with various governments concern*

A5-2	*At least 10 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable technologies* Five proposals were developed and submitted. Out of the 5 proposals, two were approved for funding by the German Development Co-operation. One project is CSA-Burkina and it is aimed at increasing the resilience of Burkina farmers to climate change, with a focus on Smart-Valleys approach in the rainfed lowland environment. The other project, ETES-Rice, has been implemented in Benin and Togo and is now completed.	*At least 5 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable technologies* In Liberia development of a proposal almost completed	*Partially Achieved*
A5-3	*Results are presented in popular journals like Rice Today* Four (4) publications produced in journals by team from Benin. One publication is in Rice Today and the others are in other journals.	*Project is broadcast on national television in Liberia and Sierra Leone* In Liberia, project activities have been broadcast on county radio (Radio Gbanga) and on national television.	*Achieved in all countries*
A5-3	*Newspaper articles are prepared and published* Journalists were invited in Benin to prepare articles to presentation and one of such was a presentation on climate smart-Valley approach aired on Radio France. Results have been published on mail online In Benin, "Smart-Valley brings rice bounty". Smart-Valleys approach was presented at the COP 22 Climate Change Conference held in Marrakech, Morocco in 2016 and was selected as an example of the adaptation of African farmers to climate change and variability.	*Newspaper articles are prepared and published* In Liberia, project activities were published in National newspaper (The Observer) https://www.liberiaobserver.com/news/smart-valleys-rice-project-flourishes-in-gbartala/	*Achieved in all countries*
A5-3	*Project briefs are prepared and shared with donors and fund council of CGIAR* Results published on CGIAR website title "In Benin, Smart Valleys bring rice bounty".	*Project briefs are prepared and shared with donors and fund council of CGIAR* Yet to be prepared for Liberia and Sierra Leone.	*Partially achieved*

General Comments

The SMART VALLEYS project has been well implemented and executed based on field observations, interactions with staff and beneficiaries. It can be described as being very successful. Most planned activities have been well executed and project objectives achieved particularly under WP1, WP2 and WP3. Farmers seem to be making progress in terms of improved land development, water management and nutrient management at all sites visited. Rice paddy yields have significantly increased and land under rice cultivation increased at all project sites paddy yields have significantly increased since inception of project. This could reflect in increased income, as marketing seems to be favourable at all countries and may result in improved living conditions. Out-scaling has been seen in greater areas in Togo and Benin but gradually picking up in Liberia and Sierra Leone. However, not much has been achieved under WP5 basically on adoption studies and incorporation of technology into national policy formulations. Impact studies (WP4) have been done in Togo and Benin but still on-going in Liberia and Sierra Leone.

Major Challenges

As presented during interaction with some farmers, storage facilities, quality management of milled rice continue to pose challenges in Togo and Benin. In Sierra Leone and Liberia, backstopping activities to support farmers adopting the Smart Valleys approach are still critically necessary. Support activities on land development, GAP application and site specific nutrient management technologies are critical key challenges that may require further assistance if the gains made are to be sustained.

Non Project farmers observing the gains by farmers in the project sites are showing great interest in the Project.

Recommendations:

(x) Capacity building and backstopping should be enhanced for Liberia and Sierra Leone, under a limited project extension, to accelerate the adoption of technologies

(xi) Training for local artisans in their respective local communities on how to fabricate simple tools /equipment that are being promoted across countries under the Smart-Valleys approach should be intensified

(xii) In the project document, both Togo and Benin were to develop 10 proposals while Liberia and Sierra Leone were expected to develop 5 proposals. It was recommended in the mid-term evaluation report that the number be reduced to about five proposals for the whole sub-region since such proposals normally involve several countries. Efforts were made to develop the 5 proposals. However, only two of the five were approved. It is therefore recommended that future project limit proposal numbers approved to at most two

(xiii) Although purchasing reapers for Benin and Togo is not included in the output tables of the Smart Valleys – Five Year Project Plan (2014–2019), its' text mentions "feasibility of importing small machineries (e.g. reapers) will be assessed". Since the purchase of reapers was not included in the 5 year project plan, reapers were therefore not considered an important factor in this evaluation

References:

~~5. Five year project plan SMART-VALLEYS (2014-2019)~~

6. SMART VALLEYS: Annual Technical Reports for Year 1, Year 2, Year 3 and Year4
7. SMART VALLEYS PROJECT Achievements in Togo and Benin (Year 1–Year 4)
8. SMART VALLEYS Annual Implementation Plans for Year 1, Year 2, Year 3, Year 4 and Year 5.
9. Summary of the Achievements in Year 5 (from October 2018 to September 2019)

Appendix 1: Project Personnel Contacted in Each Country (Name and email where possible)

Name	Country	Email Address
Dr. Ayeva Tchatchibara	Togo	ayevababa@yahoo.fr
Mr. Felix Gbaguidi	Benin	gbaf327@yahoo.fr / gbaguidufe@gamial.com
Mr. Dossou Bernard	Benin	-
Mr. N'Bouke Gnagnimon	Benin	-
Mr. Shaka C. Charley	Sierra Leone	-
Mr. Foday Sumah	Sierra Leone	-
Mr. Kantingu J. Charles	Sierra Leone	-
Mr. Takieu M. Manyeh	Sierra Leone	-
Mr. Abu B. S. Dumbuya	Sierra Leone	-
Dr. R. N. Issaka	Liberia	r.issaka@cgiar.org / rolandissaka@yahoo.com
Mr. Wesley Mineyar	Liberia	-
Miss Maritha Wehyee	Liberia	marithawehyee3@gamail.com

Appendix 3: Summary of the Achievements in Year 5 (from October 2018 to September 2019)

Togo and Benin	Project outputs (2014-2019)	Outputs Year 5 (2018-2019)	Achievements Year 5(2018-2019)
WP1: Expanding inland valley rice areas with the Smart-valleys approach			
A1-1	N/A	N/A	N/A
A1-2	Training package is available in French, and four local languages. Multiplied to 100 copies.	Translate Smart-Valley video into 2 local languages in Togo and 2 in Benin.	Translation completed and videos being distributed to technicians and lead farmers.
A1-3	10 technicians are trained as Smart-valleys instructors.	Achieved	
	40 extension officers and 40 leader farmers are trained in Smart-valleys approach.	Achieved	
	At least 300 farmers receive on-the-job training in Smart-valleys approach	Achieved	
WP2: Improving and stabilizing rice yields through improved agronomic practices and mechanization			
A2-1	RiceAdvice tool is validated in 4 zones.	Validation of RiceAdvice in a second zone in Benin and a second zone in Togo.	The validation completed in both Benin and Togo.
	12 field technicians are trained in the use of RiceAdvice and provide fertilizer advice to 120 rice farmers.	4 technicians will be trained in the use of RiceAdvice and provide advice to 60 farmers in Benin and Togo.	4 technicians were trained and provided advice to over 100 farmers.
A2-2	Farmer preference for mechanic weeders in inland valleys rice system is assessed in 4 zones.	Weeders have been tested and evaluated in 2 zones using 40 farmers. Weeders were later distributed to the 40 farmers.	Weeders will be tested and evaluated in two other zones.
	30 Local craftsmen are trained in the production and maintenance of mechanic weeders.	Achieved	
A2-3	120 farmers receive GAP training.	Achieved	
	30 field technicians are trained in PLAR.	Achieved	

	PLAR is implemented with farmers in 6 zones and on-farm agronomic practices are improved.	Achieved	
WP3: Reducing post-harvest yield losses through the introduction of locally adapted technologies			
A3-1	Postharvest technology needs are identified in 4 zones and 24 farmers are trained in use of postharvest technology.	24 farmers will be trained in use of post-harvest technology in Benin and Togo.	Farmers were trained in post-harvest technologies.
WP4: Impact assessment on livelihood of rice farmers			
A4-1	Impact assessment on farmer livelihoods performed using 2013 baseline study.	Impact assessment on farmer livelihoods will be performed in Togo.	Conducted in Togo
WP5: Assuring sustainable project implementation and adoption of technologies			
A5-1	Governments of Togo and Benin incorporate AfricaRice rice technologies in national policies and projects. Development organizations and NGO's have adopted AfricaRice rice technologies.	Achieved	
A5-2	At least 10 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable technologies.	Annual efforts continued.	Two proposals (Scaling sustainable rice cultivation in Africa; CSA-BF Phase 2) submitted to BMZ/GIZ but not funded
A5-3	Results are presented in popular journals like RiceToday.	Achieved	
	Newspaper articles are prepared and published.	Achieved	
	Project briefs are prepared and shared with donors and fund council of CGIAR.	Achieved	

Sierra Leone and Liberia			
	Project output (2014-2019)	**Outputs for Year 5 (2018-2019)**	**Achievements for Year 5 (2018-2019)**
WP1: Expanding inland valley rice areas with the Smart-valleys approach			
A1-1	5 demonstration sites are operational in each country.	Backstopping of established demonstration sites.	Demonstration sites received continuous support.
A1-2	Training package is available in English, and two local languages. Multiplied to 50 copies.	Translation of the Smart-Valley video into 2 local languages in Liberia and 2 in Sierra Leone.	Translation in progress.
A1-3	4 technicians are trained as Smart-valleys instructors.	Achieved	
	10 extension officers and 10 leader farmers are trained in Smart-valleys approach.	Achieved	
	At least 100 farmers receive on-the-job training in Smart-valleys approach.	Achieved	Project farmers still receiving both technical and material support.
WP2: Improving and stabilizing rice yields through improved agronomic practices and mechanization			
A2-1	Sustainable nutrient management method is identified and validated in 2 zones.	Continuous validation of nutrient management.	Validation of nutrient management continued in 2 zones.
	10 field technicians are trained in the sustainable nutrient management method and provide training to 100 rice farmers.	Achieved	Farmers still receiving hands-on training.
A2-2	Farmer preferences for mechanic weeders in inland valley rice systems are assessed in 2 zones. 10 local craftsmen are trained in the production and maintenance of mechanic weeders.	Weeders currently being tested at 3 sites in Sierra Leone. Activity is yet to start in Liberia. In collaboration with the SAPEC project, 2 local craftsmen were trained in Liberia.	Testing of weeders still on-going.
A2-3	40 farmers receive GAP training. 10 field technicians are trained in PLAR.	Achieved Achieved	Technicians still receiving on-the-job training.

	PLAR is implemented with farmers in 2 zones and on-farm agronomic practices are improved.	Achieved	Technicians still receiving on-the-job training.
WP3: Reducing post-harvest yield losses through the introduction of locally adapted technologies			
A3-1	Postharvest technology needs are identified in 2 zones and 6 farmers are trained in use of postharvest technology.	Training on improved parboiling technologies.	Farmers received training on improved parboiling technology.
WP4: Impact assessment on livelihood of rice farmers			
A4-1	Impact assessment on farmer livelihoods performed using 2013 WFP baseline study.	Impact assessment on farmer livelihoods to be conducted.	Preparation to conduct impart assessment underway.
WP5: Assuring sustainable project implementation and adoption of technologies			
A5-1	50 delegates from the (agricultural) development sector participate in Rice Innovations Forum. Development organizations and NGO's have adopted AfricaRice rice technologies.	Some agricultural based NGOs in Sierra Leone have been trained on the smart valley approach and the technology is being adopted.	Rice Innovation Forum was held both in Sierra Leone (November 2018) and in Liberia (September 2019). Over 120 (60 in Sierra Leone and 67 in Liberia) delegates from the Ministry of Agriculture, NGOs, Farmers attended in Sierra Leone and Liberia.
A5-2	At least 5 proposals are developed or supported that aim rice development and that integrate AfricaRice scalable technologies	Prepare proposals.	Project proposal development has been initiated.
A5-3	Project is broadcasted on national television in Liberia and Sierra Leone	Annual efforts continued.	The project activities and achievements were broadcasted for the second time in a regional FM station
	Newspaper articles are prepared and published	Annual efforts continued.	The project achievements were published in a national newspaper https://www.liberianobserver.com/news/africa rice-holds-smart-valley-innovation-forum-with-farmers/

Appendix 5:

Methodologies adopted in the impact assessment study

1. Methods

1.1. Study Area

he study was conducted in Benin, Togo, Sierra Leone and Liberia in West Africa. The Smart-Valleys approach was introduced in Benin and Togo during the first phase of the SMART-IV project (2009–2014) while it was introduced in Liberia and Sierra Leone during the second phase of the project (due to the Ebola crisis it was made only in 2016–2019). Togo and Benin are quite similar in terms of agro-ecologic condition and economic development. In 2015, the per capita GDP was estimated at USD 827.20 and 547.97 in Benin and Togo, respectively (Trading Economics 2016). In both countries, agriculture occupies some 80% of the population (FAO 2016) but the agriculture sector contributes to only 36.3% and 42% of GDP in Benin and Togo, respectively (CIA World Factbook 2016). Rice is one of the major staple foods in both countries and domestic production does not meet national supply. The climate Change is increasingly in the two countries (Arouna and Akpa, 2019). Sierra Leone and Liberia are also quite similar in terms of agro-ecologic condition and economic development and have a tropical climate with two distinct seasons. The dry season in December–April and the rainy season in May–November. Agriculture is a major contributor to GDP in both countries, primarily from rubber, coffee, rice and cassava.

1.2. Survey design and sampling

For impact assessment, two-stage stratified random sampling was used. In Benin and Togo, data were collected in 2014/2015. First, villages were selected randomly from the list of rice producing villages (30 villages were selected in Benin and 20 villages in Togo). In each village, 10 households were randomly selected in the second step. A total of 390 rice farming households were selected (Benin and Togo).

In Sierra Leone and Liberia, data was collected in 2019 in the intervention areas of the SMART-IV project. In Sierra Leone, Debia and Lokomassama chiefdoms in Port Loko district (North-west region) were selected. In Liberia the study was conducted in Bong and Magibi regions specifically in the following chiefdom: Darn, Garyea, Jorquelleh, Suakoko, Kakata, Konawolala, Konoyea, Panta, Shensue and Zoeduhan. In the first stage 16 villages were randomly selected in each country with 8 villages of adopters and 8 villages of non-adopters. To increase the power of estimation compare to Benin and Togo, 20 rice households were randomly selected which led to a total of 641 rice farming households surveyed (320 and 321 household in Liberia and Sierra Leone, respectively).

Data collection was automated using computer tablets and the CAPI software, namely Census and Survey Processing System (CSPro). The computer-based data collection avoided many biases

associated with paper-based questionnaires, such as mistakes in recording answers, changing of values of variables, and re-coding test answers for numerical variables. The household level survey was conducted on a one-to-one basis using experienced and trained enumerators. For data collection, enumerators were recruited and trained. Overall, fieldwork was closely monitored and supervised by staff from AfricaRice and Agricultural Research Institute in each country.

The questionnaire was pre-tested before data collection and included mainly information on demographic characteristics of the household, institutional characteristics, land resource endowment, qualitative and quantitative input and output data, use of rice varieties, and farm management data. The data was analyzed using STATA version 15 software.

1.3. Analysis of the determinants of adoption

The decision to adopt a new technology (smart-valley in our case) can be modelled in a random utility framework. Let us assume that a rice producer has the choice among many technologies or approaches in order to produce and maximize their consumption of food and non-food items utility, subject to some constraints on available resources and technologies. Smallholder farmer i will choose to adopt smart-valley approach only if the utility gain from adopting (T_{i1}) is greater than the utility from not adopting (T_{i0}), meaning that $T_i^* = T_{i1} - T_{i0} > 0$. Although the two utilities are unobservable, the preferred net utility of farmers is known to them and it is possible to observe the choice made by the i^{th} farmer. The net utility T_i^* can be expressed in a latent variable framework with respect to household characteristics as:

$$T_i^* = Z\gamma - U_D \qquad \text{with } T_i = \begin{cases} 1 \; if \; T_i^* > 0 \\ 0 \; if \; T_i^* \leq 0 \end{cases} \qquad (1)$$

Where T is the observed adoption status which takes the value 1 if the farmer adopts a Smart-valley approach and 0 if not, γ is a vector of parameters to be estimated, and Z is a vector of exogenous variables that explain adoption decisions. The variables Z are drawn from the literature on adoption of agricultural technologies (Kasi et al. 2011). U_D is the random error term assumed to be normally distributed. The error term captures the measurement errors and unobserved factors which are not correlated with Z but may influence the decision to adopt Smart-valley approach. The probability to adopt smart-valley approach can be expressed as:

$$\Pr(T_i = 1) = \Pr(T_i^* > 0) = \Pr(U_D > -\gamma' Z) = 1 - F(-\gamma' Z) \qquad (2)$$

Where F is the cumulative distribution function of U_D. We use probit model to estimate Equation (2) and the vector of coefficients (γ') represents the coefficients of the determinants of smart-valley approach adoption.

1.4. Impact assessment model

To assess the impact of Smart-valley approach, Local Average Treatment Effect (LATE) estimator proposed by Abadie (2003) was used. Indeed, LATE takes into account bias due to both observed and unobserved characteristics. Impact assessment aims to estimate on average the situation of smart-valley adopters if they did not decide to adopt it. A simple method is to determine the difference for the selected outcome. Outcomes selected for this study are yield, income and food security. But the interpretation of the difference as a causal relationship between adoption status lead to selection bias (Heckman 2010). An unbiased difference will be determined if the groups are similar, and the difference is only the adoption

of smart-valley approach. In order to solve this problem of selection bias and generate unbiased bias impact, Imbens and Angrist (1994) proposed the local average treatment effect (LATE) which is the average impact for the subpopulation of potential adopters. The estimation of the LATE requires the use of the instrumental variable method (Imbens and Wooldridge 2009; Heckman and Vytlacil 2005; Abadie 2003). This method assumes the existing of variable *z* called instrument that directly affects the adoption status, but indirectly the outcomes *y*1 and *y*0, once the independent variables (*x*) are controlled.

The instrumental variable (*z*) used in this study is the knowledge of smart-valley approach. Indeed, the choice of this variable is due to the fact that knowledge affects the decision whether to adopt the smart-valley approach. So only farmer having information on the technology are able to adopt it. However, knowledge alone does not directly influence the outcome. Knowledge therefore meets the definition of the instrumental variable given by Abadie (2003) and Heckman (2010).

2. Determinants for the adoption of the Smart-Valleys approach

2.1. Benin and Togo

The Smart-valleys approach adoption model is estimated using the Probit model. The maximum likelihood test indicates that the model is globally significant at 1%. The results are presented in Table 1. Six variables—total available area, lowland availability, secure land tenure, selling price of paddy and membership in an association—influencing positively or negatively the adoption of Smart-Valleys approach were identified.

The total available area influences positively and significantly adoption of Smart-valley at the 1% threshold. Then, large availability of agricultural area for the household drives increasing of probability of adoption. Results indicate that if the household has a large available area, the probability increases by 0.9%. The price represents an important determining factor for any economic actor to make decision. This determines the profit that they get from their activities. Price of paddy rice on the market included in the model has a positive and significant influence on the adoption of Smart-valley technology at the 1% of level. Its marginal effect is 0.7%, which means that if the price of paddy on the market during the previous season is high, this increases the probability of adoption by 0.7%. Producers tend to adopt new agricultural technologies in expecting to get advantage from market price and achieve economics scale. Secure access to land remains a very important aspect for adoption of new agricultural technologies. The results show a positive and significant effect of the land tenure (inheritance and rental) for the adoption of Smart-valley. Producers having secured access to land were able to invest significantly for agriculture improvement. This will facilitate the adoption of new technologies developed by the research. This result is consistent with Oladele and Wakatsuki (2009), who report that the cost-effectiveness of use of Smart-valley technology increases if the adopter has access to land by inheritance, purchase, or agrees long-term lease contract for the land with the landowner. The types of tenure included in the model (inheritance and rental) increase the probability of adoption by 19% and 89%, respectively. This positive effect met our expectations.

As indicated above, the Smart-Valleys approach provides excellent results in lowland, i.e. better water control and fertilization. The results reveal that the availability of lowland for the household influences positively the adoption of Smart-Valleys. Indeed, own lowland as growing environment increases the probability of adoption of Smart-Valley approach by 36%. Against expectations, the variable indicating membership of farmer group/association influences negatively the adoption of Smart-valley. Based on

results, the fact of belonging to group/association decreases the probability of adoption of 9.75%. This result is in opposition to that obtained by Jagwe et al. (2010) and Mathenge et al (2010). They explained that groups and associations represent an important platform for social capital improvement through which small producers might easily have access to information.

Table 1: Determinants for the adoption of the Smart-Valleys approach in Benin and Togo

Variables	Coefficients	Standard error	Marginal effect
Age (Year)	-0.001	0014	0.00
Rice Experience (Year)	-0.010	0018	-0.002
Gender (Male = 1, Female = 0)	-0292	0308	-0067
Production in the shallows (1 = yes, 0 = no)	1228 ***	0300	0365 ***
Access to land by inheritance (1 = yes, 0 = no)	1141 **	0449	0189 ***
Access to land by leasing (1 = yes, 0 = no)	3268 ***	0583	0890 ***
Access to credit (1 = yes, 0 = no)	-0234	0432	-0045
Total farm area available (Ha)	0044 ***	0013	0009 ***
Having received agricultural training (1 = yes, 0 = no)	-0214	0258	-0043
Association membership (1 = yes, 0 = no)	-0435 *	0253	-0098
Paddy market price (FCFA)	0007 ***	0003	0001 ***
Yield (T / ha)	0144	0127	0030
constancy	3482	0995	-
Number of Observations	244		
Log maximum likelihood	-74.44		
Wald chi-square (9)	103.92 ***		
McFadden Pseudo-R ^{2}	0.4111		

*: Significant at < 10%; **: Significant at < 5%; ***: Significant at < 1%.

The technology was most adopted by young and older farmers. This result did not meet our expectations. We expect a negative and significant influence, because youth has labor force to achieve the layout themselves; agriculture being family scale using rudimentary tools. Alarima et al. (2013) found a negative and significant correlation between the adoption of Smart-valley and age. Their results showed that the probability of adoption is greater over young population than older farmers. While older farmers seem to be conservative, practicing empirical knowledge, young people are rather curious and looking to experiment with new technologies.

2.2. Sierra Leone and Liberia

Table 2 presents the determinants for the adoption of the Smart-Valley approach in Sierra Leone and Liberia. The maximum likelihood test indicated that the model is globally significant at 1%. Fourteen variables out of the 24 ones are significantly driving the adoption or non-adoption of the Smart-Valleys approach. Knowledge and information indicators such as contact with extension agents, being member of farm association, listen to radio and knowledge of smart-valley were positively associated with the probability of adopting the Smart-Valleys approach. This suggests that the likelihood to adopt the Smart-Valleys is higher for households that had access to information and knowledge than those who did not. However, given that about 43% of households did not have contact with extension and around 39% of

respondents didn't have knowledge of the Smart-Valleys approach, policy options that aim to increase access to knowledge will positively affect the adoption of the Smart-Valleys approach. In addition, the significance of being member of farm association and knowledge of the Smart-Valleys in the selection equation underscores the relevance of selecting these variables as instruments for impact assessment. This is in contradiction to the result obtained by Arouna and Apka (2019) who have found that the variable "membership of farmer group/association" influences negatively the adoption of smart-valley approach. This may explained some specificity in the determinants of adoption based on the region.

Land and farm characteristics such as total available area, rice cultivated area, yield, use of NPK as fertilizer and use of tractor also positively affected the probability for a household to adopt the Smart-Valleys approach. This implies that farmers with more resources such as land, fertilizer and tractors are less risk-averse and can invest in new technology such as the Smart-Valleys. Producers with secure access to land will take the risk to invest in soil and water management. This is consistent with the finding of Oladele et al. (2010) who have reported that the Smart-Valleys approach increases if the adopter has access to land by inheritance, purchase, or agrees for a long-term lease contract for the land with the land owner. In addition, the Smart-Valleys approach includes the following three pillars: drainage canals, irrigation infrastructure (where water resources are available), and bunded and levelled rice fields in the inland valleys (AfricaRice 2010). Therefore, the availability of equipment such as tractors will facilitate the application of the approach.

Policy measures to increase access to resources such as access to micro finance will improve the adoption rate of the Smart-Valleys in Sierra Leone and Liberia. Increasing access to credit is particularly important as about 89% of rice farmers did not have access to credit facilities. Increased access to institutional support services such as extension, credit, and access to information should thus be a major part of efforts aimed at promoting adoption of modern technologies.

Table 2: Determinants for the adoption of the Smart-Valleys approach in Sierra Leone and Liberia

Variables	Coefficients	Standard error
Household characteristics		
Age of rice farmer (year)	0.02	0.05
Household size (Number)	0.02	0.03
=1 if male (%)	-0.08	0.20
=1 if married (%)	-0.49*	0.26
=1 if formal education (%)	-0.25	0.41
Number of year spent at school	0.03	0.04
= 1 if agriculture is main activity (%)	0.27	0.65
=1 if country is Sierra Leone (%)	-2.66***	0.44
=1 if listen to radio	0.42**	0.19
=1 if known Smart-valley	2.99***	0.32
Food expenditure	0.00	0.00
Institutional characteristics		
=1 if contact with extension (%)	0.54**	0.23
=1 if access to credit (%)	-0.08	0.38
=1 if member of farm association (%)	1.33***	0.23
Distance to extension agent (Km)	-0.03**	0.01
Distance to market (Km)	0.01	0.03
Distance to town (Km)	-0.01	0.01
Land and Farm characteristics		

=1 if land is heritage	-0.49**	0.22
Total available area (Ha)	0.01***	0.00
Rice cultivated area (Ha)	0.66***	0.16
Yield (Ton/ha)	0.27***	0.07
=1 if use NPK as fertilizer	0.71***	0.24
=1 if use tractor	1.39***	0.34
Environmental characteristics		
=1 if lowland	0.92***	0.31
Constant	-0.87	5.61
Number of observations	641	
Log of likelihood	-128.76	
Wald Chi-square	631.10***	
McFadden Pseudo R^2	0.71	

*: Significant at < 10%; **: Significant at < 5%; ***: Significant at < 1%.