# Sawah, Market Access and Rice Technologies for Inland Valleys (SMART-IV) project

*Annual technical project report 2011-2012*


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Funded by the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF)

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**Africa Rice Center (AfricaRice)**

The Africa Rice Center (AfricaRice) is a leading pan-African research organization working to contribute to poverty alleviation and food security in Africa through research, development and partnership activities. AfricaRice is member of the consortium of 15 international agricultural research centers known as the CGIAR. It is also an autonomous intergovernmental research association of African member countries.

The Center was created in 1971 by 11 African countries. Today (October 2012) its membership comprises 24 countries, covering West, Central, East and North African regions, namely, Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Côte d'Ivoire, Democratic Republic of Congo, Egypt, Gabon, the Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Madagascar, Mali, Mauritania, Niger, Nigeria, Republic of Congo, Senegal, Sierra Leone, Togo and Uganda.


**Inland Valley Consortium (IVC)**

The IVC, which exists since 1993, became a platform of research and development between 12 countries in West Africa (Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Gambia, Ghana, Guinea, Mali, Nigeria, Sierra Leone, Senegal and Togo). Members participate through National Coordination Units that generally include a wide array of research and development partners and, in some cases, also NGO's and community-based organizations. The goal of the IVC is to improve the livelihood of the rural poor while contributing to the development of competitive values chains for rice based systems allowing a better use of the inland valleys potential in sub-Saharan Africa through concerted management of the resources, respectful of the environment and social equity.

The IVC focuses on an integrated approach to natural resources management and value chain development in an inland valley (IV) context, and will work through gathering and disseminating information, technologies, etc. on the sustainable development of the inland valleys.

The IVC is evolving towards a Community of Practice on inland valley development in sub-Saharan Africa. This Inland Valley Community of Practice will still be known under the same acronym: IVC. Work is currently undergoing to develop a website portal which is intended for professionals working on inland valley development and research.

# 1 Introduction

Inland valley systems in sub-Saharan Africa are believed to have a high potential for agricultural production increase through intensification. However, current rice productivity in inland valleys is often low because of various human and natural constraints such as poor water control, weed invasion, low soil fertility, increasing soil degradation, labour deficiency, limited access to information, technology, resource and credit, and exposure to the risk of water-borne diseases, e.g. malaria and bilharzia. These constraints substantially limit rice productivity so that resultant economic benefits are among the lowest levels in rice production globally.

The SMART-IV project, supported by Japan's Ministry of Agriculture, Forestry and Fisheries (MAFF), started in 2009 and aims to introduce sawah system technology in inland valleys in Togo and Benin. The overall goal of the SMART-IV Project is to improve the livelihood of the rural poor by reducing imports of rice through augmenting the production of the inland valleys in SSA. The SMART-IV Project aims to explore the potential of the sawah system to increase rice productivity in inland valleys, while improving farmer access to markets and rice technologies in SSA.

Sawah systems entail good agricultural practices such as land levelling, bunding and puddling in combination with good water management. Sawah System Development (SSD) is already on-going since the 1990's in Nigeria and Ghana and is believed to sustainably improve productivity and the livelihoods of farmers in rice-based systems. The SMART-IV project offers an interdisciplinary approach where farmers, scientists from various backgrounds and development partners investigate the potentials and constraints for SSD. Sawah systems will be developed in a total of 10 regions in Togo and Benin.

*This report*

This technical report presents the results of the third year of the project (October 2011 – September 2012). The report contains contributions from **Aminou Arouna**, **Worou Soklou**, **Shin Abe**, **Felix Gbaguidi** and **Assimiou Adou Rahim Alimi**, and was compiled by **Sander Zwart**.

**First**, the results from the assessment for the potential for Sawah System Development (SSD) at regional scale will be described. **Thereafter**, research results for field plot analysis and farmer's options for rice productivity enhancement through soil and water management in SSD are provided. **Thirdly**, research activity related to impact assessment of SSD, effective technology transfer mechanisms and market access will be described. **Fourthly**, the implementation of SSD demonstration in satellite villages and the integration of SSD in the national extension systems through capacity building will be outlined. **Finally**, chapters on capacity building and project management are provided.

# 2 Regional characterization and assessment of the potential for SSD

## 2.1 Mapping the potential for development for SSD

### 2.1.1 Introduction

Inland valleys have always been considered as having a high potential for agricultural development. A largely unexploited land resource of 200 million ha of inland valleys has been identified in sub-Saharan Africa (Andriesse, 1986). Inland valley bottoms have considerable potential for sustainable land-use intensification and/or expansion, especially for rice-based cropping systems (Windmeijer and Andriesse, 1993). It is, however, known that, regardless of their recognized potential, so far only 10–20% of total area of the inland valleys has been cultivated, with associated low crop and economic productivity due to low input of resources and poor control of water, weeds and soil fertility.

The information above dates back from more than twenty years ago. Geo-information science has evolved rapidly and new methods have become available. Newly available data sets, including accurate digital elevation models, a wide range of satellite images at lower costs, and climate data allow the development of new methodologies to map the area of inland valleys and importantly their potential for development of such areas.

The goal of the remote sensing and GIS modelling is to develop a spatial model that can be used to locate inland valley systems and their potential for development of rice-based systems. The target users are national government services involved in planning of agricultural development, NGOs, donors and scientists. During the 2011-12 the research activities focused on mapping of inland valleys systems using remote sensing data (see 2.1.2). During year 4 and 5, a methodology will be developed, implemented and validated to map the potential for development for rice-based systems (see 2.1.3 for the outline of the methodology to be developed). 2.1.4 and 2.1.5 summarize major achievements in year 3 and prospects in year 4 in this topic, respectively.

### 2.1.2 Mapping inland valleys in Togo and Benin using remote sensing

In the previous year a literature study was performed to assess the different methodologies for mapping inland valleys in West-Africa. Major conclusions were that the availability of imagery is low and that prevailing cloudy conditions in Togo and Benin will limit the implementation of an exisiting methodology using satellite images from optical remote sensing. Therefore a new approach was developed based on a digital elevation model (DEM), i.e. an output of satellite remote sensing.

A DEM is a digital representation of the topology of an area. For "pixels", the lowest level of data acquisition in remote sensing, the elevation is determined. Three different DEM products are available that can be employed for assessment of inland valleys (see table below). All products have (near) global coverage and can be downloaded free of costs.

Table 1. Available standard Digital Elevation Models.

| Type | spatial resolution | coverage | costs | source |
|---|---|---|---|---|
| **GTOPO30** | 1x1kilometer | global | free download | United States Geological Survey http://eros.usgs.gov/#/Find_Data/ Products_and_Data_Available/gtopo30_info |
| **Shuttle Radar Topography Mission (SRTM)** | 90x90 meter | global | free download | United States Geological Survey srtm.usgs.gov |
| **Advanced Spaceborne Thermal Emission & Reflection Radiometer (ASTER)** | 30x30 meter | global | free download | NASA and Ministry of Economy, Trade, and Industry (METI) of Japan asterweb.jpl.nasa.gov/gdem.asp |

The ASTER dataset has recently become available at 30 meter resolution as the result of a joint project of NASA and the Japanese Space Agency. Due to the scale of inland valley systems, which usually have a width of no more than 30 meter in the context of Benin and Togo, the ASTER data set was used.

First, the DEM was used to delineate stream flows using runoff accumulation as a standard ArcGIS module. This module calculates runoff patterns by allocating the runoff to the lowest surrounding pixel. (see Figure 1). In this example it is shown that the central pixel is the lowest area for the upper 3 pixels and runoff will flow to this pixel. On the other hand the sum of these 4 pixels flows to the lower-left pixel. All runoff will accumulate in this pixel. This methodology was applied on national scales for Benin and Togo to assess the location of streams and rivers (see Figure 3A).

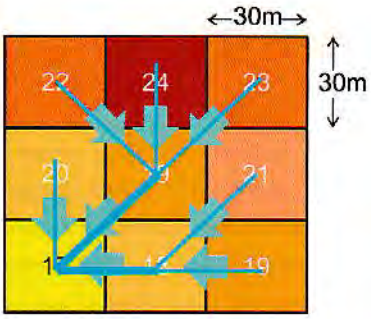



Figure 1. Hypothetical example of a digital elevation model of 3 by 3 pixels of 30 meter resolution that shows the flow direction from a specific pixel to the lowest surrounding pixel. Runoff accumulation is calculated.

Secondly, an algorithm was developed and tested to determine the location of the inland valley bottoms. The inland valley bottoms are obviously located in the vicinity of the streams. For each location of the stream, the elevation was determined. Thereafter, the nearby pixels with the same elevation were located. This is visualized in Figure 2 where a cross-section of an inland valley is shown. Pixels, projected 2-dimensionally, show the elevation for each 30 meter. In this example the stream is located at an altitude of 20 meters above sea level. The surrounding pixels of 20 meter or 21 meter (+1m) are selected as being the inland valley bottom. This algorithm was applied at national scale (see Figure 3B).

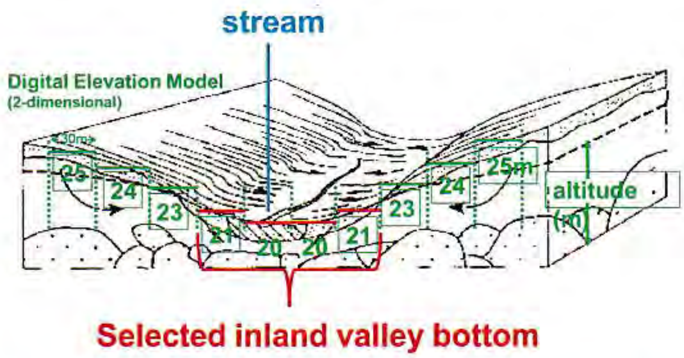
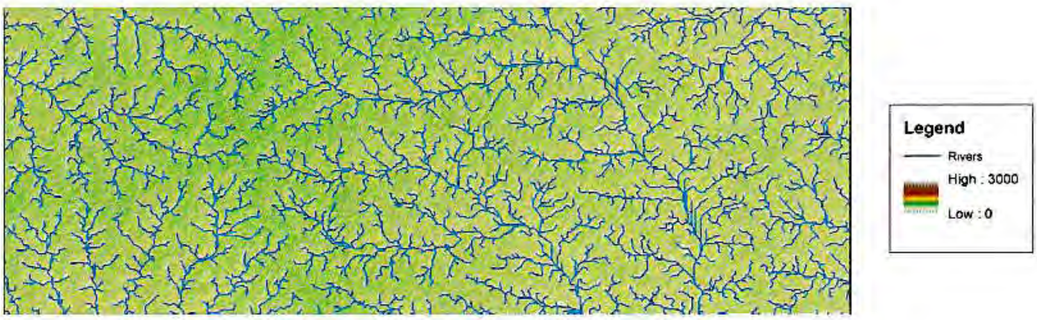



Figure 2. Schematization of the selection procedure of pixels that have the same elevation or +1m as the as the stream to assess the inland valley bottom.

Thirdly, the methodology has been validated in Benin using accurately digitized inland valleys obtained from the IMPETUS project[1]. Inland valleys developed for agriculture as well as inland valleys with natural vegetation were mapped by walking along the fringes of the inland valley with a GPS. Validation in Togo was conducted using a similar approach, but since no existing data sets are available, data were collected within the framework of the SMART-IV project. A total of 45 inland valleys were digitized. An example of the validation with data from the IMPETUS project is depicted in see Figure 3C. Finally, the results of the mapping methodology are also superimposed in GoogleEarth and validated visually (see Figure 4).

A) 


[1] The IMPETUS project was a German funded project (2000-2009) focusing on climate and hydrology in Benin and Morocco. More information is available from: www.impetus.uni-koeln.de/en/project/

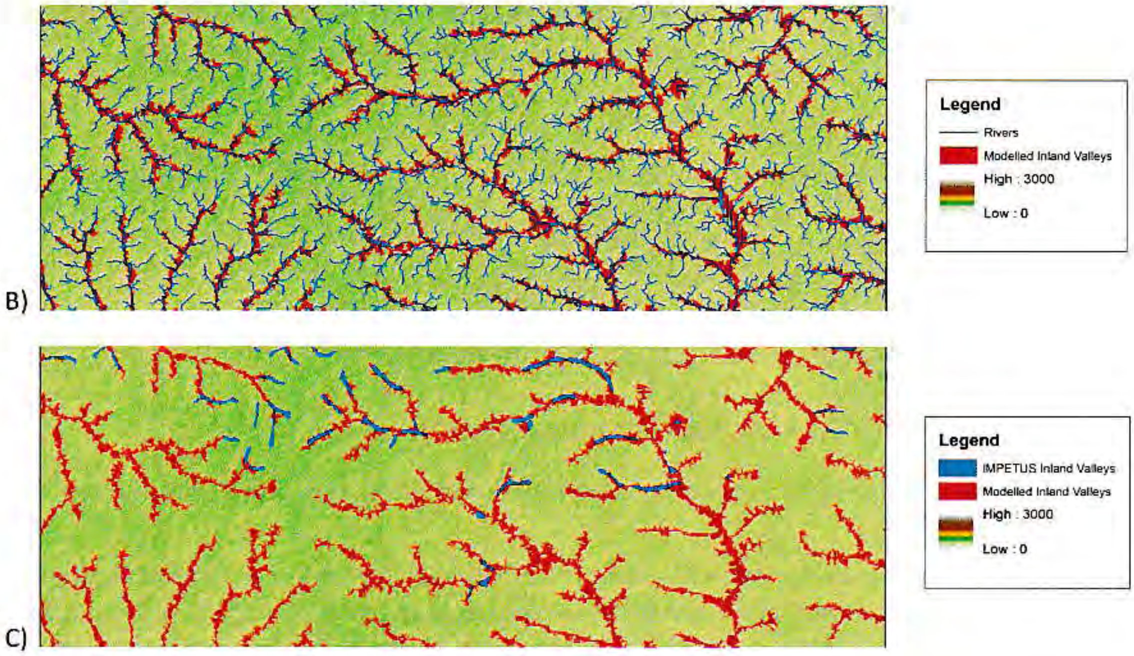



Figure 3. Derived stream flow pattern from a DEM (A), Derived inland valley bottoms in red (B) and the validation with digitized inland valleys depicted in blue (C). An area in central Benin is shown in this example.


Figure 4. Screenshot from GoogleEarth with the digitized inland valleys superimposed. This methodology is used for verification of mapping results.

### 2.1.3 Mapping the potential for development using the Random Forest methodology

Random Forest is an ensemble learning technique that builds multiple trees based on random bootstrapped samples of the training data[2]. Random Forest method is used to characterize existing paddy rice areas and identify areas suitable for paddy rice production in Laos[3]. Random forest has been shown to give good accuracy without over-fitting and it is relatively robust to outliers and noise[1,4,5]. Random Forest is considered for classification of multisource geographic data. This method has been proven to improve classification accuracy considerably[3]. Random Forest presents a comprehensive methodology to assess and analyse classification uncertainty based on the local probabilities of class membership[6]. After implementing their study, these last authors proved that uncertainty assessment with Random Forest provides valuable information on the performance of land cover classification models, both in space and time.

Digital elevation data from the Aster satellite with a spatial resolution of 30 m will be used to derive topographic variables such as slope and flow accumulation. Rainfall, poverty, and demographic variables will be resampled to 30 m to match the spatial resolution of the Aster DEM.

The importance of each variable will be calculated by taking the difference between the prediction accuracy with and without permuting the variable and then averaging this difference over all trees and normalizing by the standard error. The variables will be ranked basing on this importance measure, with the variables having the highest decrease in accuracy resulting from the permutation as the most important predictor. Variables that will have the lowest ranking (i.e., least important predictor) will be subsequently removed from the predictor set and the random forest will be re-trained[2].

Variable predictors of rice cultivation suitability are grouped in 5 categories and are outlined below:

1. topographical

| Description | Unit | Source of basic data |
|---|---|---|
| **Elevation** | Meters | ASTER[a] |
| **Elevation – coefficient of variation** | | ASTER |
| **Flow accumulation** | | ASTER |
| **Flow accumulation – 5 · 5 focal mean** | | ASTER |
| **Slope** | Degrees | ASTER |
| **Slope – 3 · 3 focal mean** | Degrees | ASTER |

[2] Breiman, L. 2001. Random Forests. Machine Learning 45:5-32

[3] Laborte, A. G., A. A. Maunahan, and R. J. Hijmans. 2012. Opportunities for expanding paddy rice production in Laos: predictive modeling using Random Forest. Journal of Land Use Science 7:21-33.

[4] Gislason, P. O., J. A. Benediktsson, and J. R. Sveinsson. 2006. Random Forests for Land Cover Classification. Pattern Recognition Letters 27:294-300.

[5] Prasad, A. M., L. R. Iverson, and A. Liaw. 2006. Newer Classification and Regression Tree Techniques: Bagging and Random Forests for Ecological Prediction. Ecosystems 9:181-199.

[6] Loosvelt, L., J. Peters, H. Skriver, H. Lievens, F. M. B. Van Coillie, B. De Baets, and N. E. C. Verhoest. 2012. Random Forests as a tool for estimating uncertainty at pixel-level in SAR image classification. International journal of applied earth observation and geoinformation 19:173-184.

2. climatic

| Description | Unit | Source of basic data |
|---|---|---|
| **Rainfall of the wettest quarter** | Millimeters | WorldClim[b] |
| **Annual rainfall** | Millimeters | WorldClim |

3. accessibility

| Description | Unit | Source of basic data |
|---|---|---|
| **Distance to nearest river or stream** | Kilometers | HealthMapper[c] |
| **Distance to nearest major road** | Kilometers | HealthMapper |
| **Distance to nearest minor road** | Kilometers | HealthMapper |
| **Distance to nearest town** | Kilometers | HealthMapper |
| **Distance to nearest urban area/city** | Kilometers | HealthMapper |
| **Distance to nearest village** | Kilometers | HealthMapper |

4. demographical and related to poverty (at INSAE in Benin)

| Description | Unit | Source of basic data |
|---|---|---|
| **Population density** | Persons/km$^2$ | GPWV3[d] |
| **Change in population density** | % | GPWV3 |
| **Proportion of rural population** | % | WB[e] |
| **Poverty rate** | % | WB |

5. other data sets

| Description | Unit | Source of basic data |
|---|---|---|
| **Land cover (polygon)** | | GlobCover[f] |
| **Current and proposed protected areas (polygon)** | | WDPA[g] |
| **Urban areas (polygon)** | | HealthMapper |
| **Large water bodies (polygon)** | | SWBD[h] |

[a]Aster DEM, URL: http://srtm.csi.org
[b]WorldClim version 1.4. Hijmans, Cameron, Parra, Jones, and Jarvis (2005). URL: http://www.worldclim.org/.
[c]HealthMapper version 4.1, World Health Organization (WHO). Distances were calculated using the path distance function in ArcGIS.
[d]Gridded Population of theWorld version 3, Center for International Earth Science Information Network (CIESIN).
[e]World Bank.
[f]GlobCover version 2.2, ESA/ESA Globcover Project, led by MEDIAS-France/POSTEL, URL: http://ionia1.esrin.esa.int/.
[g]World Database on Protected Areas, Version 2007, World Conservation Union and UNEP-World Conservation Monitoring Centre, URL: http://glcf.umiacs.umd.edu/data/wdpa/.
[h]SRTM Water Body Data. URL: http://www2.jpl.nasa.gov/srtm/.

The methodology will first be applied in Benin in the Mono-Couffo area for which a large geo data base is available. This source, obtained though the RAP-IV project at AfricaRice, will be used for validation of the methodology.

### 2.1.4 Major achievements remote sensing year 3 (2011-12)

- Geo data base of 50 digitized inland valleys established using extensive field work;
- Methodology for automated mapping of inland valleys developed and validated;
- Validated maps of inland valleys in Togo and Benin are available.

### 2.1.5 Prospects remote sensing for year 4 (2012-13)

- Scientific publication on automated mapping of inland valleys submitted;
- Geo data base established with spatial information relevant for the potential for development;
- Random forest methodology tested and validated for selected regions in Benin.

## 2.2 Impact on the natural resources and national food security

### 2.2.1 Introduction

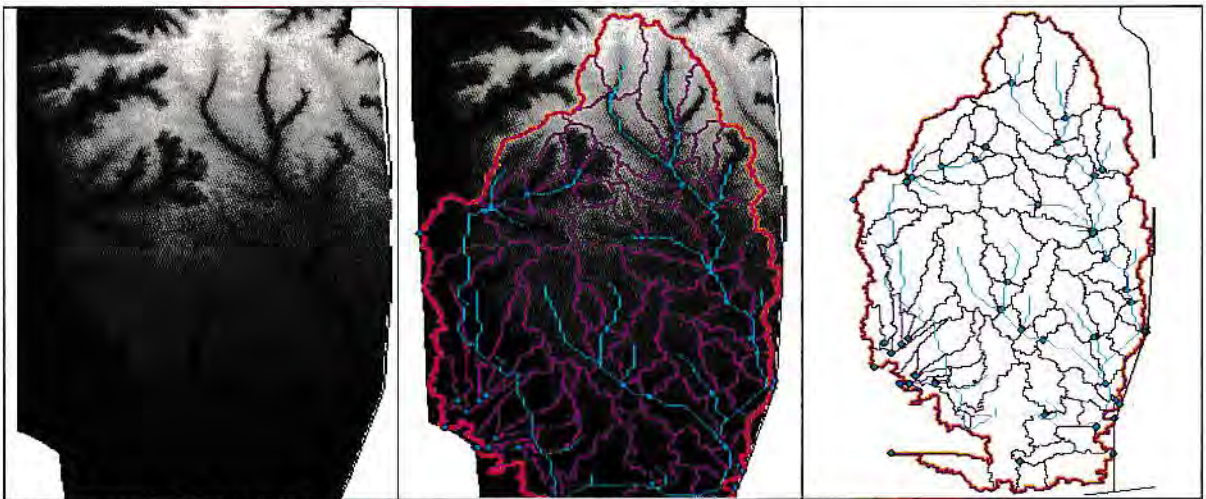
The International Water Management Institute is tasked to undertake the following work packages within the framework of this project. These are:

- Modelling basin level impacts of up-scaling Sawah technology (Work package 1)
- Mapping the suitability of inland valley systems for lowland rice production (Work package 2)
- Modelling national level scenarios of water and food supply and demand in Togo with emphasis on the rice sector (Work package 3), and
- Modelling national level scenarios of water and food supply and demand in Benin with emphasis on the rice sector (Work package 3)

During the reporting period aspects of these work packages have been addressed, except Work package 2, which was derailed due to departure of IWMI project team member with expertise in RS/GIS.

### 2.2.2 Achievements 2011-12 (WP1)

Relevant physical (elevation, land cover, soils), weather (rainfall, air temperature, solar radiation, wind speed and relative humidity), hydrological (stream flow, sediment and nutrient delivery), and non-point and point source pollution data have been gathered for two water basins in Benin (Oueme) and Togo (Zio) respectively. These data are relevant for running the Soil and Water Assessment (SWAT) model. The objective of the SWAT Model is to predict the effect of management decisions on water, sediment, nutrient and pesticide yields with reasonable accuracy on large, un-gaged river basins. The SWAT model inputs for Oueme (Benin) (Figure 5).



| Digital Elevation Model (DEM) | Watershed Delineation | Sub-basin generation |
|---|---|---|

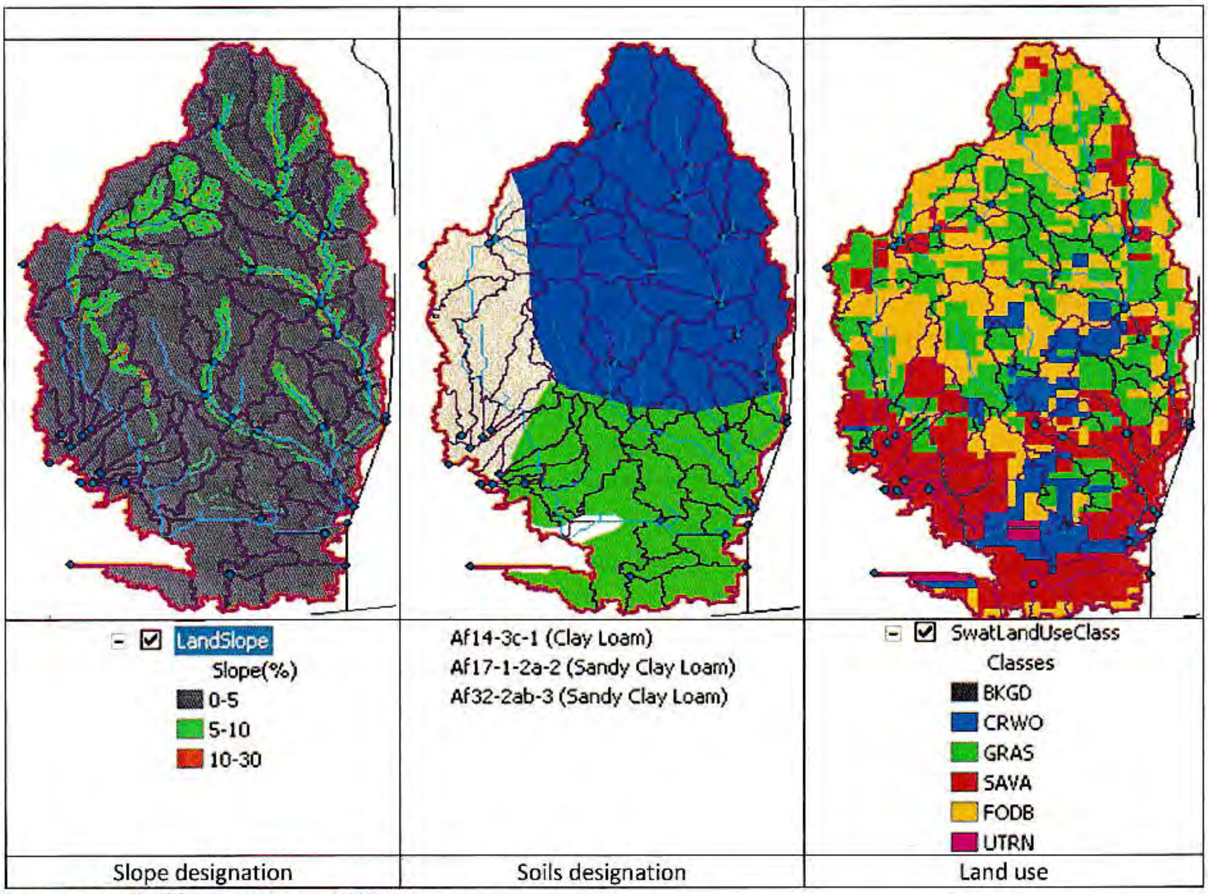
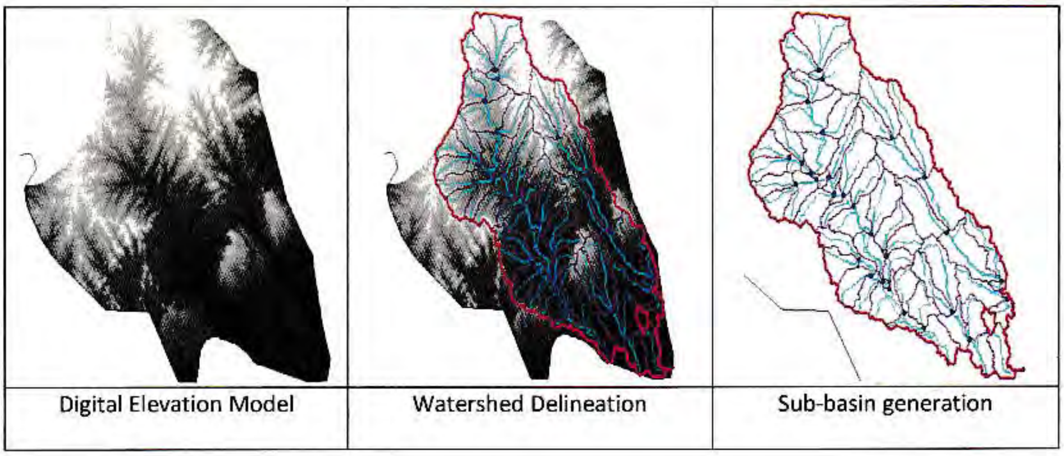


Figure 5. Ouémé basin SWAT model inputs.

Zio basin (Togo) SWAT model input is depicted in Figure 6.



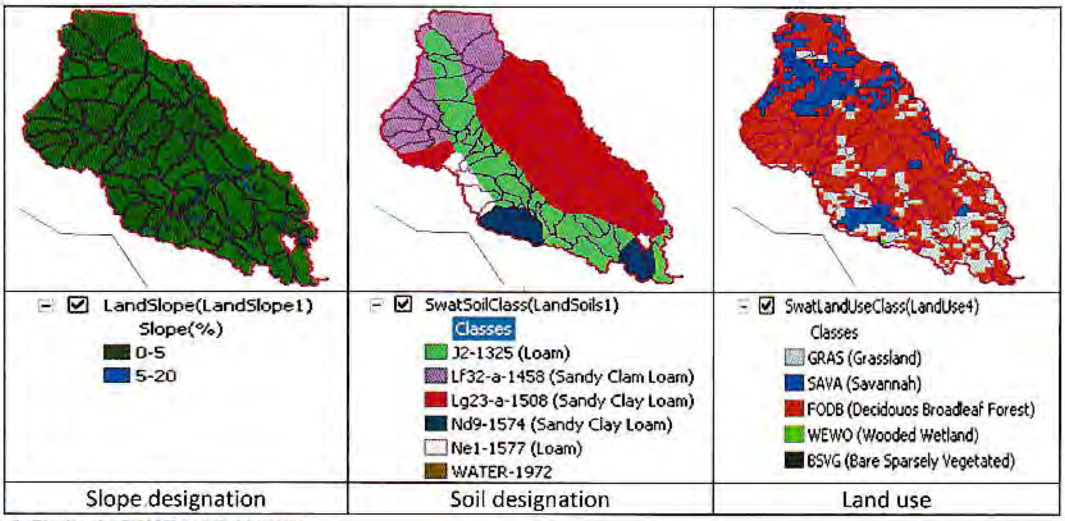



Figure 6. Zio basin SWAT model inputs.

In addition preliminary water balance components were computed for the two river basins using the SWAT model (Figure 7). The Water Evaluation and Planning Tool (WEAP) is being used to deduce allocations of the water resources in the landscape. The water balance components (Figure 7) reveal that evapotranspiration plays a big role in the basin. Based on field observations and modelled results, the contribution of groundwater in this basin is quite significant. For example, with the exception of 1985, 1988 and 1990, model results revealed that groundwater discharge was consistently higher than surface water discharge over a period of 32 years for the Zio river basin. This reveals the need for optimization and judicious management of the excess water resources in the basin which if not well managed results in low water productivity values. The SWAT model outputs will be linked to the WEAP model for allocations and scenarios analysis.

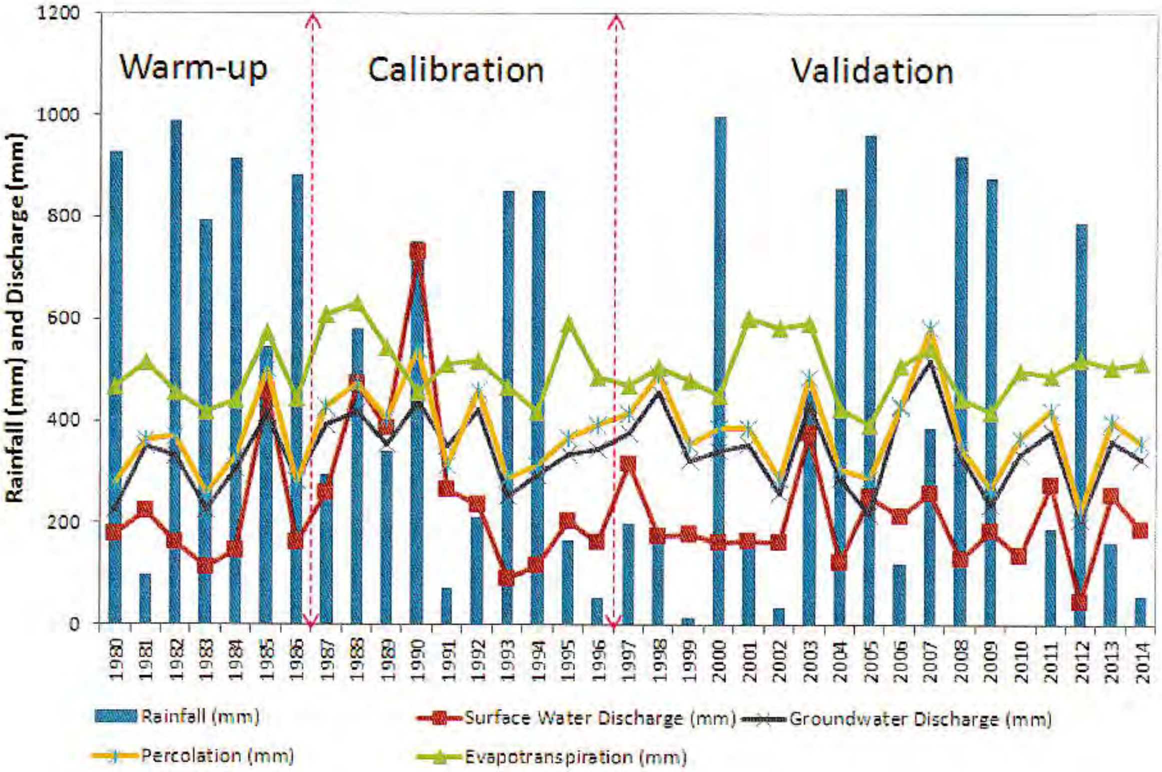



Figure 7. Water balance components for the Zio river basin in Togo.

Moreover, National level food consumption data required for running the PODIUMSIM model have been partially gathered during the reporting period. These efforts will be intensified during the next year.

### 2.2.3 Planned Activities 2012-13

The specific activities planned for the period under Work package 1 (Modelling basin level impacts of up-scaling Sawah technology) are:

- Baseline characterization of the Zio river basin in Togo and Ouémé river basin in Benin and
- Data gathering

The planned activities for the reporting period under Work package 3 (Modelling water and food future of Benin and Togo) were mainly estimating national food consumption levels, which entails gathering information on urban and rural population (and its growth rates), daily calorie supply and percentage of contributions from different dietary sources, per capita food consumption differentiated by types, and feed conversion ratios.

# 3 Rice productivity enhancement through soil and water management in SSD

## 3.1 Introduction

The sections below provide this year's achievements on research on soil and water management for SSD. The results of this work will support development activities and impact assessment.

## 3.2 Agronomy and soil fertility research

The agronomy and soil research is responsible for three output targets:

1. Wetland soil fertility map;
2. Fertility Capability Soil Classification System (FCC) in relation to rice productivity;
3. Plant nutrient management options against abiotic stresses such as drought (water deficiency) and iron toxicity;

These output targets are not restricted to the discipline of soil fertility and agronomy but include some links to other disciplines such as water management and hydrology.

***Output target 1: Wetland soil fertility map***

Soil fertility is one of the important factors determining rice productivity. To scale-up Sawah System Development from site level to regional or country level, soil fertility characteristics have to be assessed to cover a wide area of wetland regions in Benin and Togo. A preliminary soil survey was conducted to assess geographical distribution of soil fertility parameters over the country of Benin. Soil samples were collected from 25 different locations of lowlands (either inland valleys or floodplains) in Benin (See the map and table below for the locations of sampling).


| ID No. | Location Name | Commune Name |
|---|---|---|
| 1 | Deve | Lokkosa |
| 2 | Zadogagbe | Zadogabe |
| 3 | Korobororou | Parakou |
| 4 | Orokoto | Glazoue |
| 5 | Zougo | Unknown |
| 6 | Ayize | Ouinhi |
| 7 | Koussin | Cove |
| 8 | Zongoudou | Agbanigzoun |
| 9 | Loule | Dassa |
| 10 | Odochele | Dassa |
| 11 | Gome-ifada | Dassa |
| 12 | Kandi | Kandi |
| 13 | Malanville | Malanville |
| 14 | Sori | Sori |
| 15 | Ndali | Ndali |
| 16 | Okoutaosse | Bante |
| 17 | Kodowari | Bassila |
| 18 | Materi | Materi |
| 19 | Tiele | Tanguieta |
| 20 | Tampegre | Tokountouna |
| 21 | Wanrarou | Bembereke |
| 22 | Kommon | Banikoura |
| 23 | Beket-bourame | Kouande |
| 24 | Tannou | Aplahoue |
| 25 | Dkandji | Dogbo |

Figure 8. Locations where soil samples were collected in Benin.

***Output target 2: Fertility Capability Soil Classification System (FCC) in relation to rice productivity***

The essence of FCC is to interpret soil taxonomy and additional soil attributes in a way that is directly relevant to plant growth (Sanchez et al., 2003). This study examines adaptability of FCC to wetland rice farming in Benin and Togo. Extensive soil survey as well as rice yield assessment is necessary in this study.

***Output target 3: plant nutrient management options against abiotic stresses such as drought (water deficiency) and iron toxicity***

Plant nutrition management is an effective option to alleviate some abiotic stresses in rice. This study will study the influence of silica (Si) on major abiotic constraints (i.e., drought and iron toxicity) in inland valley rice farming systems. Future study may include sulphur (S) as another interesting element for the fight against iron toxicity in rice. In a preliminary pot experiment, a positive effect of silicon (Si) application on mitigating drought stresses was observed (Figure 9).

**Bouake189, -Si under drought** **Bouake189, +Si under drought**

Figure 9. Rice plants (cv. Bouake 189) with silicon application (right) and without silicon application (left) under drought.

### 3.2.1 Major achievements Agronomy and soil research year 3 (2011-12)

The achievements are summarized in the table below.

**Table 2: Output targets and their achievement degrees 2010–2011 in the agronomy and soil research section.**

| No. | Output Target | AS* | Comments |
|---|---|---|---|
| **OT 1** | Wetland soil fertility map. | B | Soil samples were collected from 25 inland valleys/floodplain in Benin for the bioassay and laboratory analysis. The analysis in undergoing. |
| **OT 2** | Fertility Capability Soil Classification System (FCC) in relation to rice productivity. | C | Reconnaissance was made over 32 inland valleys, while detailed soil survey plan is still under discussion. |
| **OT 3** | Plant nutrient management options against abiotic stresses such as drought (water deficiency) and iron toxicity. | B | The pot experiment was conducted. Silicon (Si) application relieved plant damages by drought. |

* Achievement Score (AS) is given by the scores: A, achieved; B, in progress; C, in preparation

### 3.2.2 Prospects agronomic and soil Research for year 4 (2012-13)

For OT 1 and 2, soil sampling will be continued and their analyses will be made; assessment tools for soil fertility will be developed. For OT 3, management options will be developed and tested in the field conditions.

## 3.3 Field experiment in Bamé: preliminary results and outlook

### 3.3.1 Status of the experiment

#### Introduction

The field experiment in Bamé is currently in its fifth season (see Table 3). This will be the last season of data collection and thereafter the site will be changed into a development site.

Data collection is on-going and all data on measurements and observations are stored in a central data base. The weather station is continuously collecting measurements on air temperature, relative humidity, incoming shortwave radiation and wind speed and direction.

Data analysis has started this year with respect to nutrient uptake and nutrient use efficiency. Preliminary results are presented in the following paragraph (3.3.4). After the harvest in December the data base will be completed and further data analysis will be conducted regarding the impact of water management on soil fertility, rice yields and productive use of water and nutrient resources. Grain quality is considered an important aspect for market access and laboratory analysis will be conducted to reveal the impact of SSD on grain quality parameters. The dry and wet season of 2012 will be considered.

There are four publications foreseen as outcome of this experiment:

1. *The effect of bunding and irrigation management on soil fertility and rice yields along a toposequence*
   Tognite, Zwart, Walter, Schmitter
2. *The impact of improved irrigation management on rice yield and water productivity*
   Schmitter, Zwart, Danvi, Akponikpe
3. *Calibration of AquaCrop for rice in an irrigated inland valley in Benin*
   Schmitter, Klaus, Zwart
4. *Grain quality of NERICA-L19 as affected by irrigation and soil fertility management*
   Manful, Zwart, Schmitter

Table 3. Cropping seasons in Bamé research site.

| season | | transplanting | harvest | remarks |
|---|---|---|---|---|
| **Season 1*** | wet | Sep 9, 2010 | Dec 20-28, 2010 | • soil chemical properties assessed before start of cultivation (240 samples analysed)**<br>• soil physical properties assessed for 48 samples |
| **Season 2** | Dry | Feb 17, 2011 | Jun 6-14, 2011 | |
| **Season 3** | wet | Aug 19, 2011 | Dec 15-21, 2011 | |
| **Season 4** | Dry | Feb 27, 2012 | Jun 24, 2012 | • soil chemical properties assessed directly after harvest of rice (240 samples analysed)<br>• plant chemical properties assessed (240 samples analysed) |
| **Season 5** | wet | Aug 25, 2012 | on-going | • harvest planned for December |

* Errors were made in fertilizer application during the season, cannot be used.

** See Figure 14 for the location of the analysed samples

### Experimental layout

Each sub-plot (i.e. plot with a certain fertilizer treatment within the water management treatment) had a total surface area of 100 m$^2$ and was irrigated and drained separately. In order to avoid fertilizer contamination each field was bunded (1m). Bunding was done as well for the traditional treatment in order to estimate the total amount of water irrigated. However, the outlet was never closed during the experiment so that a standing water layer was avoided. All fields in all treatments were ploughed twice by power tiller and levelled in order to reduce the number of possible factors influencing rice performance. The rice variety NERICA-L-19 was chosen for all fields and transplanted with 25 cm spacing (Table 1). Weeding was done twice manually (2 weeks after transplanting and once around maximum tillering). The first rice season was situated partly in the rainy season while the second season was started in the dry season.

Mineral fertilization: two fertilizer treatments were applied within each treatment of water management to assess the absorption of fertilizers under these conditions. Two rates were considered control plots with no fertilizer and plots were fertilizers was applied at the amounts of 109 kg/ha of N, 18 kg/ha of P and 17 kg/ha of K. The same treatment was applied whatever the season (dry and wet season).

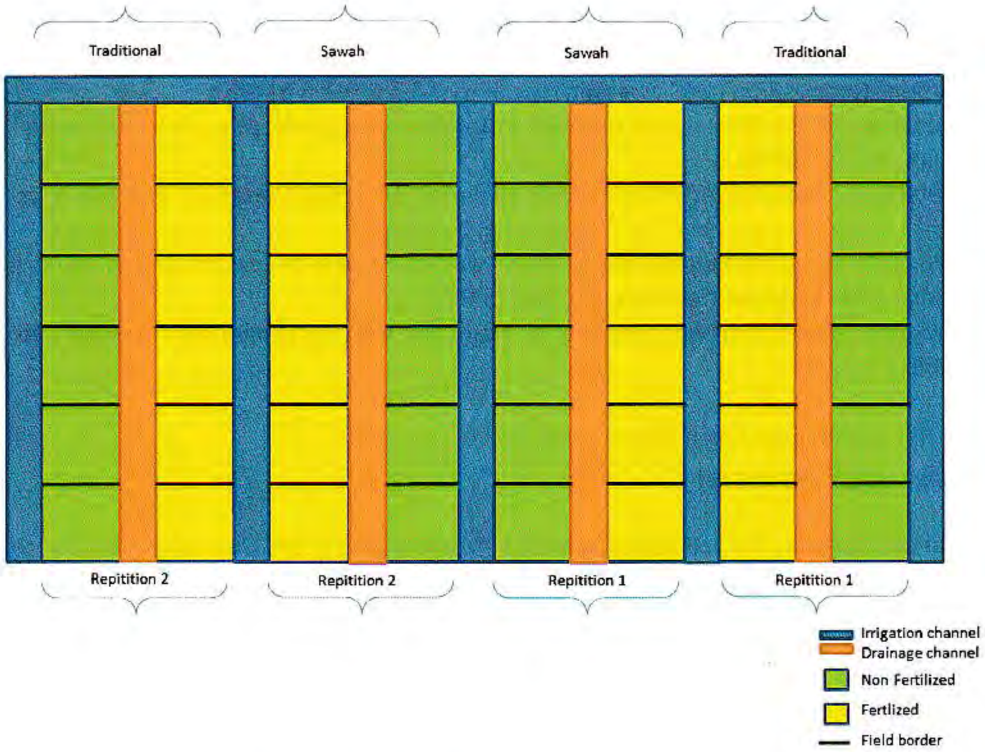



Figure 10: Schematic representation of the experimental set up.

### Measurements and observations

Plant and soil sampling was conducted in a regular grid. Nine points of $1m^2$ were defined in each 10x10m field according the following layout:

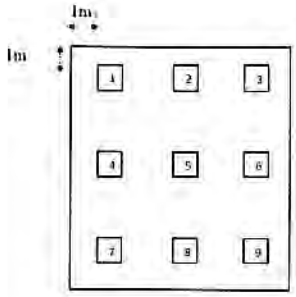



Figure 11. Overview of sampling location within a 10x10 meter field. The sampling locations are at 1m from the border of the field.

The following measurements and observations regarding soil and plants have been taken:

- **Soil texture** was determined only for the central point 5 (n=48)
- **Soil chemical compositions** was assessed for points 2,4,5,6 and 8 (n=240)
- **Water balance** was monitored for each field: irrigation water application, drainage, rainfall, evapotranspiration (n=48)
- **Plant development** was observed and recorded during the season: height, tillers, SPAD, panicles (n=456)
- **Rice yield, yield components and total biomass** was assessed in all seasons and all points (n=456)
- **Total paddy grain yield per field** was assessed (n=48)
- **Plant chemical composition** was assessed for grains and biomass separately in season 4 for points 2,4,5,6 and 8 (n=240)

**Soil texture** (for soil samples taken before the experiment, n=48):

- percentage clay, loam and silt

**Soil chemical composition** (for soil samples taken before the start of the experiment and for soil samples taken directly after season 4, n=240):

- total N (g/Kg)
- P (ppm or mg/Kg) - Bray
- pH(H2O) 1:1
- Fe (ppm)
- Ca (cmol+/Kg)
- Mg (cmol+/Kg)
- Na (cmol+/Kg)
- exchangeable K (cmol+/Kg)

**Plant chemical composition** (for grain and green biomass samples of season 4, n=240):

- % N
- % P
- % K
- ppm Fe

**Grain quality** (n=48)

- Milling parameters:
  - Brown rice yield
  - Milled rice yield
  - Levels of brokens
- Grain dimensions
- Grain hardness
- Pasting properties
- Cook rice properties
- Chalkiness
- Protein content
- Amylose content

Soil and plant chemical analysis was conducted in the soil laboratory of IITA in Ibadan.

Soil texture analysis was conducted in the soil laboratory of AfricaRice in Cotonou.

Grain quality will be conducted at the grain quality lab of AfricaRice in Cotonou.

### 3.3.2 Soil physical and chemical properties

Forty eight central samples were analyzed for particle size. Composite samples were taken at 0 -15 cm depth. The results show that there is little variation in soil texture (Table 4). The soils are highly sandy and are classified according to USDA soil classification as sandy, loamy sand or sandy loam (Figure 12).

Table 4. Average descriptive statistics of particle size classes (n=48)

| | mean | standard deviation |
|---|---|---|
| Clay (%) | 7.2 | 3.3 |
| Sand (%) | 86.1 | 5.6 |
| Silt (%) | 6.7 | 3.5 |

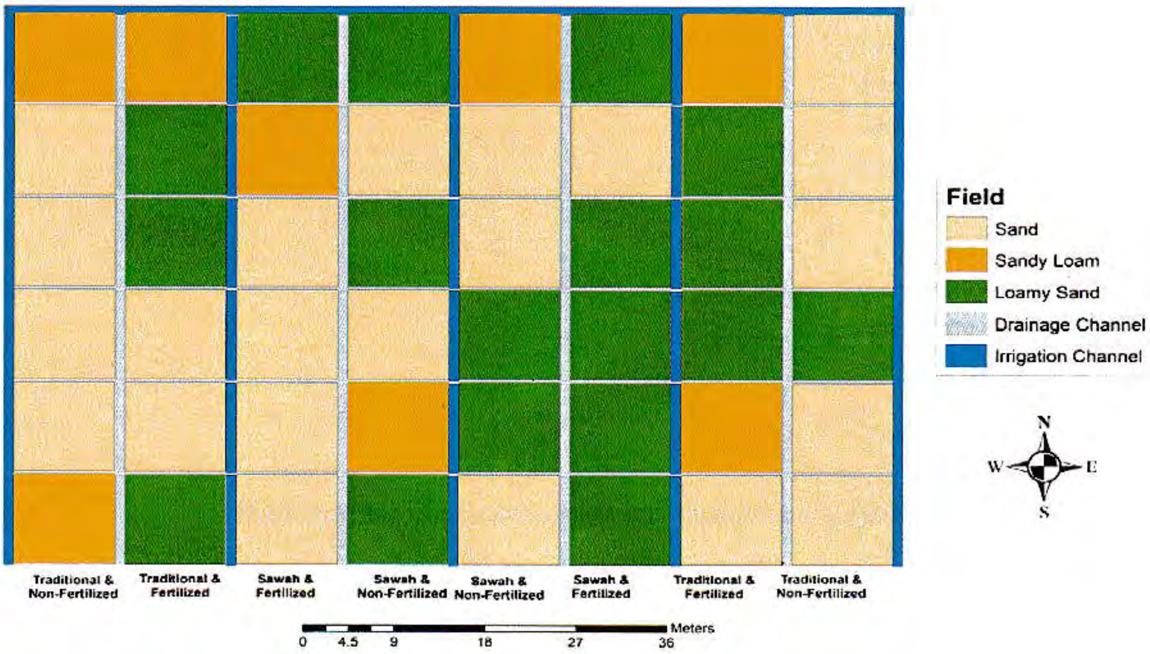



Figure 12. Soil texture map based on United States Department of Agriculture (USDA) soil texture triangle.

Table 5. Average soil chemical properties of the research site in Bamè (n=48) compared to a Ghanaian lowland and an average of paddy fields in South East Asia.

| Parameters | Mean | Range | St. Dev. | Ghanaian lowland | Paddy's in SE Asia |
|---|---|---|---|---|---|
| pH($H_2O$) | 5.5 | 4.3 - 8 | 0.6 | 5.2 | 6.0 |
| Organic Carbon (g/kg) | 8.6 | 3.1 - 16.3 | 2.7 | | |
| Total Nitrogen (g/kg) | 0.76 | 0.2 - 1.5 | 0.3 | 0.88 | 1.30 |
| C/N | 11.8 | 4.6 - 23.6 | 1.96 | | |
| Organic Matter MO | 1.5 | 0.5 - 2.8 | 0.46 | | |
| Available P (mg/kg) | 27.2 | 1.8 - 62.9 | 13.2 | 3.2 | 17.6 |
| Exchangeable K (cmol+/kg) | 0.22 | 0.04 - 0.7 | 0.09 | 0.3 | 0.4 |
| Exchangeable Ca (cmol+/kg) | 2.2 | 0.60 - 15.6 | 1.3 | 4.8 | 10.4 |
| Exchangeable Mg (cmol+/kg) | 0.33 | 0.10 - 0.9 | 0.1 | 2.5 | 5.5 |
| Exchangeable Na (cmol+/kg) | 0.1 | 0.04 - 0.3 | 0.04 | | |
| Available Fe (mg/Kg) | 221 | 140 - 274 | 29.5 | | |
| Clay (g/kg) | 72 | | | 97 | 280 |

These soils are very acidic: soil pH ranged from 4.3 to 8 with a mean of 5.5. Figure 13 shows the distribution of soil organic carbon (SOC) on the site of Bamè, according to the results of laboratory analysis. About 63% of the soil organic carbon values are greater than 10 g/kg and only 7.5 % of the values are below 5 g/kg. The maximum SOC level in these soils is 16.3 g/kg. In general organic carbon levels were quite low (average of 8.6 g/kg). This translated into lower total nitrogen levels (average of 0.8 g/kg). Available phosphorus (P) in Bamè was on average 27.2 mg/Kg, and P does not seem to be a limiting factor.

Table 5 also shows a comparison of soil properties (pH, organic Carbon, total Nitrogen, available Phosphorus, exchangeable Potassium, exchangeable Magnesium, exchangeable Calcium and clay content) determined at Bamé compared to Ghana lowlands and South East Asia paddy fields. Soils at Bamé site have lower levels of clay and are low in most nutrients compared to Ghana lowlands soils and paddy fields of South East Asia.

### 3.3.3 Impact of sawah and traditional treatments on grain yields.

The following figure show the effect of different factors taken into account on rice grains yield in the four seasons. It show mean values of the two dry season and two wet season according to water treatment and fertilizers. It summaries average yields obtained while these treatment are applied.

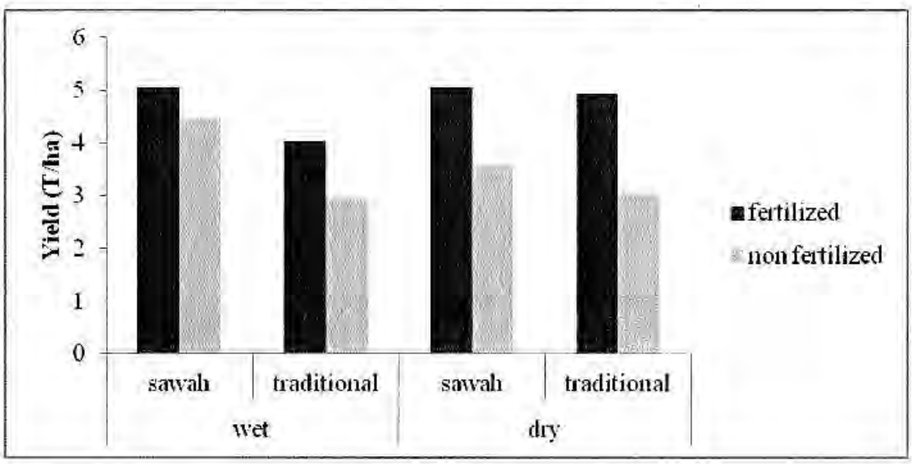



Figure 13. Effect of treatments on yields per season.

There is no significant difference between the observed yields in both dry and wet seasons. With regard to water management, when comparing all seasons there was a highly significant difference between the sawah system and the traditional. The average yields obtained in sawah system is significantly higher than that obtained in traditional system. The average performance at Bamè site is 4.2 t/ha paddy rice so an average of 2.7 t/ha milled rice for both dry and wet season and can reach a maximum of 9.3 t/ha as paddy yield (6 tons/ha of milled rice) at 14% humidity regardless of the season, observed in the sawah system.

As observed in Figure 13, water management treatment has a significant effect on yields especially in the wet season where the difference is clearly marked between the sawah system, the most productive and the traditional system. In addition, the contribution of fertilizer is presented here as an important factor as well as management of water. The contribution of fertilizers positively affects yields when we are in the traditional system, regardless of the growing season. The difference between sawah and traditional systems does not appear especially in dry season. In wet season, the effect of the contribution of fertilizer is not noticeable on yields in the sawah system.

### 3.3.4 Nutrient uptake of rice under sawah and traditional treatments

#### Introduction

This section presents the first results of analysis on soil fertility, nutrient uptake and nutrient use efficiency and the impact of SSD.

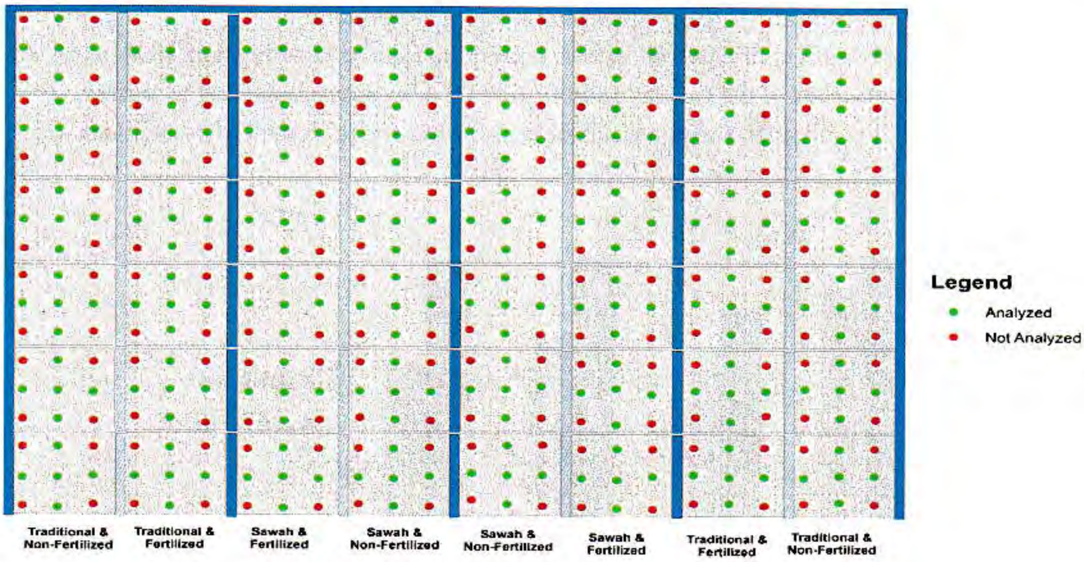



Figure 14. Map of Bamè showing analysed corners.

#### Nutrient uptake by rice straw

The table 6 shows the average uptake of nutrients by straw regardless applied treatments. Nitrogen uptake was on average 22.2 kg/ha ranging from 5.5 to 80.8 kg/ha. Phosphorus ranged from 0.7 to 17Kg/ha with a mean value of 4.1 kg/ha while potassium uptake was an average of 65.3 kg/ha ranging from 16.4 to 165 kg/ha.

Table 6. Average nutrients uptake by straw, grain and total by plant at Bamè (n=240)

| Nutrients | Straw | | | Grain | | | Total by plant (Grain+Straw) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Range | SD | Mean | Range | SD | Mean | Range | SD |
| N | 22.2 | 5.5 - 80.8 | 12.6 | 40.9 | 11.8 - 91.5 | 17.3 | 63.1 | 18 - 148 | 26.4 |
| P | 4.1 | 0.6 - 176 | 2.75 | 10.4 | 3.5 - 23.2 | 3.8 | 14.6 | 4.7 - 32.6 | 5.6 |
| K | 65.3 | 16.4 - 165 | 28.62 | 13.0 | 3.1 - 29.2 | 5.0 | 78.3 | 22.5 - 194 | 31.8 |
| Fe | 0.7 | 0.1 - 3.6 | 0.5 | 0.3 | 0.1- 0.8 | 0.1 | 1.1 | 0.2 -3.9 | 0.6 |

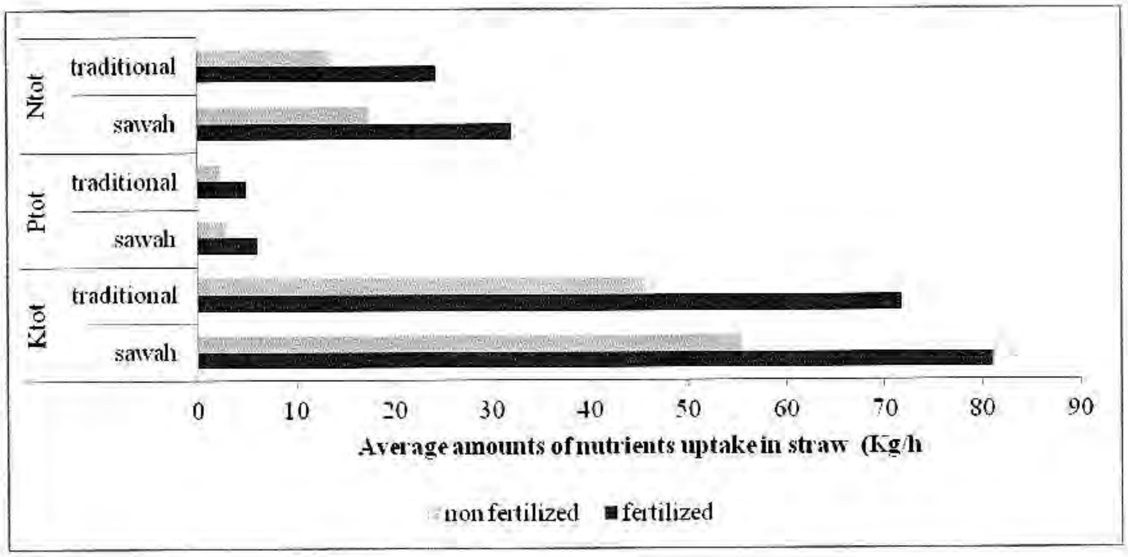



Figure 15. Nitrogen N, phosphorus P and potassium k uptake by straw.

A significantly higher nutrient N, P and K uptake is observed in the sawah system as compared to the traditional system. Under the sawah system an average nitrogen uptake of 24.8 kg/ha for sawah and 19.5 kg/ha for traditional during the fourth season is recorded. The amount of Phosphorus uptake under sawah system is 4.5 kg/ha while it is 3.8 kg/ha in the traditional. Potassium uptake is 70.5Kg/ha under sawah and 60.0 kg/ha under the traditional system.

There is also a highly significant difference between fertilized and non-fertilized plots. It is obtained 15.6 Kg/ha, 2.61 Kg/ha and 50.7 Kg/ha in average for non -fertilized respectively for N, P and K. While fertilized plots recorded an N, P, K uptake of respectively 28 kg/ha, 5.5 kg/ha and 70.3 kg/ha. The analysis of variance shows also a significant effect of toposequence on nutrients uptake (Tables 23 to 25). But interaction between these factors is no significant. According to Figure 15, higher nutrients uptake are recorded in the sawah system and also when there is fertilizers addition.

It is also important to note that the effect of water management is no significant on iron uptake by straw. Table 26 shows that there is no significant difference between sawah and traditional plot for iron uptake. But a significant difference is observed with fertilizers addition. Then, an amount of 0.6 Kg/ha in fertilized plots and 0.9 Kg/ha in non- fertilized in average are recorded Figure 15 show differences observed according to different management.

The effect of toposequence on nutrients uptake by straw is observed. There a highly significant difference of nutrients N, P, K and Fe according to the toposequence and it is noticed that the highest values of nutrients uptake are obtained on the first level, the highest while there is variability between the other levels.

**Nutrients uptake by grain**

The above table presents the amount of nutrients N, P, K, and Fe taken up by grain at the fourth season regardless different management. Globally, nitrogen uptake in average at Bamè is 40.9 kg/ha and ranged from 11.78 to 91.5 kg/ha with a standard deviation of 17.3 kg/ha. Mean values of P uptake is 10.4 kg/ha ranging from 3.46 to 23.2 Kg/ha with a standard deviation of 3.8 kg/ha. According to K uptake the mean value is 13.0 kg/ha and ranged from 3.13 to 29.2 kg/ha with a standard deviation of 5.05kg/ha. Fe uptake is an average of 0.3 kg/ha ranging from 0.1 to 0.8 kg/ha with a standard deviation of 0.1 kg/ha. Nitrogen and Phosphorus uptake by grain are higher than in straw. While the amounts of Potassium and Iron are higher in straw than in grain.

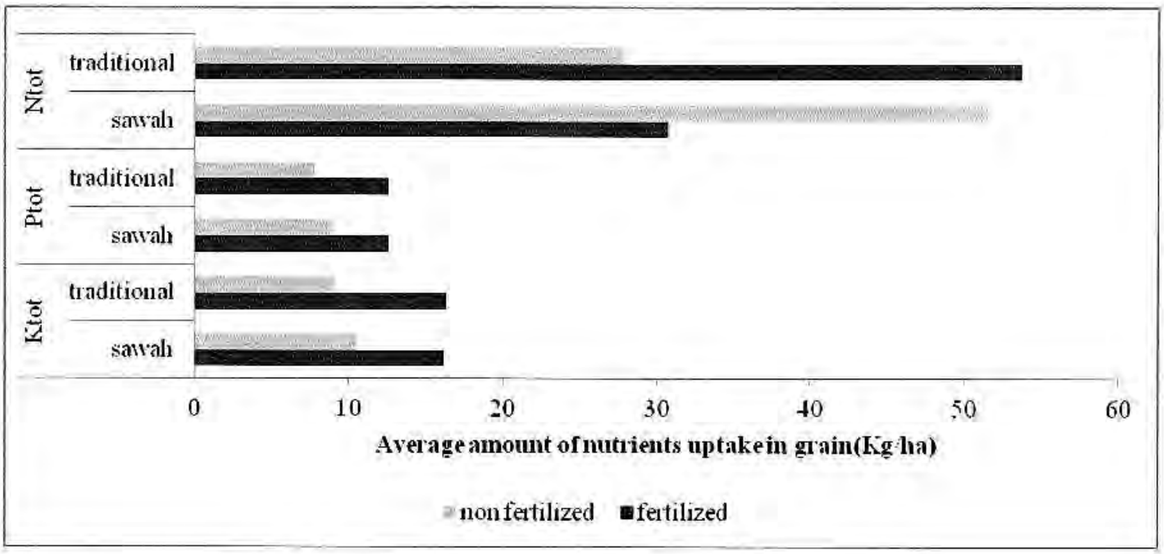



Figure 16. Effect of water management and fertilizers use on nutrients uptake by grain.

This figure shows the compared effect of the sawah and the traditional systems combined with fertilizers use on the uptake of nutrients N, P and K. Sawah fertilized plots and those traditional provide closest values while the amount of nutrients absorbed in the same system of water management is different with fertilizers addition. Fertilizers increased nutrients N, P, and K uptake by grain. This is proved by statistical analysis while comparing means value of nutrients uptake obtained in different management.

The tables 27 to 29 present the amount of Nitrogen, Phosphorus and Potassium absorbed by grains at fourth season. Statistical analysis shows no significant difference of these values according water management. Although in the sawah an amount of 41.1 Kg/ha is recorded while in traditional system an amount of 40.7 Kg/ha is obtained. According to Phosphorus there is a slight increase from 10.1 to 10.7 Kg/ha from traditional to sawah. With Potassium, it is obtained 13.4 and 12.7 Kg/ha for respectively sawah and traditional. The effect of toposequence is also not significant on these nutrients in grain. The effect of fertilizers is revealed highly significant according to this trial. Fertilized plots provide an average 52.6 Kg/ha when on unfertilized plots the amount is 29.3 Kg/ha for Nitrogen. P uptake increase from 8.3 to 12.5 Kg/ha respectively in fertilized and unfertilized plots. And K uptake is 9.8 to 16.2 Kg/ha for respectively non fertilized and fertilized plots on average.

**Total nutrients uptake**

The table above (Table 6) shows the average amount of nutrients N, P, K and Fe taken up by rice regardless different management at Bamè. An average of 63.1 $\pm$ 26.4 Kg/ha of Nitrogen is absorbed ranging from 18 to 148.4 Kg/ha. Phosphorus uptake is 14.6$\pm$ 5.6 Kg/ha and ranged from 4.7 to 32.6 Kg/ha. Plants absorbed an amount of Potassium of 78.3$\pm$31.8 Kg/ha ranging from 22.5 to 194. Iron uptake is 1.1$\pm$0.6 Kg/ha and ranged from 0.2 to 3.9.

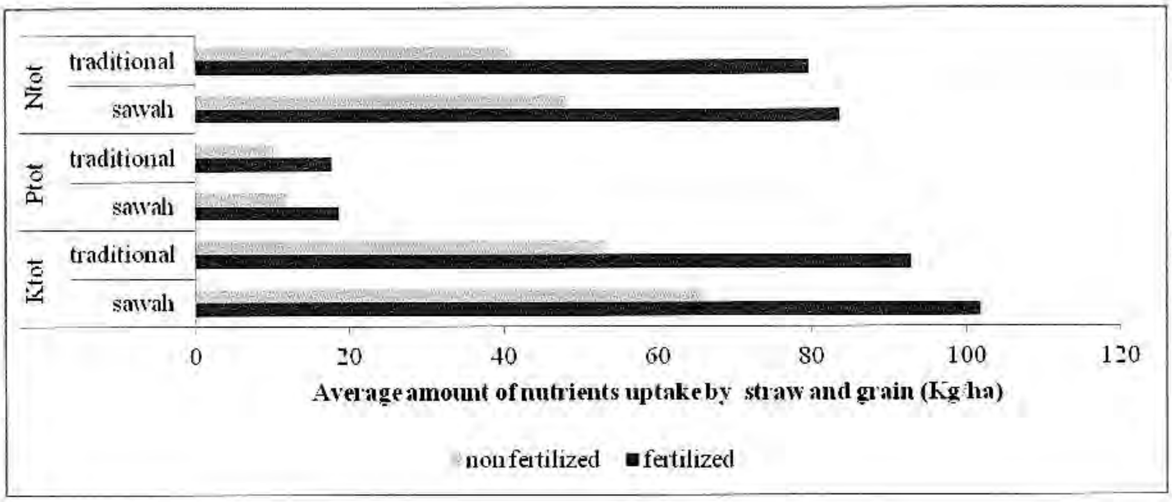



Figure 17. Effect of water management and fertilizers use on total nutrients uptake by plants.

Figure 17 shows the amount of nutrient N, P, and K uptake according to the sawah system compared to the traditional with fertilizers addition at the fourth season. There is an increasing of nutrients absorbed when moving from the traditional to sawah. The same growth is clearly marked with the contribution of fertilization. Statistical analysis gave the same results as observed on this figure.

A significant effect of different management on nutrient uptake by rice is observed. It is noticed that the adoption of the sawah system provides significantly an increase of nutrients uptake (Tables 31 to 33). Nitrogen uptake in the sawah is 65.9 and is 60.3 traditional. The sawah provides 15.2 Kg/ha and 83 Kg/ha respectively for Phosphorus and Potassium while traditional treatment depicted 13.9 Kg/ha and 72.8 Kg/ha respectively. This means that the sawah system gives benefits for rice culture in term of nutrients uptake. The effect of fertilizers is highly significant and proves the importance of addition of fertilizers. It is obtained respectively 44.6 Kg/ha, 11Kg/ha and 59.4 Kg/ha respectively for N, P, and K on no fertilized plots. Those which received fertilizers provides in average 81.7 Kg/ha, 18.2 Kg/ha and 97.3 Kg/ha respectively for N, P and K. Toposequence also impacts significantly these results as shown by analysis of variance. This means that improving of this system while eliminating the effect of the toposequence observed at Bamè could enhance nutrients uptake and then the productivity. The effect of interaction between these factors is no significant for all nutrients.

**Impact of different water management on Iron uptake**

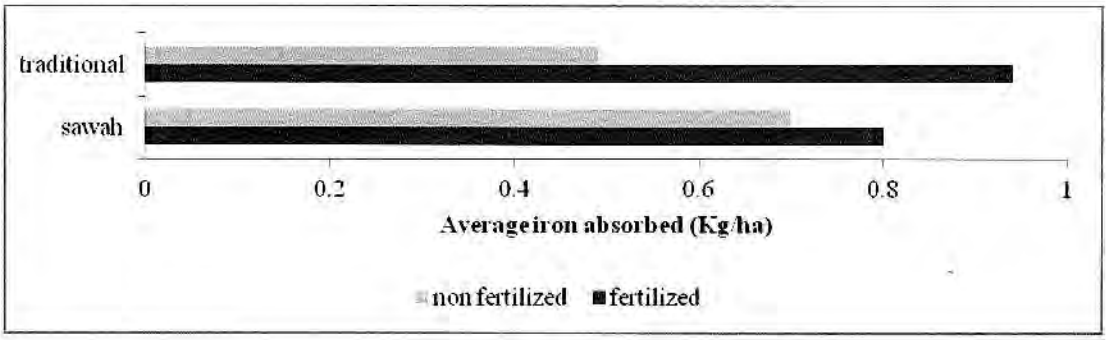



Figure 18. Iron Fe uptake by straw.

This figure presents the average values of iron absorbed by rice straw at fourth season. Ferrous iron absorbed by straw is an average of 0.5. This value ranged from 0.11 to 3.6 Kg/ha. In fertilized plots, the iron is more absorbed by the traditional system than the sawah. But in non-fertilized plots, the sawah depicted higher iron uptake than the traditional system.

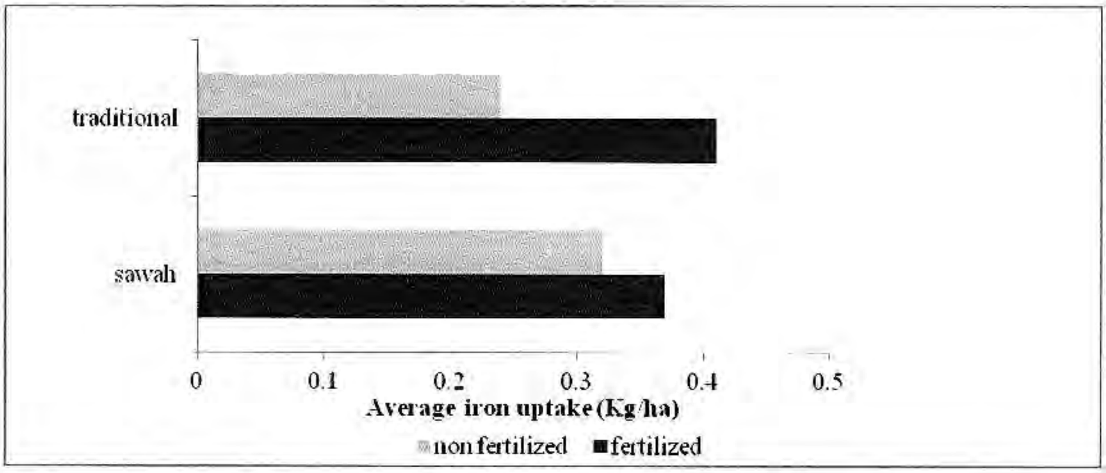



Figure 19. Compared effect of sawah and traditional with fertilizers use on iron uptake by grain.

This figure shows the compared effect of the sawah and the traditional systems combined with fertilizers use on Iron uptake. It is observed that fertilized plots recorded higher values. While those not fertilized are the lowest value. The highest average value is obtained under the traditional system fertilized.

Iron uptake is also analyzed for ANOVA (Table 30) and revealed a highly significant effect of fertilizers. It is recorded 0.4 for fertilized plots and 0.3 for the other one. Sawah plots provide 0.3 and traditional one 0.3 Kg/ha. The interaction between water management and fertilizers use is also significant and show the importance of both water management and fertilizers on iron uptake.

### 3.3.5 Major achievements water management year 3 (2011-12)

- Trials have been successfully continued in the wet and dry season in the Bamé experimental site; two harvests have been made and a fifth and final season is started.
- Nutrient use efficiency and nutrient uptake have been researched and rice cultivation under sawah system has been proven to greatly enhance productive use of fertilizer resources.
- Three students were trained by doing research in in the research site of Bamé.

### 3.3.6 Prospects water management for year 4 (2012-13)

- The wet season trial started in August 2012 is expected to finish in December. Observations and measurements will be collected and the data base of 5 seasons of trials will be completed.
- The productive use of nutrients and water resources will be further investigated using the existing data base and a crop growth model (AquaCrop).
- Grain quality is of great importance for the farmers; access to the market. It is expected to be affected by water management and soil fertility practices. The following parameters will be analysed:
  - Milling parameters:
    - Brown rice yield
    - Milled rice yield
    - Levels of brokens
  - Grain dimensions
  - Grain hardness
  - Pasting properties
  - Cook rice properties
  - Chalkiness
  - Protein content
  - Amylose content
- Depending on the results of the analysis three to four publications will be submitted on the following topics:
  - soil fertility and nutrient uptake
  - AquaCrop model validation
  - grain quality improvement under SSD
  - SSD for improved rice yields

# 4 Socio-economic determinants for SSD and impact assessment

## 4.1 Introduction

Rice is the most important food crop of the developing world and the staple food of more than half of the world's population. Worldwide, more than 3.5 billion people depend on rice for more than 20% of their daily calorie intake (IRRI, AfricaRice and CIAT, 2010). In Africa, rice consumption is increasing at a rate of 5.7% (1980 to 2009). Local production of the continent is largely insufficient to meet the demand. This caused a gap of nearly 9.8 million tons in 2009 (or 37% of its consumption) mainly satisfied by imports (AfricaRice, 2011). In Sub Sahara Africa (SSA), there is a big rice yield gap between attainable and actual farm yield (in 2009, yield was 2.57 t/ha while it was about 8-10 t/ha in Asia and Egypt).

Inland valleys lowlands represent a huge potential for increasing both rice productivity and production, especially with the increasing erratic rainfall due to the climate changes. However, improvement of water control is a pre-condition for enhance and sustain rice productivity in inland valleys. Sawah System Development (SSD) is an opportunity for rice intensification due to improved water control and soil fertility management. Sawah based rice farming can overcome soil fertility problems through the enhancement of the geological fertilization process, conserving water resources. Sawah system is a man-made improved wetland basin with bunding, levelling, and puddling for rice cultivation. The potential of Sawah based rice farming is enormous in SSA. Among the 250 million ha of lowlands in SSA, about 10% (20 million ha) are estimated as appropriate sites for sustainable irrigated Sawah based rice farming (Wakatsuki et al., 2011). Ten to twenty million ha of sawah can produce additional food for more than 300 million people in future.

Based on this potential of the Sawah, the overall objective of the SMART-IV project is to explore the potential of the Sawah system for increasing rice productivity in inland valleys in West Africa, while improving farmer's access to markets and rice technologies. The SMART-IV project is implemented through four work packages: water and soil management, GIS, Socio-economy and development activities. The overall objective of socio-economic aspects is to identify factors driving massive adoption of Sawah System Development (SSD) and assess socio-economic impact of Sawah system for the purpose of improving livelihood of smallholder producers. This section of the annual report presents the achievements of the socio-economic work package during the year 2011-2012.

## 4.2 Activities during the period 2011-2012

**Development of the work plan**

After two years of field testing the performance of the Sawah system, development activities started with the expansion of Sawah system in different villages of Benin and Togo. Related to this development a work plan was elaborated for the socioeconomic work package. The work plan is elaborated for the remaining period of the project (Table 1). Baseline surveys (EC.02 and EC.03) were planned as the main activity schedules for the year 2012. The objectives of the baseline survey are threefold: to understand socio-economic conditions of the development sites of the SMART-IV project; to determine factors that will help adoption of the Sawah System Development (SSD) by rice producers; and to serve as reference for impact assessment of the SSD. In2013, farmers' perceptions of the Sawah system will be analysed after three growing seasons and ex-ante adoption rates of SSD in inland valleys by rice producers will be assessed. A proposal for market access will be also executed (EC.06). In the last year of the SMART-IV project, early impact assessment of the SSD on smallholder livelihoods will be completed.

Table 7. Planned socio-economic activities 2012-14.

| ID | Activities | Period |
|---|---|---|
| **EC.01** | Participate in the selection of demonstration and development sites (region and villages/inland valleys) of SMART-IV project focusing on the "Rice Sector Development Hubs" approach and in collaboration with other disciplines in the project. | **2012** |
| **EC.02** | Design and execute the baseline survey in the demonstration and development sites of SMART-IV project (taking into account socio-economic conditions, land tenure systems, labor availability and use, traditional soil and management, productivity, market assess, etc.) | **2012** |
| **EC.03** | Supervise MSc student on the topic 'Resources and technologies use for rice production in inland valleys: soil and water management practices and adoption of good agricultural practices for rice production'. | **2012** |
| **EC.04** | Design a survey on investment and farmers' perception of enablers and constraints of Sawah System Development (SSD) | **2013** |
| **EC.05** | Analysis of willingness to adopt / Ex ante adoption or potential adoption rate of SSD in IV by rice producers | **2013** |
| **EC.06** | Market opportunities and constraints and consumer preference and demand for inland valley rice in Benin and Togo assessed through a survey on contract farming (production contract and business contract) to improve resource use and market assess | **2013** |
| **EC.07** | Impact assessment of SSD adoption on productivity, food security and farmer income | **2014** |
| **EC.08** | Ex-ante impact assessment of SSD on regional rice production in Benin and Togo (maybe in coastal West Africa region: Benin, Ghana, Nigeria and Togo) | **2014** |

### Baseline survey

The baseline survey in the development sites started during the reporting period. The questionnaire design and sampling proposal were completed. Two questionnaires were developed and standardized with the NARS partners in Benin and Togo. The first questionnaire is the village level structured questionnaire divided in 12 modules. The second questionnaire is divided into two parts: a core producer questionnaire with 15 modules and the agronomy questionnaire with 10 modules. The modules of the questionnaires are summarized in Table 2.

Table 8. Modules of the developed questionnaires for baseline survey.

| Villages modules | Producer core modules | Agronomy modules |
|---|---|---|
| Identification of rice ecologies in the village | Prior information on the survey | Seed choice and management |
| Identification of varieties introduced in the village | Identification and socio-demographic structure of the household | Land preparation |
| Community-based evaluation of varieties grown | Evaluation of rice productivity constraints | Crop establishment |
| Community-based evaluation of known imported rice | Knowledge, use, access and management of rice varieties | Weed management |

| | | |
|---|---|---|
| Community-based appreciation of varieties grown | Information on farmers' plots | Soil fertility management |
| Evaluation of rice productivity constraints | Agricultural practices | Water management |
| Village infrastructure | Information on rice production | Diseases and pest management |
| Labor cost in the village | Information on household agricultural production | Harvest practices |
| Knowledge and use of agricultural equipment | Farming/marketing contract | Post-harvest practices |
| Knowledge and use of agricultural methods | Transactions | Other constraints. |
| Consumed foods and ingredients | Income, expenditure and food consumption | -- |
| Equivalent of unit used in the village | Children schooling | -- |
| -- | 1. Household members' health | -- |
| -- | 2. Medias and communication | -- |
| -- | 3. Well-being and household domestic equipment | -- |

All modules of questionnaires have been converted to the Mlax application for automation of the data collection with Smartphones. The data collection will be automated using Smartphone in order to improve the quality of data collected. For instance, the automation system will help to avoid many errors related to interviewers. The Mlax application will not allow an enumerator to type a character where it should be a numeric value. Automation of data collection will also save time for data entry and cleaning in the computer. However, automation system needs to be tested before starting with data collection. For this reason, the Mlax application has been tested twice in field (Figure 20). The NARS partners of Benin were also trained on how to use the Smartphone for data collection.

Photo 1 Photo 2

Figure 20. Test of automation of data collection using Smartphone in group discussions (Photo 1) and in individual interviews (Photo 2).

A proposal has also been developed for sampling villages and households. A stratified sampling method will be used to sample households. Two types of households will be selected: treated households and control households. Treated households are households in which at least one member has participated in the demonstration and development of the Sawah system. These households will be selected in the development sites of the SMART-IV project. In each development site, 10 treated households (referred to as participants) will be selected. Three types of control households will be considered: (1) households in villages where Sawah is not introduced (referred to as non-beneficiary type I); (2) households growing rice in mechanized sites (referred to as non-beneficiary type II); (3) and households living in development sites but do not participate in the Sawah demonstration sites nor in its development (thereafter referred to as non-participant).

Prior to the selection of non-beneficiary type I, control villages will be selected. The key to identifying and measuring the impact is to have a proper counterfactual - that is, a comparison group (control) that is similar to the intervention group (treatment) with the exception that it did not receive the intervention. This entails ensuring that the villages selected as controls have characteristics similar to the treatment villages. The selection of control villages will be carefully done in two steps. First, using census data and other secondary data, potential control villages that have basic characteristics similar to the treatment villages will be identified. The characteristics that will be used are: population size, geographical situation, rice and agricultural production and rice ecologies. Second, once a potential set of villages is identified, they will be discussed with local research and extension services with the purpose of determining if they were indeed comparable to the treatment villages. The control village must be at least at 10 km to the core villages to avoid bias due to the diffusion of the technology. One to two control villages will be selected for each treated village. However, no more than 10 control villages will be selected in each country (Benin and Togo). In each control village, 5 control households will be randomly selected.

Non-beneficiary type II will be selected in the village where mechanization techniques have been used to develop lowland for rice production. Indeed, there are lowlands that were developed using techniques similar to Sawah but with heavy investment. Households using these sites will be used to see the difference between man-made sawah system and mechanized sawah system. One site will be chosen in each country and 30 households randomly selected in each site.

Within each treated village, there may be households who are rice farmers but do not participate in the Sawah development. There are two concerns about including non-participants in the treated villages as part of the counterfactual. First, they may have chosen not to participate and therefore may be fundamentally different from the participants. Secondly, since they live in close proximity to beneficiaries they may obtain indirect benefits from the Sawah development and in fact many technology adoption programs hope to have these types of spill-over effects. Thus, solely using these households as a control group is likely to be problematic, but that depends on what actually happened during the intervention of the SMART-IV project. The ideal comparison group partly depends on whether there are indirect, or spill-over effects on the non-participants. If there are such effects, including non-participants in the counterfactual would lead to an underestimation of program impact. If indirect effects are substantial it may be desirable to include non-participants as treated households to get the total effect (direct and indirect effect) of the program and use only non-eligible households as a counterfactual. For these reasons, it is important to know if non-participants can be found in the treated villages. If possible, 5 non-participants will be selected in each treated village. The summary of the sample size is presented in Table 3.

Table 9. Sample size for base line survey and impact assessment of the SSD adoption

| Country | Number | Region/ department | Prefecture/ commune | Inland valley / village | Sample size | | |
|---|---|---|---|---|---|---|---|
| | | | | | Participants | Non-participants and controls | Total |
| **Benin** | 1. | Zou | Ouinhi | Zoungo | 10 | 10 | 20 |
| | 2. | Zou | Ouinhi | Kaffa | 10 | 10 | 20 |
| | 3. | Zou | Ouinhi | Agosou | 10 | 10 | 20 |
| | 4. | Collines | Glazoué | Kpakpaza | 10 | 10 | 20 |
| | 5. | Collines | Glazoué | Todjotin | 10 | 10 | 20 |
| | 6. | Borgou | Parakou | Koroborou | 10 | 10 | 20 |
| | 7. | Zou | Zanganando | Bamé | 10 | 10 | 20 |
| ***Sub-total Benin*** | | | | | *70* | *70* | *140* |
| **Togo** | 8. | Plateaux | Amou | Sodo | 10 | 10 | 20 |
| | 9. | Plateaux | Kpele | Kpele Tutu | 10 | 10 | 20 |
| | 10. | Plateaux | Kpele | Bémé 2 | 10 | 10 | 20 |
| | 11. | Centrale | Blitta | Tchanganidè | 10 | 10 | 20 |
| | 12. | Kara | Kozah | Kawa | 10 | 10 | 20 |
| | 13. | Kara | Kozah | Gnatre | 10 | 10 | 20 |
| | 14. | Kara | Kozah | Atchangbadé | 10 | 10 | 20 |
| ***Sub-total Togo*** | | | | | *70* | *70* | *140* |
| ***Regional sample size*** | | | | | ***140*** | ***140*** | ***280*** |

A framework that allows analysis of SSD adoption and impact assessment in the frame of agricultural household model was also developed during the reporting period.

**Proposal on contract farming for market access**

SMART-IV aims not only to increase rice productivity and production but also to improve farmers' access to the market for selling their production. In fact, it is meaningless to increase the production if the farmers are not able to sell their output. This justifies developing a proposal on contract farming (CF) for market access. The main objective is to promote selected models of contractual farming and marketing arrangements between rice-value chain actors and evaluate the outcome of each setting on market access.

The implementation and evaluation of the CF schemes is planned for three years and will follow six steps that are summarized in Figure 1.


Figure 21. Establishment of CF schemes for market access.

**Capacity building**

With respect to activity EC.03 (see Table **1** of planned activities), two MSc positions were advertised. The students will conduct their research project on the general topic "Resources and technologies use for rice production in inland valley: soil and water management practices and adoption of good agricultural practices for rice production". One student will work in Benin and the second in Togo. The deadline to candidates to apply is October 15th, 2012.

## 4.3 Major achievements socio-economics year 3 (2011-12)

- A work plan for the last three years of the project was developed;
- Sampling proposal is achieved;
- Application for automation of data collection is ready;
- A baseline survey has started;
- Proposal on contract farming for market access improvement;
- The process for recruitment of MSc students has started.

## 4.4 Prospects socio-economics for year 4 (2012-13)

- Training of NARS partners on socio-economic data collection using Smartphone and sampling of control villages and households
- Field data collection for baseline survey
- Baseline data analysis and reporting
- Two MSc students will be selected
- The process of the contract farming and marketing arrangement will start.

# 5 SSD demonstration and development

## 5.1 Introduction

**Benin**

In Benin the SMART-IV project is officially hosted by the Institut National de Recherche Agricoles du Benin, INRAB [Benin national agricultural research institute]. The Directorate of Rural Engineering (DGR) based in Porto-Novo is responsible for implementation and the Cellule Bas-Fonds, a unit under the DGR carries out field activities. The head of the Unit is the National Coordinator for the project. The Unit relies on the expertise of technicians specialised in agriculture and natural resources management. Each specialist technician works in a Communal Centre for Agricultural Promotion (CeCPA). The CeCPA is under the control of the Regional Centre for Agricultural Promotion (CeRPA). Therefore, the technician's line manager is not the head of Cellule Bas-fonds, but the CeCPA Director. He therefore carries out other activities within the scope of his duties. The monitoring of development works within the framework of the SMART-IV project is an activity among many others for the latter and his availability, even limited, cannot also be guaranteed. Out of the five technicians trained in Kumasi on the project, three work in the field on a part time basis. The other two persons do not currently work for the project. It should be noted that the technicians all work in different CeRPA and CeCPA spread across Benin.

**Togo**

The Institut Togolais de Recherche Agronomique, ITRA [Togolese agronomical research institute] is the institution responsible for hosting and implementing the project in Togo. The National Coordinator also works for the same agency. The Regional Director of the centre carrying out the activities is responsible for coordination at the regional level. The same applies for the northern region where the activities of the technicians are monitored daily by an engineer. This system is consistent with the resolutions of the project mid-term workshop which was held at the Africa Rice headquarters in Cotonou on 19, 20 and 21 May 2012. The southern region is coordinated from Lomé, a situation which according to the managers of the institution, should be eventually corrected. Out of the five technicians trained in Kumasi within the framework of the project, four are operational in the field for the development component of the project. They are mostly general agricultural technicians who do not have a specific background in the area of lowland development.

## 5.2 Validation of potential SSD sites

For lowlands, site validation aims at ensuring that the local beneficiaries have a need for the project and that the planned activities adequately address their concerns. In particular, site validation seeks to:

- have available reliable information on the reasons for the selection of the project area,
- reduce the risk of activity failure during implementation,
- provide assurance to donors and financial backers of the relevance of the choice made.

Validation is a process and in this regard can be adapted to all projects. The essential factor is the definition of relevant criteria to be taken into account in selecting the communities or areas for the project. Often, it is carried out in teams by persons from outside the agency responsible for project implementation and occurs after site identification and selection by the implementing agency. It is done at the request of the local, district or national government authorities or financial backers or donors seeking to guarantee the success of the activities being funded.

The validation criteria are designed on the basis of very clear terms of reference. With regard to inland valleys, validation occurs in two phases: (i) field phase and (ii) meeting with beneficiary community. The first phase is solely concerned with the biophysical aspects and the second phase deals with the socio-economic aspects.

With regard to the biophysical aspects, the following criteria are taken into account: site location, surface area, lowland shape, hydrodynamics, slopes, vegetation, etc.

The socio-economic aspects include community participation, the project implementing agency, information received by the local community regarding the project, farmer organisations, land tenure matters, problems related to use of the lowlands, community expectations from the project, etc.

A questionnaire designed to end this made it possible to put together the information collected. Following this exercise for all the selected sites, an analysis was done. The sites which presented the best matches on basis of the criteria defined by the donors were then selected.

In practice and for the success of field activities, the socio-economic aspects are much more important than the biophysical factors. The chances of success for the project are very limited for a site which meets all the biophysical criteria but is beset with land tenure issues or the lack of involvement of the beneficiary community.

While validation is not a 100% guarantee for success, it nonetheless makes it possible to limit the risk of failure and is thus a compulsory step.

## 5.3 Project Implementation and Outcomes

### 5.3.1 Benin

**Summary of 2011 activities**

In 2011, a single site of about a hectare was developed in Aïzé, Ouinhi commune in the department of Zou. The site received water supply from an artesian well. It was being farmed by sixteen people including six women making up a group called Sèdzro. It was used solely for seed production. Output obtained was approximately 3t/ha with the IR 841 variety. The group experienced some problems in selling the produce. The seed was finally given to SONAPRA [national agricultural promotion company] at the rate of 300 Francs/kg.

Given the small surface area of this site and the fact that it was already being used by the emergency programme to support food security (PUASA), the group decided to use the site solely for seed production and use another site with a much larger surface area (about 25ha) and more farmers.

**Validation of selected SSD sites**

This involved granting approval or leave for CeCPA technicians to work on the selected sites based on previously determined criteria.

The process occurred in two phases – the "field" phase and the "meeting with the beneficiary communities" phase.

During the "field" phase, care was taken to ensure that the selected site corresponded to the needs of the project. The purpose of meeting with the local community was to ascertain that farmers understood the nature of the project and subscribed to it. It was also to ensure that the selected sites did not have any major land tenure issues. In summary, the process was aimed at confirming or invalidating the information collected by CeCPA technicians.

Initially, the National Coordinator for the project selected three sites which were submitted for validation. They include the Korobororou, Kpakpaza and Zoungo sites. During site development, the Todjotin and Agosou sites were added.

Table 10. Location of validated SSD sites in Benin.

| Site | Geographic coordinates | Village | Arrondissement (access) | Commune | Department. | Dist./Com in km |
|---|---|---|---|---|---|---|
| Korobororou | 9° 22.790' N<br>2°40.350' E | Korobororou | Parakou<br>Easy access | PARAKOU | Borgou-Alibori | 5 |
| Kpakpaza (Toga) | 7° 56.935' N<br>2°11.867' E | Kpakpaza | Kpakpaza<br>Easy access | GLAZOUE | Collines | 6 |
| Todjotin | 8° 21.133' N<br>2°06.641' E | Djamandji | Aklampa<br>Easy access in dry season | GLAZOUE | Collines | 50 |
| Zoungo (Osrogbomè ) | 7° 06.853' N<br>2°31.016' E | Zoungo | Ouinhi<br>Very easy access | OUINHI | Zou | 4 |
| Agosou | 7° 7.073' N<br>2°30.194' E | Ganhoumè | Ouinhi<br>Easy access in dry season | OUINHI | Zou | 2 |

Out of the five sites, only one is located in the North of the country, two are in the department of Zou and two in the department of Collines. There are two sites in the Ouinhi commune and another two in Glazoué commune.

The main biophysical and socio-economic characteristics of the different sites are summarised in Table 11 and Table 12.

Table 11. Biophysical characteristics of the SSD sites in Benin.

| Site | Shape | Nature of soil | Inundations | Water table | Potential land area in ha |
|---|---|---|---|---|---|
| **Koroborou** | Wide U-shaped with slight lateral slope | Sandy-clay to clay-sand | Strong | Temporary | >10 |
| **Kpakpaza (Toga)** | River terrace Slight slope | Sandy silt - silt | Fairly rapid | Temporary | >10 |
| **Todjotin** | Mild V shape Average slope | Very sandy | Gradual | Semi- permanent | 3 |
| **Zoungo (Osrogbomè)** | Hydromorphic area with average, long slope | Sandy – sandy clay | Fairly rapid | Temporary | >8 |
| **Agosou** | Alluvial plain Very slight slope | Sandy – sandy silt | Rapid | Temporary | >50 |

The Koroborou site lies over several kilometres and is about 150 to 200m wide. An unpaved road runs across it. The developed part is located at the lower end of the road and receives water supply from a culvert. The soil is sandy-clay to dark sandy-clay similar to vertisol and floods once the rains start. The soil is difficult to work. Late start of activities at the beginning of the rains prevents their development.

In Kpakpaza, the site looks like a river terrace. It is flanked by a water course at its lower end. The soil is sandy to sandy-silt with shallow compact clay on the surface (<50 cm). The soil floods and dries out quickly although the top soil is easy to work.

The site is Todjotin is a true inland valley which is very entrenched. The soil is very sandy and thus quite poor. It is located 50km from Glazoué and access can be difficult at the height of the rainy season.

In Zoungo, the topography of the lowland is not evident. There is a very long slope which truncates at the tarred road and several culverts through which water is drained during the winter. Soil texture varies from sandy-clay to sandy in the much lower lying lands. Flooding is rapid in the sandy-clay area and gradual in the sandy areas.

The Agosou site is in reality an alluvial plain which spreads over several hectares. The slope of the land is not visible. The soil remains flooded for several weeks even after the rains have stopped. The soil is sandy to sandy-silt.

Table 12. Socioeconomic characteristics of SSD sites in Benin.

| Site | Community participation | No. of persons present | Land tenure | Mode of land transfer | Farmer expectations |
|---|---|---|---|---|---|
| **Korobororou** | Strong | >40 | Household | Unconditional gift | Practically everything is provided by the project |
| **Kpakpaza (Toga)** | Average | ± 20 | Household | Gift with voluntary consideration | Provision of technology and input |
| **Todjotin** | Strong (all farmers) | ± 20 | Household | Unconditional gift | Provision of technology and possibly input |

| | | | | | |
|---|---|---|---|---|---|
| **Zoungo (Osrogbomè)** | Average | ± 20 | Household | Rented (12,500F/ha) | Provision of technology and possibly input |
| **Agosou** | Poor | ± 10 | Household | Unconditional gift | Provision of technology and possibly input |

For the socio-economic aspect, community participation was deemed to be strong in Korobororou and Todjotin as all the farmers were present. The farmers at the Agosou site were not all present as they had not been informed of the arrival of the Regional Coordinator. The low level of participation was thus not a sign of lack of interest as the farmers themselves made the request for technical assistance.

The land ownership for all sites is household-based. Generally, land use is obtained as an unconditional gift except at Kpakpaza where a voluntary consideration may be given. The Zoungo site belongs to two families, the farmers obtain land by renting at the rate of 12,500 F/ha per season prior to development. One cannot be certain that the price will not change after the site has been developed. Eventually, a multi-year contract is necessary to provide security for farmers.

With regard to farmer expectations, the project must provide everything for the farmers at the Korobororou and Kpakpaza sites *(from labour to inputs)* while farmers at the other sites have shown great interest for the approach used in developing the sites and the technical method for growing rice.

**Organisation of development works**

This relates to the measures to be taken before development. It involved clearing the land, looking for pegs and particularly the mobilisation of all farmers during the different stages of work. For the pegs, an average of 400 pieces per hectare was required. It was not always easy to make farmers at all the sites understand that they were to carry out the bulk of the work especially as they were accustomed to the easy solutions obtained through the different past and on-going projects. It was easier to carry out preparatory work on previously used land than the new farmlands.

The entire lowland was developed and the work was not done farmer after farmer or plot after plot. It is therefore needful to create awareness beforehand on the implementation of activities which the local community are not accustomed to.

For each site, pictures are provided in Annex 3 to illustrate the progress of the development activities.

The staff at the national coordination agency should be informed that for the execution of the works, the farmers need to be provided with food supplies during the community works, different colours of paint should be available for the conduct of the different works. The technicians must be available during the works so that they take ownership of the technology and monitor farmers during its implementation.

**Preparation of plans and site development**

In nature, very few inland valleys are similar. Therefore, each one is a special case. Each inland valley thus has its particular development plan which is prepared with the help of farmers who have better understanding of the lowlands having farmed the land for years. Based on the information supplied by the farmers, information on water flow, development problems, the development plan was prepared accordingly. The technicians responsible for implementation also made their contributions. The plan was presented to the farmers and also discussed with the technicians. Corrections were made where necessary. Thus, the final plan resulted from a consensus.

The plan is implemented with the use of pegs painted in different colours each specifying a type of work.

The placing of pegs was immediately followed by the works. One must have mastered the approach in order monitor the farmers more effectively. Regular monitoring of those using the approach for the first time was essential as poorly developed lowland causes more significant damage than at the initial stage.

**Monitoring and cultivation**

Visits to monitor the works made it possible to ensure compliance with the development plan and make any necessary readjustments. This is a normal procedure given the technological innovation and delay experienced in the implementation of field activities. It also provided an avenue to reassure and support the technicians responsible for the sites. Through monitoring, the results of the activities could be seen on fairly difficult sites (Korobororou and Kpakpaza) where the farmers had very high expectations from the project.

The cultivation process involved ensuring that the technical method for rice growing was complied with, from the establishment of the nursery, ploughing, levelling, transplanting in lines to accurate dosing and timely application of fertiliser. Table 13 below shows the land area developed per site, fluctuation in farmer numbers and level of ownership of the technology.

Table 13. Surface developed and farmer involvement.

| Site | Developed area in ha | Potential Surface | Number of Farmers | | | | | | Type of organization |
|---|---|---|---|---|---|---|---|---|---|
| | | | May – June | | | Sept | | | |
| | | | M | F | T | M | F | T | |
| Korobororou | 0.7 | >10 | 30 | 0 | 30 | 13 | 0 | 13 | Barely functioning group |
| Kpakpaza (Toga) | 1.8 | 10 | 2 | 14 | 16 | 2 | 14 | 16 | Group being formed |
| Todjotin | 1.4 | 3 | 9 | 7 | 16 | 9 | 7 | 16 | Highly functioning group |
| Zoungo (Osrogbomè) | 11.6 | 8 | 42 | 13 | 55 | 46 | 15 | 61 | Group being formed |
| Agosou | 5.7 | >50 | 16 | 8 | 24 | 16 | 8 | 24 | Group being formed |
| Total Area Developed | 21.2 | | | | | | | | |

The total land area developed across the five sites in Benin was 21.2 ha or 106 % of the initial objective. The number of farmers varied from site to site. In Korobororou, numbers went from thirty to thirteen with a more or less stable core of six people, indicating that the people had little interest for the project. The numbers at the other sites remained constant and even increased in Zoungo. Kpakpaza was farmed by mostly women, a fact which presented a manpower problem for executing the works. At all the sites, the farmers formed groups but required support from the specialised units of the CeCPA. Farmers on all the sites quickly took ownership of the technology but the dynamism and speed of appropriation varied from site to site. It was noted that farmers at the Todjotin, Kpakpaza, Zoungo and Agosou sites were more dynamic.

**Early impact of the technology**

The early technological impact of this simple lowland development approach was quickly felt in the field and at two levels - water management in the bunded plots and reproducing the approach.

In the area of water management, relative drought for almost two weeks in the Zou and Collines departments had no significant effect on the rice sown or transplanted in the bunded plots across all the sites in the department. At the Korobororou site located further north, in spite of the late start of the season, the season was saved due to the field preparation which withstood the floods. Normally, a late season start would prevent any activity on the site. The farmers therefore quickly understood the advantage of the development.

In the area of transplanting, especially at the Zoungo site located beside a tarred road, requests for assistance by the farmers came from all quarters. Although the Todjotin site was far from Glazoué, the large Djamandji group of rice farmers (more than a hundred) was very interested by the approach as was the CeCPA staff of that locality, thus constituting an advantage for site selection during the extension phase.

**Conclusion**

In spite of the late start of the season, more than twenty hectares of lowlands were developed. This was possible through the involvement of all stakeholders. Changes occurred better or more quickly on some sites than on others. The reasons for this can be found in the site selection and the understanding the farmers had of the project. Many were accustomed to the easy solutions obtained from many previously executed projects. In the future, it is important to create awareness and identify truly needy farmers or those who believe that the technology being used can significantly improve productivity in the lowlands and raise their living conditions.

### 5.3.2 Togo

**Summary of 2011 activities**

In 2011, ITRA developed a land area of one hectare at the Sodo site in the Plateaux region with the aim of correcting some of the works carried out on a previously developed site which had seriously deteriorated. The remodelling included re-dividing the fields, at the point where they rose and the drainage opened up, in order to improve water management. There was permanent water supply to the site from an intake point supplied by close-by mountains. The Amenee canal was rehabilitated by the project. It is important to point out that the farmers working at the site have long experience in the practice of rice growing. Compliance with the technical method of cultivation led to output of about 5 t/ha for the IR841 variety.

Tests were also carried out on another site – the Tutu site located come twenty kilometres further west with eight farmers. This was an old developed site with total water management with the reservoir that was silted and the main canal in a bad state. The technical method for cultivation was not correctly followed by the farmers and the output obtained for the project was not different from the normal output of other farmers working at the site. The output was about 3 t/ha. For 2011, the impact of the project considerably improved the output of the remodelled Sobo site.

**Validation of selected sites**

ITRA shortlisted six sites that were submitted for validation. They include Tchanganidè, Few Hélélé, Kawa CEG, Gnatre, Atchangbadè DRDR and Atchangbadè (Tanendé Few) sites. At the end of the exercise, three sites were officially selected. They are the Tchanganidè, Kawa CEG and Gnatre sites. A fourth site, the Atchangbadè DRDR site, which did not fully meet the biophysical criteria set by the project was « let through » due to the level of farmer participation.

The socio-economic difficulties related to the implementation of the project in 2012 led the regional coordination agency to make a last minute request for new sites to be selected in the region of Plateaux. Thus the Bémé2 site was included among the four shortlisted sites.

Table 14. Location of validated sites in Togo.

| Site | Geographic Coordinates | Village | Canton | Prefecture | Region | Dist./Pref in Km |
|---|---|---|---|---|---|---|
| **Bémé2** | 7° 05.318 N<br>0° 43.284 E | Bémé | Adéta<br>Very easy access | KPELE | Plateaux | 3 |
| **Tchanganidè** | 8° 20.325 N<br>1 °02.906 E | Tchanganidè | Blitta<br>Easy access | BLITTA | Central | 5 |
| **Atchangbadè** | 9° 29.021 N<br>1° 07.851 E | Atchangbadè | Atchangbadè | BLITTA | Central | 10 |
| **Gnatre** | 9° 37.746 N<br>1° 02.694 E | Sara | Sara Kawa<br>Very easy access | KOZAH | Kara | 12 |
| **Kawa CEG** | 9° 37.527 N<br>0° 59.584 E | Kawa | | KOZAH | Kara | 15 |

One of the five new sites is located in the Plateaux region and another in the Central region. The other three are located close to one another and are in the same region and the same prefecture. All sites have easy access. The biophysical and socio-economic characteristics are contained in Table 15 and Table 16.

Table 15. Biophysical characteristics of sites in Togo.

| Site | Shape | Soil type | Flooding | Water table | Potential area in ha |
|---|---|---|---|---|---|
| **Bémé2** | U-shaped<br>Long and mild longitudinal slope | Sandy to sandy-clayey-silt | Gradual | Temporary | 3 |
| **Tchanganidè** | U-shaped<br>Long and pronounced longitudinal slope | Predominantly sandy | Gradual | Temporary | 10 |
| **Atchangbadè** | V-shaped<br>Fairly pronounced slope | Very Sandy | Gradual | Temporary | 5 |
| **Gnatre** | | Sandy to sandy-silt | Gradual | Temporary | 5 |

| | | | | | |
|---|---|---|---|---|---|
| **Kawa CEG** | U-shaped<br>Average slope with water supply from 4 culverts | Sandy | Quick | Temporary | 3 |

Generally, the predominant soil texture on all the sites was sandy. Therefore, chemically, the sites were very poor. Although flooding was gradual on all sites, the land dries up quickly enough only a few days after the rains. Erosion was very pronounced at Atchangbadè due to the slope and the very sandy soil texture. The Kawa CEG site floods fairly quickly especially due to the water that rushed forcefully out of the four culverts onto the site. Erosion was also very pronounced at this site. All the sites were farmed to a fair extent.

Table 16. Socioeconomic characteristics of the SSD sites in Togo.

| Site | Community Participation | No. of persons present | Land tenure | Mode of Land transfer |
|---|---|---|---|---|
| **Bémé2** | Strong | ± 10 | Household | Gift with or without compensation |
| **Tchanganidè** | Very strong | ± 20 | Household | Gift without compensation |
| **Atchangbadè** | Very strong | ± 20 | Household | Gift without compensation |
| **Gnatre** | Poor | ± 15 | Gov. | Gift without compensation |
| **Kawa CEG** | Poor | ± 20 | Household | Gift without compensation |

There is strong local participation in three out of the five sites. They are Bémé, Tchanganidè and Atchangbadè. In Kawa CEG, the farmers expect everything from the project. In Gnatre, the lack of organisation of the farmers hindered the progress of work in the field. Land ownership on all sites is household-based with no special problems in obtaining use of land.

**Organisation of SSD activities**

The approach here is similar to the one used in Benin. Farmers were informed of the measures to be taken before the start of the development works. The sites needed to be cleared and pegs provided. The agency responsible for the project must take necessary measures to support the farmers in the field works. With lowland development being season-dependent and carried out over an extremely short period, any organisational failure will compromise the operations. The chronological order of events must be strictly adhered to. With all the sites already being used for farming, most of the organisation required was from the agency in charge of activity implementation. It is expected that the farmers at the selected sites would be put in groups before the implementation of the activities.

**Preparation of Plans and Site development**

Farmers, technicians and persons responsible for development works went throughout the lowlands in order to identify natural drainage pathways, unique aspects and other particular features of the field. The farmers raised the difficulties they had encountered in developing the sites in terms of water management. Based on observations made in the field and information obtained from farmers, a development plan was prepared and proposed to farmers. It was discussed and amended. The development would be carried out on the basis of the final document which was mutually accepted. It would serve as the fundamental document for the development works. The normal process continued and pegs were placed and marked, works executed, etc. At Tchanganidè for example, the farmers were familiar with the approach after having practice it in 2011, progress was quick as less time was required for explanations. On other sites, one had to be patient to get the beneficiaries to understand the process.

For each site, pictures are provided in **Annex 4** to illustrate the progress of the development activities.

**Monitoring and Cultivation**

Monitoring made it possible to ensure that the plan was respected or amended as dictated by the needs in the field. Rains are desired during this period, making it possible to observe if the different processes designed would work well. Rain during execution of development works remain the best indicator for the accuracy of the plan and quality of field works.

In addition, it is necessary to state that the stability of the works would depend on the soil type. Bunds are stable on all clayey soils from the first year while for sandy soils, it is necessary to wait two to three years to make corrections or readjustments at each rain given the poor stability of the materials.

The need for a specialist to work at the sites is justified for sites where the topography is fairly difficult thus requiring masonry works.

Table 17. Developed SSD sites and farmer involvement.

| Site | Developed area in ha | Potential Surface | Number of Farmers | | | | | | Type of organization |
|---|---|---|---|---|---|---|---|---|---|
| | | | May – June | | | Sept | | | |
| | | | M | F | T | M | F | T | |
| **Bémé2** | 1.7 | 3 | - | - | - | 12 | 10 | 22 | Individual farmers |
| **Tchanganidè** | 0.9 | 10 | 8 | 7 | 15 | 7 | 8 | 15 | Group being formed |
| **Atchangbadè** | 1.3 | 5 | 10 | 7 | 17 | 9 | 6 | 15 | Highly functional group being formed |
| **Gnatre** | 0.7 | 5 | 13 | 3 | 16 | 7 | 3 | 10 | Barely functional group being formed |
| **Kawa CEG** | 0.8 | 3 | 14 | 8 | 22 | 7 | 2 | 7 | Group being formed |
| **Tutu** | 1 | 25 | 11 | 6 | 17 | 9 | 4 | 13 | |
| **Total Area Developed** | 6.4 | | | | | | | | |

A total of 6.4 hectares were developed across all the sites. The Sodo site was not taken into account as practically nothing was done there. The average number of farmers on the sites was about 15. It should be noted that farmers at the Bémé2, Tchanganidè and Atchangbadè sites were dynamic. At the other sites, farmers showed little interest for the works. At Gnatre, the lack of organisation of the farmers was quite striking. It was difficult for them to agree on the works. The number of farmers went from 16 to 10. At Kawa, the scope of the works to be carried out far exceeded the number of farmers working on the site. The disagreements between members and the desire for easy solutions led ITRA to undertake the works at the site which is easily accessible and where results could be seen from the road which had high traffic. The number of farmers went from 22 to 7.

**Early impact of development**

There was drought for over ten days during the winter period at the Central and Kara regions. The development made a difference in the behaviour of the rice on the developed and non-developed sites. Farmers at the Bémé2, Tchanganidè and Atchangbadè sites were committed to the development cause. Requests for assistance from rice farmers in surrounding villages were recorded. At Kawa where participation was poor, lowland development made it possible to save the rice fields from heavy rains in the area which affected most of the farms. Easy access to site enabled all passers-by to stop and appreciate the initiative. Dissemination of technology and extension of the area developed should not present any problems in the years to come.

**Conclusion**
The system put in place which involves giving the ITRA regional directorate the responsibility of coordinating activities has led to increased visibility for project activities in the field. Although the land area developed fell short of the target, the dynamism of the team involved in the project is noteworthy. The southern part recorded little success due to the socio-economic problems experienced at the site (formerly developed sites of Sodo and Tutu) and the system put in place for monitoring field activity.

## 5.4 Analysis of the progress

### 5.4.1 Benin

**Identification, validation of sites and participation of beneficiary communities**
All the sites shortlisted by the team were validated. This exercise witnessed the participation of high numbers at the Koroborou site. Participation across the other sites was poor to average. It should be noted however that that there was a significant difference in participation from the validation to the field implementation phases. Most of the inland valley sites in Benin have had at least one development project bringing easy solutions. The same applies with regard to the peoples' expectations of the SMART-IV project, at some sites (Koroborou, Kpakpaza), the farmers were disappointed because all the activities were not carried out on their behalf. The complaints were constant. The result was a reduction in the number of farmers during the implementation phase in the field. At the sites where the project was successful, the national coordination body should help the farmers form groups which would be officially recognised by the regional rural development services.

**Land tenure**
Land use is obtained as a free gift at all sites except Zoungo where the plots are rented. A plot of 20m x 20m or 400m$^2$ is rented as the rate of 500F CFA or 12, 500 F CFA per hectare. This was not a major difficulty for the farmers at the site. As this was an annual contract, it is important that the land is secured for the project beneficiaries by putting in place a long term contract. After the land has been developed, it is not certain that the land owners would continue to rent out the land at the same rate. The national coordination body in conjunction with CeCPA should approach these owners with a view to ensure long-term access to the land for the farmers.

**Markets**

The distribution of paddy rice was not really a problem in Benin. The national agriculture promotion company (SONAPRA) through the CeCPA, is responsible for collection in the major production areas on behalf of the hulling factories in Glazoué and Malanville which in turn deliver the final product to the national office for food security (ONASA). Individual farmers can also take the crops directly to the factory. The most highly sold variety is the IR 841.

The price is attractive at 162.5 FCFA/kg. The Glazoué factory which is closest to the project sites functions at a sixth of its capacity. The sales problem occurred in the areas with low level production. Some farmers complained to the CeCPA of the delay in receiving payments.

The Entreprises de Services et Organisations de Producteurs (ESOP) promoted by the NGO « Entreprises Territoires et Développement » (ETD) present in Togo and Benin also buys and processes paddy rice but at a very small scale and at less attractive prices.

**Land area developed**

The project developed a total of 21.2 ha or 106% of the initial objective. Considerable efforts have been made by the national coordination body of the project in terms of freeing up all types of means for implementation in the field. The land areas developed would have been larger had all the technicians been present at all the sites for more regular monitoring. Another major problem was the several lowland development projects which all offered their own approach. Generally, the people were accustomed to quick fixes and it becomes difficult for a project to take firm root if only the least effort is required from the beneficiaries. The activities were much more successful in areas where which have not had a lot of projects or areas far from the major urban centres.

**Capacity building for different stakeholders**

The capacities of the technicians who regularly attended site were enhanced and they were able to reproduce the approach. This was not the same for those who were absent or showed little interest for the project in spite of the considerable assistance provided by the National Coordinator. It is true that they have other concerns but their performance fell short of incentives provided. Many farmers quickly mastered the approach and repeated it immediately. Some of these farmers can become indigenous developers in order to support their peers but their skills are limited to their lowland. They need additional training as very few lowlands are alike in nature.

Another important area to highlight is the attraction of all types of people who passed beside the developed sites located along the major roads. They could not help but stop to observe or admire the activities underway in the field. Many farmers have requested for the technology to use in future agricultural seasons.

**Conclusion**

In spite of the delay in the start of activities in the field, the works had visibility on all the project sites.

### 5.4.2 Togo

**Identification, validation of sites and participation of beneficiary communities**

ITRA shortlisted six sites and four were selected after the validation exercise. These include the Kawa CEG, Gnatre and Atchangbadè sites in the Kara region and Tchanganidè in the Central. In reality, the site in Atchangbadè was selected on a discretionary basis as it did not meet the biophysical criteria for the project but the involvement of the local community was very high. The socio-economic problems encountered on the two sites in the Plateaux region, sites that were formerly developed, led the regional coordination agency to request that new sites be selected. There was a late shortlist exercise in this region and one new site out of the four (4) shortlisted was selected. This is the Bémé2 site. Community participation was high at the Bémé2, Tchanganidè and Atchangbadè sites. For the Kawa CEG and Gnatre, the poor farmer turnout and especially the disagreements between members led to the slow progress of field activities. The farmers at the last two sites placed a lot of demand on the project. They were inclined towards quick fixes. The system in place in the northern part of the country was very functional. It complied with the decisions taken during the project mid-term workshop which took place on 19, 20 and 21 May 2012 at the Africa Rice headquarters in Cotonou. It involved the provision of a regional coordination effort for the project. These activities did not fare as well in the southern part of the country due to the system in place which should be reviewed. Recommendations have been made in this regard to the national coordination body.

**Land tenure**

For all the sites, land tenure was not an issue. Land ownership was family based and land use is obtained as a free gift, with the exception of the Tutu site, a formerly developed site where the land is rented for use. The cost of rent has increased over time. It was 2,500 F CFA in the 2000s. It presently (2012) costs 3,000 F CFA per 400 $m^2$ or 60,000 F CFA per ha. It must be noted that total water management had been achieved with the possibility of planting several times a year. Land is also obtained by renting at the Sodo site which was not developed this year. The crops harvested are shared on the basis of one-third for the land owner and two-thirds for the farmers.

**Markets**

There is no market at the national level for the purchase of paddy rice. However, the Togo agency for food security (ANSAT) has given loans to rice farmers to prevent them from being exploited by traders. At harvest, the agency receives the hulled rice after ensuring it is of satisfactory quality. It buys the hulled rice (IR 841 variety) and the purchase price varies from 300 to 350 F/kg. ESOP, food processing microenterprises promoted by the NGO Entreprises, Territoires, Developpement (ETD), about ten of which are scattered almost throughout the country, organise the rice farmers, support them in the use of technical methods, buy and sell paddy under the label "riz Délice". The price varies from 135F to 140F per kilo. This price can rise to 150F in cases where no support is provided for farmers. The IR 841 variety is the one produced and sold.

**Land area developed**

Togo developed a total of 6.4 ha across six sites or 32% of the initial objective. The land area developed is as follows: 1 ha of the developed land at Tutu, 1.7 ha of the new site at Bémé2, 0.9 ha at the Tchanganidè site, 0.8 ha at Kawa, 0.7 ha at Gnatre, 1.3 ha at the Atchangbadè site. Farmers at Sodo did nothing. They were satisfied with the opening of two drainage pathways on the 2ha of formerly developed land. The bunded plots were not remodelled. This site was not considered in the accounting. Farmer participation was particularly high at the Bémé2, Tchanganidè and Atchangbadè sites. The structure put in place in Kara led to significant results especially in terms of support to farmers and regular monitoring of sites.

**Capacity building for the different stakeholders**

Regular monitoring by the technicians and their permanent presence at the different sites led to the enhancement of the capacities. They have always implemented the recommendations from every visit of the regional coordinator. They have mastered the technique and are able to carry out development works in line with a plan. Farmers at some sites were also well informed on the approach and were able to continue on their own following corrections made after the rains. They learned a lot on the profitable mode of rice production, that is, the need to adhere to the technical method for cultivation.

**Conclusions**

Although the outcome fell short of the initial objective, considerable effort was deployed especially in the northern part of the country due to the support mechanism in place. The outcome in the southern part was less encouraging for two reasons namely, poor farmer participation at the formerly developed Sodo and Tutu sites and also the support system in place which did not always make it possible to regularly follow up these farmers who are inclined towards easy solutions.

# 6 Training and capacity building

## 6.1 Internships and thesis research

The table below provides an overview of students who have been involved or who are involved through a traineeship or a M.Sc. research within the SMART-IV project during year 3 (2011-2012).

Table 18: Students having performed within the SMART-IV project.

| Name | Institution | Level | Nationality | Title of thesis (topics) | Status |
|---|---|---|---|---|---|
| Maurice Mondegnon | University of Parakou, Benin | M.Sc. | Benin | Integrated management of water and nutrients in the sawah rice system in the inland valley of Bamé (Zagnanado District) | Defended thesis |
| Gertrude Tognite | University of Rennes, France | M.Sc. | Benin | The impact of Sawah rice cultivation on soil fertility and crop performance in Benin | Defended thesis |
| André Kindjinou | University of Abomey-Calavi, Benin | M.Sc. | Benin | topics: inland valley mapping, agricultural intensity | In progress |
| Bjorn Nikolaus | University of Kiel, Germany | M.Sc. | Germany | topics: land use, hydrological modelling, rice intensification | In progress |
| vacant, student being recruited | | M.Sc. | | topic: adoption of good agricultural practices in IVs | In preparation |
| vacant, student being recruited | | M.Sc. | | topics: socio-economic analysis of water resources use in IVs | In preparation |
| vacant, student being recruited | | M.Sc. | | topics: yield assessment, soil science, spatial analysis, inland valley | In preparation |

## 6.2 PhD research

Within the SMART-IV project a PhD position will be financed. The topic of the PhD will be 'Modelling the hydrological impact of rice intensification in inland valleys in Benin'. Contacts were established with Professor Bernd Diekkrüger of Bonn University in August 2011 and the research topic was agreed upon.

This PhD proposal will focus on the hydrological behaviour between inland valleys. A toposequence of inland valleys will be studied to investigate the impact of intensification and SSD on the next inland valley. This study aims to get a better understanding of cumulative effects of SSD on water quantity and quality in inland valleys. The scale is between field level and basin level and close interactions are foreseen between researches at these two scales. The field level studies may support the understanding of water use of sawah rice cultivation at the level of inland valleys, whereas a better knowledge on the hydrology in inland valleys and the cumulative effects will support basin hydrology modelling. This research is therefore complementary to the existing activities that are undertaken in the SMART-IV project and it is well embedded.

Due to administrative problems, the final contracts were signed only in August 2012. The recruitment process was started in October 2011 and Mr Alexandre Danvi was selected for this position. Danvi is engineer in Water Science and Technology (University of Abomey-Calavi, 2008). His knowledge on languages includes French, Fon and English (TOEFL results: 76). He is employed since two years by the Cellule Bas-Fonds (CBF) and he is responsible for data collection and site management of research trials in Bamé, central-Benin.

# 7 Project management

## 7.1 Coordination

Major project coordination activities included:

- Discussing and aligning research and development activities between researchers and partner institutes;
- Preparation of SSD development planning for 2nd half of the project;
- Preparation of work plan and budget for project year 4 (2012-13);
- Preparing annual research contracts with project partners CBF, ITRA and IWMI;
- Preparing contract between AfricaRice and Bonn University regarding the PhD position;
- Administration for MSc and PhD students;
- Organization of a project-meeting in Lomé on January 17 with participation of the national partners and IMWI;
- Budget control;
- Organization and coordination of the mid-term review mission of Dr Buri;
- Organization of the SMART-IV mid-term review workshop, and
- Maintaining website smartiv.wordpress.com. A total of 16 blog posts have been made and the blog has been viewed by approximately 3,398 visitors since its start.

## 7.2 Mid-term review process

### 7.2.1 Introduction

According to the project principals a mid-term project review was held to assess the progress and strengths and weaknesses of the project. The different steps and their planning are outlined in the table below. The following paragraphs outline the internal self-evaluation report, the mid-term workshop and the project implementation plan for the second half of the project.

Table 19. Planning of the mid-term review process.

| | |
|---|---|
| **March-April 2012** | Internal review/self-evaluation report submitted to the donor (deadline: April 13, 2012). |
| **May 2012** | Project progress workshop + discussion with MAFF on the evaluation and output targets. |
| **July 2012** | Overall project implementation work plan for second half of the project developed and submitted to the donor. |
| **August 2012** | Work plans for 2012 based on review and discussions. |

### 7.2.2 Internal review/self-evaluation

Dr Buri of the Soil Research Institute in Ghana was invited to perform the internal project review. Buri has long experience in Sawah System Development in Ghana and in collaboration with Japanese colleagues and projects.

In March 2012 Dr Buri visited AfricaRice and discussed with project scientists and national partners. A field visit was paid to the research and developments sites around Ouinhi. His finding and observations regarding the expected outputs and recommendations for improvement are outlined in the review report, which can be found in Annex 1.

It was concluded that development activities lacked progress and that research activities had advanced sufficiently. In the second half of the project timeline major emphasis should be put to the development activities in order to achieve the expected outputs. Specific recommendations were made regarding the research component of the project, especially regarding soil fertility research. A full outline of all observations and recommendations in provided in the review report in Annex 1.

### 7.2.3 Mid-term review workshop

A mid-term workshop was organized from May 21-23 in Cotonou, Benin. The workshop was attended by all national and international partners, all project scientists and students, as well as the donor.

The workshop consisted of two days discussions, including presentations of achievements and goals, planning of upcoming activities, and one day field visit to Ouinhi and Bamé. The report of the workshop is available in Annex 2.

Figure 22. Participants of the mid-term review workshop. From left to right: Maléki Badjana , Shin Abe, Felix Gbaguidi, Tossimide Houngbadje, Fred Kizito, Takanobu Kobayashi, Worou Soklou, Hiroaki Shimokawa, Koichi Futakuchi, Sander Zwart, Bjorn Nikolaus, Aminou Arouna, Alexandre Danvi, Gertrude Tognite, Moro Buri

### 7.2.4 SSD planning 2nd term of the project

Based on the outcome of mid-term review process, two important actions were immediate made effective:

1. In order to boost development activities, Dr. Worou Soklou was appointed as regional coordinator of development activities in Togo and Benin.
2. In order to better balance research and development in the project, the position of researcher water management was cancelled and extra funds were made available to support the development.

The national partners, the regional coordinator of development and the project leader thereafter developed the planning for development activities for the remainder of the project. The targets per year were defined, development activities were outlined a general planning for the remainder of the project, detailed planning for year 4 (2012-2013), a monitoring system for the development activities.

### *Targets for SSD*

The table below provides the target areas for Sawah system per country. In each country at the end of the project approximately 20 ha must be developed in the dry season and 100 ha must be under rice cultivation in the rainy season. Farmers will be trained on the job by the regional development coordinator from AfricaRice and staff from ITRA and CBF.

Table 20. Targets for SSD per season in Togo and Benin.

| Season | Moment of evaluation | Target Total |
|---|---|---|
| Rainy season 2012 | December 2012 | 20 ha |
| Dry season 2013 | June 2012 | 10 ha |
| Rainy season 2013 | December 2013 | 50 ha |
| Dry season 2014 | June 2013 | 20 ha |
| Rainy season 2014 | September 2014 | 100 ha |

### *General planning 2012-14*

| AfricaRice fiscal year | 2012 | | | 2013 | | | | | | | | | | | | 2014 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project year | 2012-2013 (YEAR 4) | | | | | | | | | | | | 2013-2014 (YEAR 5) | | | | | | | | | | | | | | |
| Agricultural season | WET | | | DRY | | | | | | WET | | | | | | DRY | | | | | | WET | | | | | |
| Month | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
| Training site selection - Togo | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Training site selection - Benin | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Training participatory implementation SSD - Togo | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Training participatory implementation SSD - Benin | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reflection meeting for extension staff ICAT/ITRA | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reflection meeting for extension staff CBF/CECPA | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Farmer exchange meetings Togo | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Farmer exchange meetings Benin | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Regional field technician exchange meetings | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Back-up mission development activities | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SSD implementation demonstration video | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| start SSD activities for wet season | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| site-selection and validation for wet season | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| harvest of rice in development sites (wet season) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| start SSD activities for dry season (where possible) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| harvest of rice in development sites (dry season) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| site-selection and validation for dry season | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| monitoring missions harvested area / rice yields | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 21. Description of planned development activities.

| AfricaRice fiscal year | 2012 | | | 2013 | | | | | | | | | | | | 2014 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project year | 2012-2013 (YEAR 4) | | | | | | | | | | | | 2013-2014 (YEAR 5) | | | | | | | | | | | | | | |
| Agricultural season | WET | | | DRY | | | | | | WET | | | | | | DRY | | | | | | WET | | | | | |
| Month | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
| Training site selection - Togo | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Training site selection - Benin | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Training participatory implementation SSD - Togo | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Training participatory implementation SSD - Benin | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reflection meeting for extension staff ICAT/ITRA | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reflection meeting for extension staff CBF/CECPA | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Farmer exchange meetings Togo | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Farmer exchange meetings Benin | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Regional field technician exchange meetings | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Back-up mission development activities | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SSD implementation demonstration video | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| start SSD activities for wet season | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| site-selection and validation for wet season | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| harvest of rice in development sites (wet season) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| start SSD activities for dry season (where possible) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| harvest of rice in development sites (dry season) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| site-selection and validation for dry season | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| monitoring missions harvested area / rice yields | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | |
|---|---|
| **Training site selection** | • Two trainings will be organized, one in Benin, one in Togo.<br>• The training will be developed and provided by the development coordinator of AfricaRice.<br>• Target audience is field technicians of CBF, ITRA, CECPA and ICAT.<br>• Subject of the training is the selection of suitable sites for SSD.<br>• Two days training, three days field analysis. |
| **Training participatory implementation SSD** | • Two trainings will be organized, one in Benin, one in Togo.<br>• The training will be developed and provided by the development coordinator of AfricaRice.<br>• Target audience is field technicians of CBF, ITRA, CECPA and ICAT.<br>• Subject of the training is participatory implementation of SSD, including design, implementation and good agricultural practices.<br>• Two days training, three days field work. |
| **Reflection meeting for extension staff** | • Two meetings will be organized, one in Benin, one in Togo.<br>• The trained technicians will discuss achievements, problems and improvement options will be discussed.<br>• Meeting will take place after the rainy season 2013. |
| **Farmer exchange meetings** | • Two meetings will be organized in each country, possibly it will be repeated in new regions in the final year (year 5)<br>• Farmers from surrounding areas will visit SSD sites<br>• Information will be provided on SSD, the benefits and how to implement it.<br>• Interested farmers will provide contact details to national coordinators and sites will be visited for validation. |

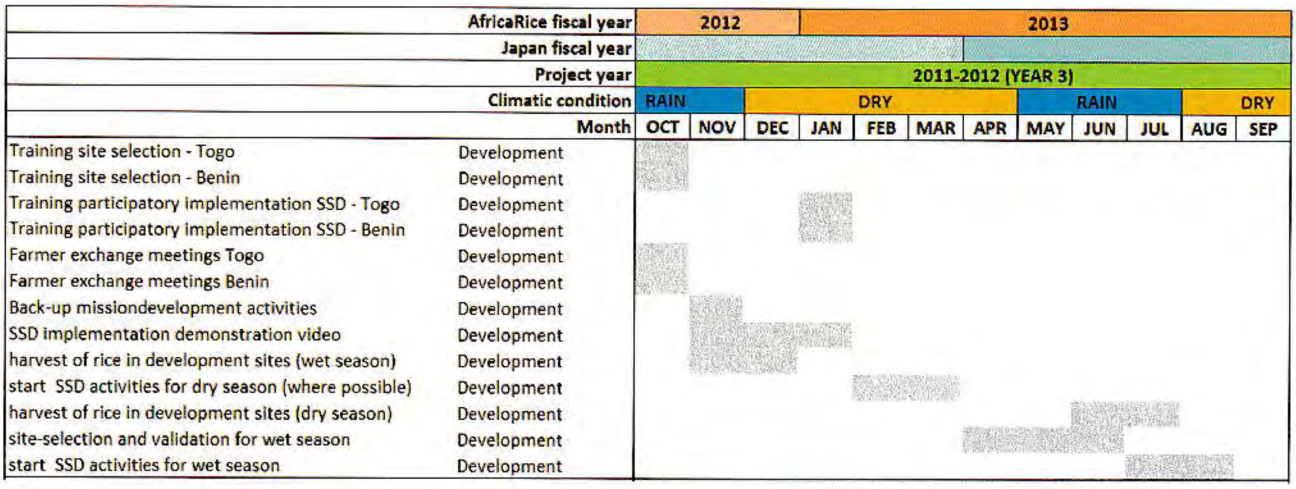
| | |
|---|---|
| **Regional field technician exchange meetings** | • Trained field technicians will visit SSD in their region.<br>• Several meetings will be organized with the goal for exchange between field technicians and to discuss successful supervision of farmers in SSD. |
| **Back-up mission development activities** | • Two back-up missions are planned in two rainy seasons.<br>• Dr Buri, specialist in SSD in Ghana, will provide guidance on how to improve SSD in both countries.<br>• Missions will be planned by the region development coordinator and target the national organization as well as backup for the regional coordinator. |
| **Instruction video for farmers on 'Design and implementation of Sawah System Development'** | see section 5 below |

### *Detailed planning 2012-13*

The table below provides a detailed planning of development activities as agreed by AfricaRice and the national partners. On the next page a Gantt chart provides the planning of the activities.

**Table 22. Detailed planning of development activities in year 4 (2012-13).**

| date | location | activity | type |
|---|---|---|---|
| August 20, 2012 | Lomé, Togo | discussion on integration of national extension service (ICAT) into the project | meeting |
| September, 2012 | Benin | mission to three regional extension services (CERPA) to discuss integration into the project | meeting |
| October 15-19, 2012 | tbd, Togo | 'site selection for sawah system development' | training |
| October 22-26, 2012 | tbd, Benin | 'site selection for sawah system development' | training |
| October, 2013 | tbd, Togo | farmer exchange meetings Tchanganidè & Atchangbadè | demonstration |
| October, 2013 | tbd, Benin | farmer exchange meetings in Todjotin & Zoungo | demonstration |
| November, 2012 | Benin & Togo | Backup- mission development activities Dr Buri | meeting |
| November – December, 2012 | Benin & Togo | selection of at least ten new development sites | development |
| November – January, 2013 | Benin | realization of farmer demonstration video in four national languages: Fon & Dassa (Benin), Ewe & Kabye (Togo) | extension |
| November – December, 2012 | Benin & Togo | harvest of first season (rainy season 2012) | development |
| January 21-25, 2013 | tbd, Benin | 'participatory development of sawah systems' | training |
| January 28 – February 1, 2013 | tbd, Togo | 'participatory development of sawah systems' | training |
| February – March, 2013 | Benin & Togo | start of activities for dry season (where possible) | development |
| June – July, 2013 | Benin & Togo | harvest of dry season | development |
| April – June, 2013 | Benin & Togo | Site-selection and validation | development |
| July – August, 2013 | Benin & Togo | start of activities for wet season | development |



*Monitoring of development activities*

Development activities are continuously monitored by:

- maintaining an excel spread sheet with development indicators collected during each season;
- taking pictures of the development sites;
- measuring once per season the exact acreage under rice cultivation in each SSD site using GPS; and
- assessing rice yields after harvest by sampling.
-

Table 23. Parameters for monitoring and evaluation of the development activities.

| | |
|---|---|
| **Name and location** | Inland Valley<br>Prefecture<br>Region<br>North<br>East |
| **Site characteristics** | Water source<br>Land Form<br>Initial Land Use<br>Stability<br>Annual Rainfall<br>Flooding<br>Drainage capacity<br>Number of seasons<br>Accessibility<br>Potential area (ha) |
| **Development activities** | ITRA/CBF technician<br>Telephone<br>Farmer Organization<br>Dam<br>Drainage Canal<br>Irrigation Canal<br>Land Preparation<br>Start season 1<br>Harvest season 1<br>Area developed<br>Yields attained<br>Female farmers<br>Male farmers<br>Total farmers |

*Training video on Sawah System Development*

For the purpose of scaling out a video is proposed that shows farmers the advantage of SSD and that allows farmers to implement it themselves, usually with support of field technicians from CBF, ITRA or the extension services in both countries (CECPA and ICAT). Field technicians of all four institutes are being trained and the video will be provided to them to support sensitization of farmers.

**Target audience**

The audience is farmers, whether already cultivating rice in inland valleys or not.

**Subjects covered in the video**

The following subjects will be included:

| | |
|---|---|
| **Introduction** | Well-designed system & good practices will improve rice yields; 4-5 ton is possible in sawah system. Advantage: fertilizers stay in the fields, good water control/management |
| **Design of sawah system** | using knowledge of topography, placing irrigation canals, drains, fields |
| **Implementation** | creating the canals, bunds, using sticks with different colours |
| **Land levelling** | tools for proper levelling of land, water on the field |
| **Use of powertiller** | |
| **Transplanting** | preparation of seedlings, transplanting in lines, planting distance |
| **Fertilization** | |
| **Credits** | Video by Africa Rice Center, ITRA, CBF - contact details, MAFF |

**Filming location**

Inland valley of Zoungo, close to Ouinhi, is proposed. The inland valley is located next to the road between Ouinhi and Porto Novo. In this inland valley, farmers have developed 11 hectare of sawah system and they are considering further development. Filming must start in November when rice is growing full. The harvest in planned for November/December.

**Languages**

Original/filming language will be French. Subtitles prepared in English. Translation into Fon & Dassa (Benin), Ewe & Kabye (Togo)

**Length of the video**

30-45 minutes, subdivided in chapters/sections that can be shown independently

**Time frame**

September: receiving quotes from producers / companies + selection of company
October: development of script
November–December: filming
December–January: production of the video
January–February: translation in three other languages

## 7.3 Project staff

The SMART-IV project started the third project year with two scientists: Dr Abe (Soil Scientist, Japan), and Dr Zwart (Remote sensing & GIS specialist, Netherlands). Dr Dembélé (IVC coordinator) was regional coordinator development activities.

The recruitment processes for both open vacancies were on-going. Dr Arouna (Agricultural economist, Benin) was recruited as of February 2011. The position water management was advertised and Dr Masiyandima was recruited. However, it was decided she will not work for the SMART-IV project, but focus on other activities. This decision was the immediate outcome of the mid-term review which requested development and research activities and budgets to be better balanced. Water management will now be covered by IWMI with support of Dr Zwart.

Table 24. Senior positions within the SMART-IV project.

| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil scientist | | | | | | | | | | | | |
| PDF Water management * | | | | | | | | | | | | |
| PDF Economy & impact | | | | | | | | | | | | |
| Remote sensing & GIS specialist | | | | | | | | | | | | |
| Development specialist ** | | | | | | | | | | | | |

* A PDF Water Management will no longer be employed by the SMART-IV project. The mid-term review report requested that research and development should be better balanced.

** After the decease of Dr Dembélé, Dr Soklou was appointed as consultant development between May and August 2011. As of September 2011, Dr Soklou is regional coordinator development for the SMART-IV project.

## Annex 1: Mid-term review report, Dr Buri

# MID-TERM REVIEW REPORT

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

2009-2014

Presented to:

The Project Coordinator (Dr. Sander Zwart),

Africa Rice, 01 BP 2031, Cotonou, Benin

Reviewer:

Dr. Mohammed Moro BURI,

CSIR - Soil Research Institute, Kumasi, Ghana

E-mail: moro_buri@yahoo.com

APRIL 2012.

## Table of Contents

**Executive Summary**

"Sawah", Market Access and Rice Technologies for Inland Valleys (SMART-IV) project is a Japanese funded project under the Ministry of Agriculture, Forestry and Fisheries (MAFF). It is a lowland development project being executed by the Africa Rice Center (Africa Rice) in collaboration with other partners. It is expected to benefit several countries including Benin and Togo. The SMART-IV Project goal is to improve the livelihood of the rural poor by reducing imports of rice through exploring the potential of the "sawah" system to increase rice productivity in inland valleys while improving farmers' access to markets and rice technologies in SSA. This is to be achieved through the execution of several work pages under the "sawah" system development procedure. The expected end results are the training of 150-200 farmers, development of 200-300ha of land, farmer guaranteed minimum paddy yield of 4.0t $ha^{-1}$, establishment of 20-30 demonstration sites, site specific management recommendations, production of maps and publications, among others.

However, at the mid-term stage of the project, it was found that on the research side considerable progress has been made, while the development activities are far behind on schedule. During the second stage of the project greater efforts must be put in place if the above goals and outputs are to be achieved. Minimum basic structures for the establishment and effective functioning of "sawah" systems are yet to be fully operational. As a result, a number of recommendations have been put forward with immediate priority placed on farmer organization and land development. More machinery and training for machinery operators is very necessary. This should be followed with advanced exploration of market access for rice being produced. Research should be carried on-farm, site specific management options need to be established and the use of local, available and affordable materials to improve soil fertility should be given much attention.

**Introduction**

The "Sawah", Market Access and Rice Technologies for Inland Valleys (SMART-IV) project is supported by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan. It is a lowland development project being executed by Africa Rice in collaboration with other partners. The Project is expected to immediately benefit both Benin and Togo. It is to cover variable agro-ecological zones across both countries. It commenced in 2009 and the first phase is expected to be completed within five years (2014).

**Terms of Reference (ToR)**

I was hired as a consultant to review the project under the following terms of reference:

1. Review the project based on the five year implementation plan for 2009-2014, and
2. Collect information from annual reports and project updates, and discuss progress and work plans with scientists of the project implementing organizations.

**Review Methodology**

As outlined in the ToR, the consultant had the opportunity to read through one annual report (2010-2011). He had a series of discussions and interactions with project scientists. He went on a field visit to a research site at Bamé, a demonstration site at Aizé and a developmental site at Kaffa-Ouinhi, all in Benin. The consultant also had the opportunity, while on the field, to speak to a farmer at the demonstration site at Aizé and a few other farmers at Kaffa-Ouihhi. Observations made from the field and as reported by both scientists and farmers were weighed against expected outputs. Recommendations were then provided.

**Project Objectives**

The overall goal of SMART-IV is to improve the livelihood of the rural poor by reducing imports of rice through augmenting the production of Inland valleys of Sub-

Saharan Africa (SSA). The project aims to explore the potential of the "Sawah" system to increase rice productivity in Inland Valleys while improving farmers' access to markets and rice technologies in SSA.

**Characteristics of the "Sawah" system**

The "Sawah" system entails good agricultural practices such as construction of bunds around rice fields, soil puddling and levelling of fields in combination with good water management. Thus it 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.

**Project Expected Coverage**

The immediate targeted countries for SMART-IV are Benin and Togo where "Sawah" System Development (SSD) is to take place/established in ten regions (agro-ecological zones) across both countries. Project is expected to be later expanded to cover Liberia and Sierra Leone.

**Working Packages**

In order to achieve its objectives, the project was expected to conduct activities based on the following working packages:

1. Organize workshops for launching meeting and Participatory Learning and Action Research (PLAR) training for rice farmers;
2. Establish satellite villages for SSD according to agro-ecological zones in both countries (Benin and Togo);
3. Develop simple decision-support rules and training materials for SSD based on lessons learned at two original sites in Ghana and Nigeria;
4. Provide training for farmers using PLAR approach in rice technologies;

5. SSD suitability mapping of inland valleys at country level using existing data and additional surveys on bio-physical, socio-economic, technical and eco-environmental factors;
6. Identify site specific constraints and their management options against SSD implementation, rice farming, water and nutrient dynamics at selected sites.

**Expected Outputs**

In conducting or carrying out the above mentioned working activities, the following outputs were expected:

1. Workshops for annual meetings and PLAR training for farmers;
2. Sustainable developments of each 2-3 ha of "Sawah" demonstrations sites in 20-30 satellite villages with minimum rice yields of 4 t $ha^{-1}$;
3. Total area of 200-300 ha will be put under SSD;
4. Total of 150-200 farmers will be trained under SSD;
5. Production of technical manuals and video products on SSD in inland valleys;
6. Farmer-training by PLAR approach for at least 150 agricultural leaders and representatives from various villages having in-use or potential inland valleys for rice production;
7. Suitability mapping, at minimum in 30 selected inland valleys in IVC member countries; and
8. Management options for SSD, rice farming, water and nutrient dynamics in response to site-specific constraints.

**Current Status/Situation (Observations)**

My interactions with project scientists, farmers and field observations made indicate that progress has been made or is being made under research as evidenced by some on-going activities and outputs. However, while efforts are being made to enhance developmental activities, more remains to be done.

*(A) Development*

Comparing the developed working packages against the expected outputs, the following observations were made:

i. More work remains to be done under land development. Only about 1.5ha (less than 1% of minimum targeted area) has been partially developed so far in Benin and cropped as against a target of 200 - 300 ha for both countries. First crop is yet to be harvested and therefore yield figures cannot be quoted, even though research has reported paddy yields of over 4.0 tons per hector.

ii. One demonstration site was established in 2011 in Benin but because of the absence of supporting structures, it did not achieve much as it was not patronized by extension and farmers. This is against a project target of establishing 20-30 demonstration sites.

iii. Currently,

- there are 10 technicians trained on basic SSD principles. However there are no field development officers (only officer currently indisposed) who can liaise and supervise the activities of these technicians and farmers.
- there seems to be no functioning rice farmer-groups in place,
- out of the 10 regions for both countries, only seven (7) sites have been selected so far (4 sites in Benin and 3 sites in Togo),
- selected sites have not yet been characterised (bio-physical/socio-economic),
- farmer sensitization and training is yet to start,
- no land tenancy arrangements have been put in place,

As a result of the absence of the above, no effective field developmental activities could effectively proceed.

*(B) Research*

Major activities under Research include; (i) Land Evaluation, (ii) Agronomy and Soils, (iii) Water management and (iv) Socio-economics. Some progress has been made here as most activities are either at advanced stages and/or some results have already been obtained.

1. Land Evaluation:
    a. Inland valley identification and mapping for both countries (Togo and Benin) at country level is in progress and at various stages of completion.
    b. Suitability and fertility mapping is yet to be done.
2. Agronomy and Soils
    a. Land use changes in soil organic matter dynamics experiments have been established. Some results obtained which are being published.
    b. Plant Nutrient Management options experiments also established. Preliminary results obtained on mineral fertilizers use which have been reported or are being published.
    c. Weed control in relation to water management. Results obtained have been reported in ICCAE
3. Water management

    Work in progress with some results already obtained in relation to "Sawah" system effect on:
    - paddy yield,
    - fertilizer use efficiency,
    - water management improvement.
    - work to soon begin on "Sawah" system effect on water productivity, quality and quantity (availability) along the valley.
    - PhD research on hydrology in inland valley is started up. Contract has been signed by both parties and student has been selected.

4. Socio-economics

Report indicates that some baseline data has been collected from a survey at one site (Bame' in Benin). Baseline information for the other sites is yet to be collected.

**Recommendations:**

*(A) Development*

a. The foundation for SSD is the establishment of basic structures that are necessary for the system to function effectively and efficiently.
b. Field development is central to the success of the project and must therefore be the number one priority for 2012 and 2013 activities.

In order to get the project on track towards achieving its target, goals and objectives, I wish to recommend that the following steps be taken as soon as possible:

a. The few months before the start of the 2012 rice season for each agro-ecology should be used for the establishment of structures for the normal functional of "sawah" systems. There is therefore the immediate need to move into the fields.
b. Care-taker development officer(s) need to be engaged to lead the execution and supervision of field operations. They will also directly supervise the activities of trained technicians. Such operations/activities include:
c. Organization (group formation) and sensitizations of rice farmers
d. Land tenancy arrangements by farmers (project facilitates)
e. Characterizations of selected sites (physical & socio-economic - part of research),
f. Provision of simple tools (mattocks, spades, hoes, guiding ropes, wooden planks) and credit inputs (fertilizers, agro-chemicals) in addition to power tillers (more power tillers may be acquired to quicken the rate of field development)
g. Farmer training, demonstrations and land development must be put together for effectiveness and unity of purpose,
h. For greater impact to be made within the remaining time frame of the project, the number of agro-ecologies in each country may be limited to only areas where rice production is major activity.

i. Begin to look at marketing mechanism/options (project and extension).

j. Deeper involvement of extension staff in field activities (production).

*Note*:

Field work can only be successful with effective coordination and collaboration between staff.

*(B) Research*

Progress has been made under research even though much remains to be done.

I therefore recommend the following:

a. Need to establish fertilizer recommendations specific to agro-ecologies,
b. Possibility of extending organic matter dynamics studies to selected sites across agro-ecologies
c. Possibility of adding soil organic amendments (chicken droppings, cattle/sheep/goats manure, rice straw, rice husk, compost, etc.) based on availability for site specificity under nutrient management)
d. IWMI and other collaborating partners seem to have done a lot on water management in relations to water productivity, quantity and quality along a valley system and therefore further research into such areas should be de-emphasized.
e. Suitability and more importantly fertility maps should be developed for basic baseline information. Suitability mapping based on the site assessment are yet to commence. Soil fertility mapping is critical for developing site specific management options.

**References**

1. "Sawah" Market Access and Rice Technologies for Inland Valleys (SMART IV) Project: Annual Technical Project Report (2010-2011).

## Annex 2: Report of the mid-term project workshop

# Sawah, Market Access and Rice Technologies for Inland Valleys (SMART-IV)

*Mid-term project workshop*

*May 21-23, 2012*
*Cotonou, Benin*

# Introduction

The SMART-IV started its activities in October 2009 and is expected to run for 5 years until September 2014. From May 21-23, 2012 a workshop was held with the following goals:

1. to perform a mid-term review of the project activities, and
2. to discuss, plan and coordinate activities for the remaining half of the project.

The workshop was attended by the project partners from Togo, Benin and Ghana (ITRA, CBF and IWMI respectively), the project scientists and students from AfricaRice, Dr Buri from Soil research Institute in Ghana and two officials from the Ministry of Agriculture, Forestry and Fisheries of Japan. A full list of all participants is available in Annex 1.

The workshop was organized in three days of which one consisted of a field visit to the research site in Bamé and to the development site of Kaffa-Ouinhi. On Monday afternoon presentations were given on the status of development activities in Togo and Benin, and on the mid-term evaluation of the project and recommendations by Dr Buri. Thursday started with four presentations on research progress by Scientists from AfricaRice and the International Water Management Institute (IWMI). Thereafter, the Japanese delegation was given the opportunity to interact with all scientists in short discussion sessions. Parallel, two sessions were organized to 1) coordinate water management research between PhD students, IWMI and AfricaRice, and 2) coordinate and plan development activities and approaches. The workshop ended mid-afternoon allowing participants from Togo and Accra to return. The full program of the workshop in provided in Annex 2.

# Report - day 1

## Morning

The workshop was opened by **Dr Aliou Diagne**, acting Deputy Director. On behalf of our Director General he welcomed all participants, and in special the Mr Kobayashi and Mr Shimokawa, to the Africa Rice Center in Benin.

**Dr Sander Zwart**, project leader, started his presentation by remembering the late Dr Youssouf Dembélé, who died on April 24 after a long period of illness. Dr. Dembélé was regional coordinator of the development section of the SMART-IV project and was leading it since July 2011. Dr Dembélé will be remembered as a dedicated member of the project team.

Zwart further explained the review process, the budget for next year and the capacity building within the project. The review process has the aim to evaluate the past activities and to provide recommendations and changes in the project goals and output where needed. An internal review was conducted by Dr Buri from SRI from Ghana. Dr Buri has long experience with Sawah System Development and with collaboration with Japanese partners (JICA, Prof Wakatsuki, etc.). Dr Buri visited AfricaRice and discussed with scientists, collaborators and visited the research and development sites in early April. His internal review document was presented to the donor on April 17. Some of his major findings were:

- Research has made considerable progress but not everywhere.
- New research should be on on-farm experiments, site-specific options needs to be explored and focus on soil fertility improvement with locally available and affordable materials
- Development activities are far behind on schedule and must be pushed in order to research the expected outputs (EO) of the project.

In order to respond to the recommendations from the internal review, some immediate actions taken:

1. Dr Worou Soklou from Togo was hired as consultant to work fulltime on Sawah System Development until the end of August. His target is to develop 20 ha of demonstration farms by end of August.
2. New powertillers will be ordered in June to support the development activities.
3. A better balance between research and development will be established. The Researcher water management will no longer be recruited for SMART-IV project and funds will be made available to CBF and ITRA to hire two consultants to assist in development activities.

The budget of the SMART-IV project for next year is 602,000 US$, slightly lower than previous year. Contracts with the partners will be prepared in June. Budgets will be reduced proportionally.

Finally, Zwart presented capacity development activities. Three PhD students will be working on the project. One position will be financed by the SMART-IV project. Mr Alexandre Danvi is admitted in Bonn University and is expected to start in July. Two other positions are financed by the WASCAL project and will be attached to the project. Limited funds may be made available if required. Mr Maurice Ahouansou from Benin and Mr Maléki Badjana from Togo will be working on 'Hydrological modeling of water availability for rice-based systems in inland valleys under climate change' in Benin and Togo respectively. Four students are working in the project:

- Maurice Mondegnon (Benin), University of Parakou (Benin ), topic: water productivity in sawah systems, will finish June 2012
- Andre Kindjinou (Benin), University of Abomey-Calavi (Benin), topic: inland valley mapping and assessing the agricultural intensity, started January 2012
- Bjorn Nikolaus (Germany), University of Kiel (Germany), topic: hydrological modeling and application of AquaCrop model – started March 2012
- Gertrude Tognite (Benin), University of Rennes (France), topic: soil fertility in sawah systems), started March 2012

A successful Sawah System Development training was held in Kumasi for ten extension officers who will develop sawah in and demonstration sites in Benin and Togo. The officers are employed by ITRA's extension service and by SECPA, the national extension service in Benin. The training was held in November/December 2011 and supervised by Dr Abe, Dr Dembélé and Prof Wakatsuki.

Further SSD training is foreseen for farmers using on the job training of SSD, whereas 7 farmers have been trained in the SSD site of Kaffa-Ouinhi.

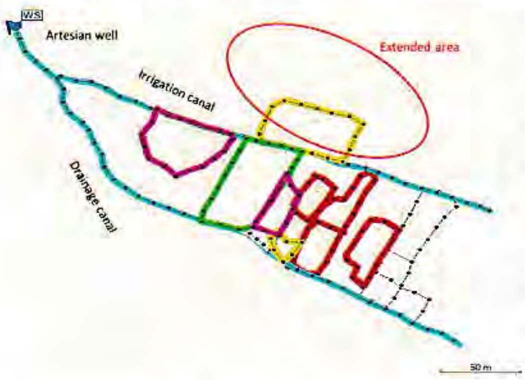

## <u>Afternoon</u>

The afternoon session focussed on Sawah System Development. Presentations were given by Mrs Houngbadji of ITRA, Mr Gbaguidi of CBF and Dr. Buri of SRI.

**Mrs Houngbadji** outlined the importance of lowland rice ecology in Togo. About 60% of the total rice production stems from lowland rice production whereas the total potential is estimated at around 175,000 ha. The systems are in general less than 20 ha in size and about 90% of the lands are not managed.

A total of seven sites have been selected across Togo (see figure right). The sites of Kpele-Tutu and Sodo have been characterised so far. In both inland valleys lands are owned by several families. Rice can be cultivated twice a year. Farmers pay 3000FCFA per field (25x25m2) in Kpele-Tutu, while in Sodo farmers pay 1/3 of their yield. Land preparation has been conducted with farmers as well as the construction of drains and bunds. Sites selection and validation has been finished.

**Mr Gbaguidi** outlined the need to develop inland valleys in Benin. There is a potential of 205,000 ha and between 1957 and 1970 around 9,700ha were equipped with irrigation infrastructure. Nowadays less than 600 ha are used due to low involvement of farmers and low levels of knowledge on the irrigation infrastructure and management.




A total of seven inland valleys were selected and evaluated for SSD: Aïzè, Zoungo and Kaffa (Ouinhi municipality), Kpakpaza (municipality Glazoué), Koroborou (municipality Parakou), Tikou-Darou (municipality Kouandé ) and Lahotan (municipality Savalou). In the Site of Kaffa-Ouinhi 1,5ha were developed so far (see figure right), but the potential is more than 20ha. The site is suitable due to the availability of water throughout the year (artesian well), however farmer organization appears to be weak. Currently a total of 6 farmers are working on SSD.

**Dr Buri** ended the afternoon session with a review and discussion of the progress made in the SMART-IV project. His work is based on the mid-term review that he conducted in April 2012. His main conclusions are that 1. Progress has been made under research as evidenced by some on-going activities and outputs, but that 2. while efforts are being made to enhance developmental activities, a lot more remains to be done. Only 1% of the 200ha SSD aimed by the end of the project has been reached and only 1 site has been established.

Several recommendations are made regarding development and research activities including the recruitment of development care-takers, preparation of land-tenure agreements and providing of on the job training of farmers. Next, marketing mechanisms must be assessed together with extension services to assure that farmers can sell their products.

# Photos - day 1








# Report – day 2: terrain visit Bamé and Kaffa-Ouinhi

During a one-day field mission two sites were visited. First, a stop was made at Ouinhi to visit the development site of Kaffa. In this site 1.5 ha is developed together with 6 farmers. In a participatory process land was cleared, irrigation infrastructure was designed and constructed. Water is provided from an artificial well and allows irrigation throughout the year. Nerica-19 was planted three months before the visit and harvest was planned for two weeks later. Farmers expressed their gratitude to the project and indicated that they site can be extended to more than 10 ha. However, marketing of their product is still an issue.

The second site that was visited is the research site of Bamé. Here 0.5 ha is developed and research is conducted to assess the influence of good water management and soil fertility on crop yields. A comparison is made between a traditional system and a sawah system. Farmers work on the site and have been trained on the job in SSD. On the borders of the experimental site, farmers have extended the area and perform good agricultural practices.

# Photos – day 2: terrain visit Bamé and Kaffa-Ouinhi

Research site in Bamé

Demonstration of hydrotiller

Rice field covered with nets to prevent birds

# Report – day 3

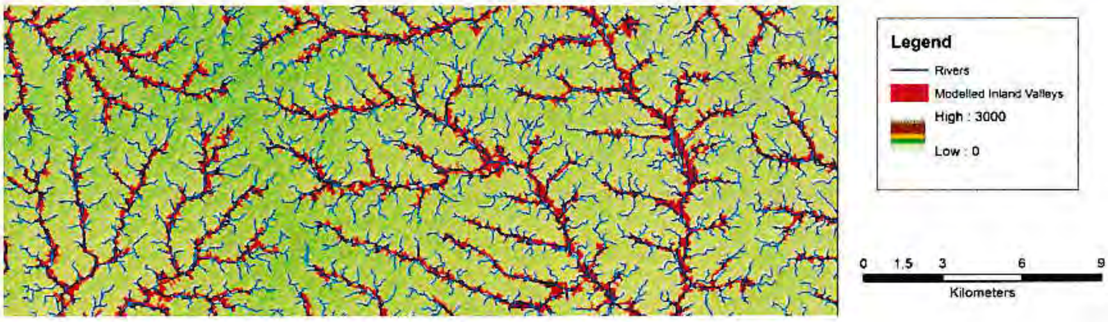
Day three was divided into two sessions: a research session with four presentations regarding sawah systems and parallel discussion sessions.

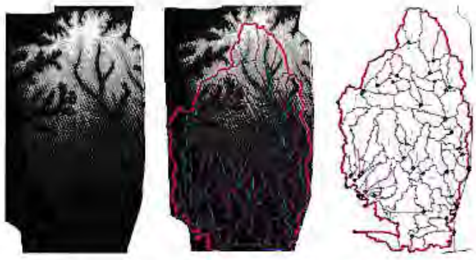
**Research sessions**

**Dr Abe** presented the progress and outlook of fie research targets for the project which are related to soil fertility. Soil fertility experiments were conducted with soils of 25 inland valleys sampled throughout Benin. The fertility was assessed using a pot experiments and comparisons were made with counterpart upland soils. To assess Nutrient Use Efficiency under traditional and Sawah farming systems a field experiment with a complete block design will be set up in Ouinhi. Thirdly, pot experiments were made to assess the role of plant nutrient management during abiotic stresses of iron toxicity and drought. Silicon was applied and different varieties were evaluated to assess their performance (see an example in the figure above). Fourthly and fifthly, plans were presented to investigate the dynamics of soil organic matter in inland valleys systems and to develop a decision-making support system (DSS)for Sawah Development.

Bouake189, -Si x drought Bouake189, +Si x drought

**Dr Zwart** presented the work of spatial inventory of inland valleys using remote sensing data and a methodology to assess the potential for development. Using a Digital Elevation Model (DEM) from Aster satellite (NASA/JPL) stream flow patterns were derived using slopes and flow direction. Thereafter the altitude of the stream at each point was determined and surrounding areas with same elevation or 1-2 meter higher were defined as inland valleys using transect. Validation of the method is on-going, but first results look promising (see figure below). Two validation data sets will be used, which are those of the IMPETUS project: +/- 100 digitized inland valleys from Benin and a field survey is established for collecting field data with GPS, 50 in Benin and 50 in Togo.

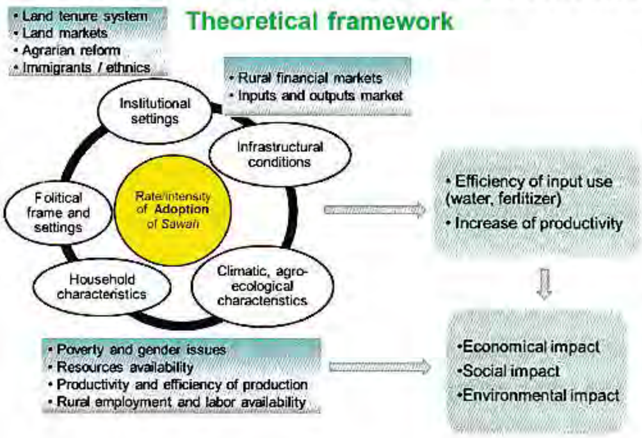




DEM Watershed Delineation Sub-basin generation

**Dr Kizito** of IWMI presented the plans and activities related to water management and hydrological modelling. The goal of this work is to investigate the impact of Sawah system Development on the water resources in terms of water quality and quantity. Two basins will be used as pilot studies: the Zou basin in southern Togo and the Ouémé basin in Central Benin. Major challenges will be the data availability in both areas and a request was made to contribute as much as possible. Once the SWAT model is calibrated the outputs will feed the WEAP model which allows making proper allocation and analysing scenarios. The example on the right shows delineation of river catchments and stream flows based on a digital elevation model.

Finally, **Dr Arouna** outlined the plans and progress for the socio-economic activities to assess the impact and adoption of Sawah system by rice farmers. Expected outcome is that the economic, social and environmental impact derived from the Sawah system will be determined while monitoring the local socio-economic and environmental enablers and constraints. A theoretical framework was presented that places SSD within the context of the value chain of rice production. On-going activities include a baseline survey in the demonstration/ development areas with respect to socio-economic conditions, land tenure systems, land market, labour availability and use, traditional soil and management, productivity, and market assess. For 2013 activities were presented that focus on farmers' perceptions of SSD and the willingness by rice farmers to adopt.




**Discussions sessions**

Water management discussions:

- The Zou basin in Togo will not be analysed, but instead the Oti basin in northern Togo, which feeds in Lake Volta, Ghana. Data availability is higher and the basin is water stressed, which makes it challenging for rice intensification through SSD. Several weather stations are available as well as discharge measurements.
- Kizito will work closely together with two PhD students who work in the same area: Mondegnon (Benin) and Maléki (Togo).

Development discussions:

- The recommendations of Dr Buri were discussed. The role of development officer at AfricaRice will be fulfilled by Dr Worou who has long-term experience in development of inland valleys for agricultural production.
- Budgets will be adjusted so that in each country a care-taker for the northern areas can be recruited. This allows continuous support to SSD activities.
- Trainings will be organized for the SSD technicians on site selection and participatory implementation of SSD.
- SSD works will be started up as soon as possible under lead of Worou.

No reports are given here on the one-to-one discussions of project members with the Japanese delegation.

Mr Shimokawa thanked the participants and stressed the importance of commencing the development activities since they are behind on schedule. Another important subject is the importanceto link research to the development activities.

At approximately 3pm the workshop was closed by Dr Zwart. The audience was thanked for their participation and contributions.

## Photos - Day 3




# Annex 1: List of participants

| | Participant | Affiliation | Position |
|---|---|---|---|
| 1 | Mr Takanobu Kobayashi | Ministry of Agriculture, Forestry and Fisheries of Japan | Director for International Trade Policy Negotiations, International Cooperation Division, International Affairs Department |
| 2 | Mr Hiroaki Shimokawa | Ministry of Agriculture, Forestry and Fisheries of Japan | Deputy Director, International Cooperation Division, International Affairs Department |
| 3 | Dr Sander Zwart | AfricaRice, Benin | Project leader<br>Researcher Remote Sensing and GIS |
| 4 | Dr Shin Abe | AfricaRice, Benin | Researcher soil fertility |
| 5 | Dr Aminou Arouna | AfricaRice, Benin | Researcher Agricultural Economics |
| 6 | Dr Koichi Futakuchi | AfricaRice, Benin | Researcher Agro-physiology |
| 7 | Dr Worou Soklou | AfricaRice, Benin | Consultant development |
| 8 | Dr Moro Buri | Soil Research Institute, Ghana | Consultant mid-term review |
| 9 | Dr Fred Kizito | International Water Management Institute (IWMI), Ghana | Researcher Hydrology |
| 10 | Mr Felix Gbaguidi | Cellule Bas-Fonds (CBF), Benin | National coordinator |
| 11 | Dr Adou Alimi | Institut Togolais de Recherche Agronomique (ITRA), Togo | National coordinator |
| 12 | Ms Tossimide Houngbadje | Institut Togolais de Recherche Agronomique (ITRA), Togo | Researcher |
| 13 | Mr Alexandre Danvi | Cellule Bas-Fonds (CBF), Benin | Field observer Bamé research site<br>PhD student Bonn University (July 2012) |
| 14 | Ms Gertrude Tognite | University of Rennes, France | MSc student soil fertility |
| 15 | Mr Bjorn Nikolaus | University of Kiel, Germany | MSc student crop & water modeling |
| 16 | Mr Maléki Badjana | University of Abomey-Calavi, Benin | PhD student hydrology & climate change |

*From left to right*: Maléki Badjana , Shin Abe, Felix Gbaguidi, Tossimide Houngbadje, Fred Kizito, Takanobu Kobayashi, Worou Soklo, Hiroaki Shimokawa, Koichi Futakuchi, Sander Zwart, Bjorn Nikolaus, Aminou Arouna, Alexandre Danvi, Gertrude Tognite, Moro Buri

# Annex 2: Workshop program

## Sunday May 20

| | | | |
|---|---|---|---|
| | arrival of participants to Cotonou | Ms Carine Kan | AfricaRice |

## Monday May 21

| | | | |
|---|---|---|---|
| **11:00-11:30** | **Coffee + registration and welcoming of visitors** | Ms Carine Kan | AfricaRice |
| 11:30-11:40 | opening of the workshop | DDG or acting | AfricaRice |
| 12:00-12:30 | outline of the workshop and SMART-IV project update | Dr Sander Zwart | AfricaRice |
| **12:30-13:30** | **Lunch break** | | |
| 13:30-14:15 | development update: activities and status in Togo | Dr. Adou Alimi | ITRA |
| 14:15-15:00 | development update: activities and status in Benin | Mr Felix Gbaguidi | CBF |
| **15:00-15:30** | **Coffee break** | | |
| 15:30-16:00 | recommendations form the mid-term review | Dr. Moro Buri | SRI |
| 16:00-17:00 | discussion on the way forward, priority setting | Dr. Moro Buri | SRI |
| **19:00-21:00** | **dinner in Taranga restaurant** | **Dr Sander Zwart** | **AfricaRice** |

## Tuesday May 22

| | | | |
|---|---|---|---|
| 08:00-11:00 | travel to Bamé research site | | |
| 11:00-12:00 | visit research site Bamé | Mr Alexandre Danvi | CBF |
| 12:-0-12:30 | travel to development site in Ouinhi | | |
| **12:30-13:00** | **lunch** | | |
| 13:00-14:00 | visit to development site Ouinhi / Ayize | Dr Shin Abe | AfricaRice |
| 14:00-17:00 | return to Cotonou | | |

## Wednesday May 23

| | | | |
|---|---|---|---|
| 09:00-09:30 | Research update: soil fertility | Dr Shin Abe | AfricaRice |
| 09:30-10:00 | Research update: GIS & remote sensing | Dr Sander Zwart | AfricaRice |
| 10:00-10:30 | Research update: water management | Dr Fred Kizito | IWMI |
| 10:30-11:00 | Research update: socio-economics and impact | Dr Aminou Arouna | AfricaRice |
| **11:00-11:30** | **Coffee break** | | |

**parallel session 1 (11:30-14:30)**

| | | | |
|---|---|---|---|
| 11:30-12:30 | discussion: water team: Danvi, Nikolaus, Kizito, Zwart, Badjana | Dr Sander Zwart | AfricaRice |
| **12:30-13:30** | **Lunch break** | | |
| 13:30-14:30 | discussion: development team: Soklou, Buri, Gbaguidi, Alimi, Zwart | Dr Sander Zwart | AfricaRice |

**parallel session 2 (11:30-14:30)**

| | | | |
|---|---|---|---|
| 11:30-11:50 | discussion with Japanese delegation: development Togo | Drs Alimi and Soklou | AfricaRice |
| 11:50-12:10 | discussion with Japanese delegation: development Benin | Drs Gbaguidi and Soklou | AfricaRice |
| 12:10-12:30 | discussion with Japanese delegation: economics | Dr Aminou Arouna | AfricaRice |
| **12:30-13:30** | **Lunch break** | | |
| 13:30-13:50 | discussion with Japanese delegation: soil fertility | Dr Shin Abe | AfricaRice |
| 13:50-14:10 | discussion with Japanese delegation: water management | Dr Fred Kizito | IWMI |
| 14:10-14:30 | discussion with Japanese delegation: remote sensing/GIS | Dr Sander Zwart | AfricaRice |
| 14:30-15:30 | closing of the workshop | Dr Sander Zwart | AfricaRice |
| **15:30-16:00** | **Coffee break** | | |
| 16:00-17:00 | meeting project leader / MAFF mission | Dr Sander Zwart | AfricaRice |
| 17:00-18:00 | return to hotel | | |

## Thursday May 23

| | | | |
|---|---|---|---|
| 08:00-08:30 | travel hotel to JICA | | |
| 08:30-09:30 | meeting JICA | Dr Shin Abe | AfricaRice |
| 09:30-10:00 | travel JICA to Japanese Embassy | | |
| 10:00-11:00 | meeting Japanese Embassy | Dr Shin Abe | AfricaRice |
| 11:00-11:30 | travel to research station | | |
| 11:30-12:30 | tour of the research station | Dr Koichi Futakuchi | AfricaRice |
| **12:30-13:30** | **Lunch break** | Dr Futakuchi & Abe | AfricaRice |
| **18:30-20:30** | **dinner Japanese MAFF delegation with Japanese** | **Dr Koichi Futakuchi** | **AfricaRice** |

## Annex 3: Photographic impression of SSD in the demonstration sites in Benin

### **Todjotin** (Glazoué, Zou-Collines)

June 14, 2012

July 25, 2012

July 25, 2012

September 1, 2012

September 1, 2012

October 1, 2012

October 1, 2012

# **Koroborou** (Parakou, Borgou-Alibori)


June 11, 2012


June 12, 2012


June 13, 2012


June 26, 2012


July 26, 2012


September 1, 2012


October 1, 2012


October 1, 2012

## **Kpakpaza** (Glazoué, Zou-Collines)

May 26, 2012

June 28, 2012

June 28, 2012

July 28, 2012

July 28, 2012

September 3, 2012


September 3, 2012


September 3, 2012


October 3, 2012


October 3, 2012

# **Zoungo** (Ouinhi, Zou-Collines)

May 25, 2012

June 26, 2012

July 18, 2012

July 18, 2012

July 28, 2012

September 4, 2012


September 4, 2012


September 4, 2012


October 4, 2012


October 4, 2012


October 3, 2012

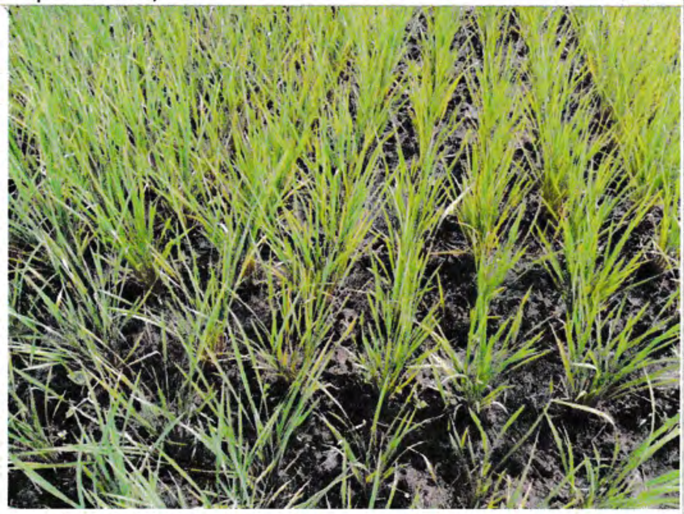
# **Agosou** (Ouinhi, Zou-Collines)

September 4, 2012

September 4, 2012

September 4, 2012

September 4, 2012



October 4, 2012

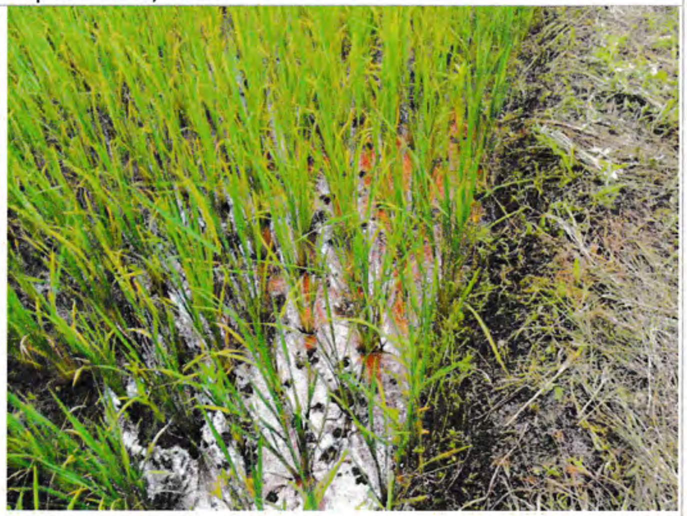
October 4, 2012

## **Kaffa** (Ouinhi, Zou-Collines)

September 5, 2012

September 5, 2012

September 5, 2012



September 5, 2012

## Annex 4: Photographic impression of SSD in the demonstration sites in Togo

# **Atchangbadé** (Kozah, Kara)

May 17, 2012

July 4, 2012

July 5, 2012

July 3, 2012


August 14, 2012


August 30, 2012


September 29, 2012


September 29, 2012


September 29, 2012


September 29, 2012

## Annex 4: Photographic impression of SSD in the demonstration sites in Togo

# **Atchangbadé** (Kozah, Kara)

May 17, 2012

July 4, 2012

July 5, 2012

July 3, 2012

# **Gnatre** (Kozah, Kara)

July 4, 2012

July 4, 2012

July 4, 2012

July 6, 2012

August 13, 2012

August 15, 2012


August 30, 2012


August 30, 2012


September 29, 2012


September 29, 2012


September 29, 2012


September 29, 2012

## **Kawa** (Kozah, Kara)

June 7, 2012

July 6, 2012

July 6, 2012

July 4, 2012

August 13, 2012

August 13, 2012


August 30, 2012


August 30, 2012


September 29, 2012


September 29, 2012


September 29, 2012

# **Tchanganidè** (Blitta, Centrale)

June 9, 2012

June 9, 2012

June 9, 2012

July 7, 2012

August 17, 2012

August 17, 2012


August 29, 2012


August 29, 2012


September 28, 2012


September 28, 2012


September 28, 2012

# **Sodo** (Kpele, Plateaux)

May 18, 2012

July 9, 2012

July 9, 2012

July 9, 2012

August 11, 2012

August 11, 2012


August 11, 2012


September 25, 2012


September 25, 2012


September 25, 2012

# **Kpélé-Tutu** (Kpele, Plateaux)

July 10, 2012

July 9, 2012

August 18, 2012

August 18, 2012

September 25, 2012

September 25, 2012


September 25, 2012

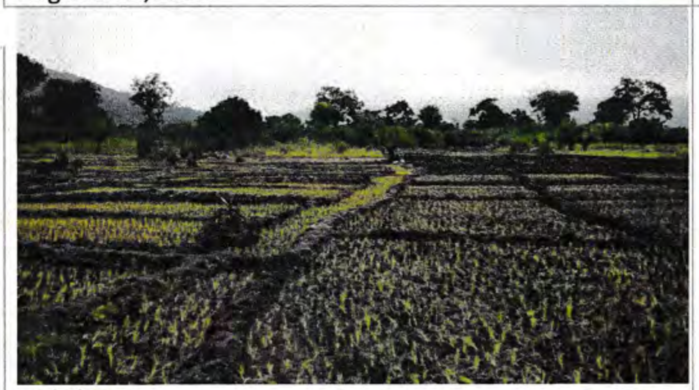
# **Bémé2** (Kpele, Plateaux)

August 8, 2012

August 8, 2012

Augusut 10, 2012

August 10, 2012



18/8/2012

18/8/2012


18/8/2012


18/8/2012


August 28, 2012


August 28, 2012


September 25, 2012


September 25, 2012


September 25, 2012


September 25, 2012