SOIL RESEARCH INSTITUTE (GHANA)/KINKI UNIVERSITY (JAPAN) JOINT STUDY PROJECT.

ANNUAL REPORT FOR 2006 AND OUTLINE OF ACTIVITIES FOR 2007

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1.0: INTRODUCTION

The CSIR- SRI (Ghana)/Kinki University (Japan) joint study project was established with an overall objective of bringing about food security to Ghana in particular and the West African sub-region in general through increased and sustained production of rice. The project hopes to achieve this objective through (i) increased and sustainable rice production, (ii) restoration of degraded environment through the conservation of soil, water & forest, and (iii) increase in rural income and improvement in rural livelihood, In line with the above, a number of activities were either continued or initiated during year 2006 towards realizing the key objectives of the project. Activities undertaken during the year included:

(i). Hydrological flow characteristics of various rivers in Benchmark sites

(ii). Soil fertility and water management under “sawah” systems

(iii). Evaluation of sustainable rice-based cropping systems in the Inland valleys under “sawah” system.

(iv). Continuation of the preparation of the guide to “Sawah” development and rice cultivation for the Inland Valleys

(v). Training of farmers and Ministry of Food and Agriculture (MoFA) extension staff.

From experiences gathered during the year from both field visits and from farmers, certain pertinent problems facing rice farmers and hindering the rapid adoption of the “sawah” technology were identified. These included effective land preparation, luck of field machinery for new sites, low technical know-how and back stocking of established “sawah” sites particularly at Adugyama and Biemso I. Proposed ways of addressing the above problems have been included in the way forward as an outline of activities for the year 2007.

2.0: Hydrological Characteristics and Water Quality of Rivers in Benchmark Sites

A two-year study of the surface and soil hydrology of the Mankran Watershed was undertaken to assess the potential of their valleys for 'Sawah' expansion. This activity which started in the minor seasons of 2005 was continued during 2006.

The main objective of the study was to evaluate the quantity of water available in the Mankran catchments and their quality for the expansion of irrigated rice production by assessing their main-d'eau in the form of their discharges and their nutrient content respectively. And to also assess the suitable soil textures and hydraulics for water retention. The parameters that were looked at in the study were

(i) the discharges of he rivers and their potential irrigable area

(ii) the seasonal variation in the discharges

(iii) the flood regimes of the rivers

(iv) the cycle of changes in the water volume of the rivers and the period of steady flow.

(v) the best time for planting rice during the minor wet season.

(vi) The plant nutrient content of irrigable water.

(vii) The textural classes and hydraulic conductivities of predominant soils.

The discharges of the rivers and their potential irrigable area:

The study classified the rivers as;

1. Annual rivers that flow throughout the major and the minor wet seasons and only dry up at the peak of the dry season between Mid January to Mid March. These rivers are Mankrankese, Biem and Dwinyan.

2. Seasonal rivers that flow in the major and the minor season dry but up during the minor season drought in August and the main dry season of December to April. These rivers are Mankrankuma and Asikesu .
3. Ephemeral rivers that stop flowing just after two weeks of no rains either in the major or the minor seasons. These are Aponapon and Punpunya.

The stream size of the rivers in terms of their discharge is provided in the tables below.

Stream size of rivers and their discharge - Annual Rivers

	Peak Discharge (Flood flow)		Steady flow Discharge	
River	2005	2006	2005	2006
Mankran lower	24.3 m³/s	12.4 m³/s	3m³/s	3m³/s
Course	(24,000 l/s)	(12100 l/s)	(3000 l/s)	(3000 l/s)
Mankran (Middle)	10.6 m³/s	5.5 m³/s	2m³/s	2m³/s
			(2000 l/s)	(2000 l/s)
Biem Lower	6.67m³/s	6.1m³/s	2m³/s	2m³/s
	(6670l/s)	(6100l/s)	(2000 l/s)	(2000 l/s)
Dwinyan lower	3 m³/s	3 m³/s	0.5m³/s	0.5 m³/s
	(3000l/s)	(3000l/s)	(500l/s)	(500l/s)

Stream size of rivers and their discharge - Seasonal Rivers

	Peak Discharge (Flood flow)		Steady flow Discharge	
River	2005	2006	2005	2006
Asikesu	2 m³/s	2 m³/s	0.5m³/s	0.5m³/s
	(2000l/s)	(2000l/s)	(500l/s)	(500l/s)
Mankrankuma	2.2m³/s	2.2m³/s	1m³/s	1m³/s
	(2200l/s)	(2200l/s)	(1000l/s)	(1000l/s)

It has been documented by Roscher K. (1994). that the operational stream size a small-scale farmer can effectively handle at field level (main –d'eau) is between 15l/s to 35l/s. This indicates that with an effective rainfall of over 500mm in the period of August and December both the annual and the seasonal rivers can supply enough water for irrigated rice production.

Fortnight cumulative rainfall (mm) for the study period

	Month									
	August		September		October		November		December	
	05	06	05	06	05	06	05	06	05	06
Ist half	9.7	10.9	10.5	55.6	106.7	141.3	57.6	35.3	10.0	60.8
2nd half	27.9	45.4	188.5	133.4	75.3	60.5	42.0	0	0	0
Total	37.6	56.3	199.0	189.0	182.0	206.3	99.6	35.3	10.0	60.8

Water quality of some of the rivers for 2006

	Parameter							
River	pH	TN (mg/L)	P (mg/g)	K (mg/g)	Na (mg/kg)	Ca (mg/L)	Mg (mg/L)	Fe (mg/kg)
Asikesu	7.2	0.21	0.10	19.9	40.0	51.3	30.1	
Mankrakuma	7.1	0.41	0.07	8.2	9.9	22.4	16.0	-
Dwinyan	6.8	0.44	0.27	7.10	10.8	16.2	12.6	-
Biem	7.1	0.52	0.34	3.5	7.8	9.8	6.8	10.0
Mid Mankran	7.0	0.21	0.46	4.5	8.7	10.8	6.6	-
Lower Mankran	7.1	0.44	0.75	5.9	8.2	18.8	10.8	15.0

After the two-year study, a paper was presented at the 4th International conference for African Soil Science Society (ASSS) in Accra, Ghana from January 7th – 13th 2007. The summary of the paper is given below

Hydrological Characteristics and Water Quality of Rivers in the Mankran Watershed for "Sawah" Rice Production.

Oppong J.[1] Buri M.M.[1] and Wakatsuki T.[2]
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With the development and introduction of the 'Sawah' technology of rice production for the lowlands, Ghana has the potential to produce rice like any of the countries it imports the commodity from. Rice is produced mainly under rain fed conditions in the country. The country has abundant rivers, streams and springs whose water can be harvested easily at lesser irrigation cost through the "Sawah" system. This study assessed the hydrological characteristics of the Mankran River and its major tributaries in the Ahafo Ano South district of Ashanti, Ghana in terms of water quality and quantity available for "Sawah" expansion.

The study identified the Lower Mankran and the Biem rivers as the most reliable in terms of time of recharge, quantity of water, their perennial nature as well as consistency of discharge during dry spells. All the rivers produced their peak discharge between mid-September to mid-October. The Lower Mankran and the Biem rivers by the end of October gave discharges of 2988mm/hr/ha and 1080mm/hr/ha respectively that meet the water requirement of the entire growth period of a rice crop including that of land preparation. This rough estimate implies that steady flow of these two rivers at the end of October gives discharge that for only one hour can supply the water need of rice crop from land preparation to maturity.

Analysis of water sample for pH, total N, Phosphorus and some cations indicated that the rivers are all neutral with a pH range of 6.3 to 7.9. The concentration of the cations although low will supplement soil nutrient supply when water from these rivers is used in the production of irrigated rice.

3.0: Soil Fertility and Water Management Under "Sawah" Systems

Work continued during the year on ways and means of developing simple but sustainable nutrient and water management options under the "sawah" systems. To this end, field experiments were conducted to determine the effect of different rice growing environments, including the "sawah" system on rice growth and yield. Partial results of this experiment are presented below. It is worth mentioning that, theses experiments started quite late due to the late arrival of funds. This coupled with the sudden ceasure of the rains, greatly affected crop performance and hence field results. Other activities undertaken included (i) assessing the impact of the "sawah" system on farmers yield and income, (ii) its effect on soil fertility maintenance and (iii) problems hindering the rapid adoption of rice cultivation in general in the country were also looked at. Two papers were presented at the International Soil Science conference organised by the African Soil Science Society in Accra, Ghana. Jan. 7th – 13th, 2007. Extended summaries of those papers are also presented here.

3.1: Effect of rice growing environment on the growth and yield of four rice varieties

Issaka, R. N., Buri, M. M. and Wakastuki, T.

Introduction

Annual high importation of rice to satisfy ever-growing demand is not the best for the country. Encouraging farmers to produce rice efficiently will ensure self-sufficiency in rice, provide employment and better the economic status of farmers. Generally water, variety and fertilizer influence rice production. With a good understanding of these relationships, better production systems can be developed for efficient rice production in the country. This study is part of the on-going effort to ensure that the country cuts down the huge importation of rice through better production practices. The study examines the effect of various rice-growing environment on the yield of different rice varieties.

Methodology

The experiment was established in 2006 at Biemso No. 1. A split-split plot design with three replications was employed. Main plot treatments: Four rice growing environment

1. Farmer's environment (rice grown under normal farmer's practices)
2. Bunded no levelling: (bunds are constructed to retain water but rice field is not levelled.
3. Bunded and levelled (rice field bunded and levelled but no irrigation)
4. Sawah (bunded, puddled and levelled rice field with irrigation and drainage facilities

Subplot treatments consist of two levels of fertilization:

1. No fertilizer
2. Fertilizer application (80-60-60 kg/ha N-P_2O_5-K_2O)

Sub-subplot treatments consisted of four rice varieties:

(i) Buouke 189 (medium maturing rice); (ii) Jasmine 85 (early maturing rice)

(iii) Sikamo(medium maturing rice); (iv) Wita 7 (medium maturing rice)

All the rice varieties were initially nursed and later transplanted at 20 x 20 cm at three seedlings per hill. Half of the nitrogen and all phosphorus and potassium were applied a week after transplanting. The remaining nitrogen was applied five weeks after transplanting.

The experiment was started late (date of planting 13-10-2006) and coupled with early stoppage of the rain the whole field was irrigated periodically. The dry period was so severe that the rate of irrigation was not enough to ensure normal rice growth.

Results

Grain yield and other yield parameters are generally very low due to the conditions explained in the methodology. Fertilization did not result in increases in either grain or stover yield (Table 1). Climatic factors were too hash to allow for efficient use of fertilizer

Table 1. Effect of fertilizer on grain yield (t/ha) and other yield parameters

Fertilizer	Grain yield	Stover yield	No of pan./plt
Fertilized	3.95a	4.35a	11.5a
No-Fertilizer	3.70a	4.18a	10.4b

Within a column numbers followed by similar letter(s) are not significantly different at the Standard error level of significance.

Table 2. Effect of rice growing environment on selected yield (t/ha) parameters

Environment	Grain yield	Stover yield	No of pan/plt
Farmer's	3.21b	3.82b	10.4b
Unlevelled	3.90a	4.31a	11.0a
Levelled	3.92a	4.28a	11.2a
Sawah	4.25a	4.34a	11.1a

Table 2 shows grain yield and other yield parameters as affected by rice growing environment. All the rice fields that were bunded (unlevelled, levelled and "sawah") gave similar but higher grain and stover yields than the farmer's environment. Number of panicles for these three environments were also higher. Water for rice growth was basically from irrigation hence the similarity for all the bunded fields. Water lost due to run off was very high under the farmer's environment and explains the lower yield for this environment.

Table 3. Selected yield parameters of four rice varieties

Variety	Grain yield (t/ha)	Stover yield (t/ha)	No of pan/plt	Plant height (cm)
Buouke 189	4.39a	4.5bc	10.8a	109a

Jasmine 85	3.95ab	4.2c	10.9a	91b
Sikamo	3.19c	5.2a	11.2a	111a
Wita 7	3.77b	4.8ab	10.9a	110a

Under normal conditions and with fertilization the medium maturing varieties can give over 6.0 t/ha paddy. Paddy yield was generally very low. Of the four varieties Sikamo seems to be less tolerant to draught. Grain yield was significantly lower than the other varieties (Table 3). Stover yield for Sikamo was relatively better than some of the varieties indicating that the harvest index was very low giving the prevailing climatic conditions. Rice plants were generally shorter than normal. The medium maturing varieties were taller than the early maturing variety.

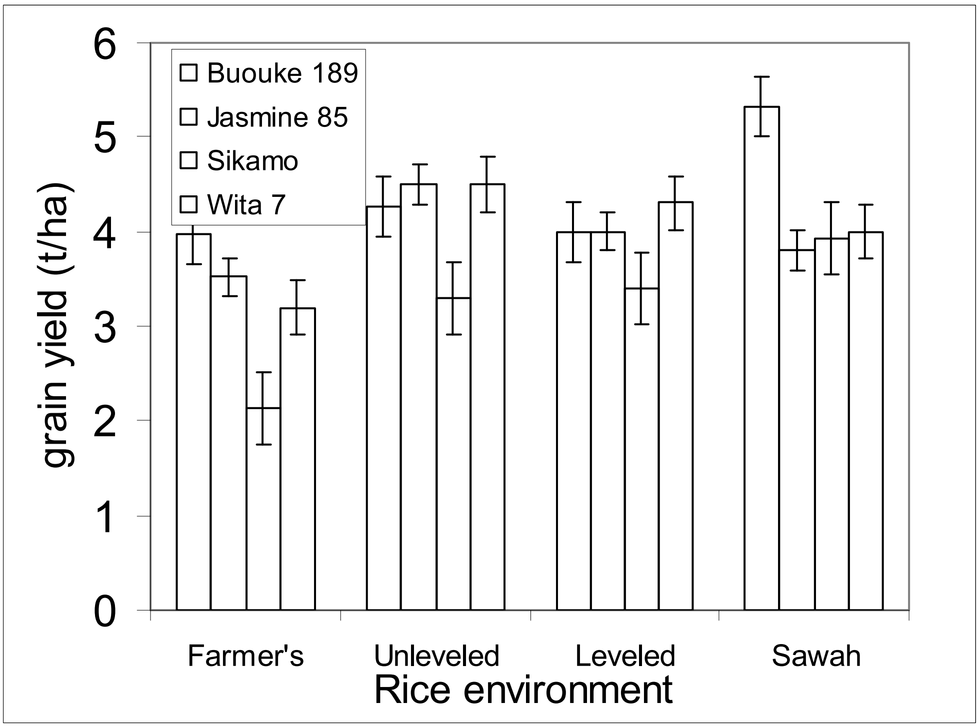

Figure 1. Effect of interaction between environment and rice varieties on grain yield

Figure 1 shows the behaviour of the varieties under the various conditions. Even though all the varieties performed poorly under the farmer's environment, Sikamo was affected most. Grain yield for Sikamo was significantly low. Wita 7 and Jasmine seem to be stable under the three bunded conditions while Buouke 189 reacted positively producing the highest yield under "Sawah" conditions. It is important to repeat this study under normal climatic conditions for better understanding of environment x variety interaction.

3.2: The "Sawah" technology of rice production for the lowlands: An effective tool for poverty alleviation in southern Ghana.

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The "sawah" technology primarily involves the creation of an environment that effectively and efficiently controls water for rice production by bunding, puddling and levelling, with inlets and outlets connecting irrigation and drainage systems.
The main objective for the introduction of the "Sawah" system is to ensure food security and reduce rural poverty through increased and sustained rice production. This paper reports on the sustainability and adaptability of this new system of rice production for rural poverty alleviation in Southern Ghana.

The study was conducted in the Ahafo Ano South District of Ashanti region**.** The sites are located within the semi-deciduous forest zone of Ghana. Paddy grain yields of five farmer-groups and the soil fertility levels of their rice fields were monitored over a period (2001-2005). For each year, farmers were assisted to adopt the "sawah" system. At harvest, grain yield samples were collected for yield estimation. Income generated was calculated based on actual yield obtained by farmer-groups. Soil samples were collected each year for laboratory analysis to determine fertility levels.

Grain yield: In the first year, grain yield (paddy) increased from less than 1.0 t/ha under the traditional system to more than 4.0 t/ha under the "sawah" system. For the past four years average grain yield showed an increasing trend: 4.1t/ha (2001); 4.3 t/ha (2002); 5.3 t/ha (2003); 5.5 t/ha (2004) and 5.0t/ha (2005).

Soil fertility maintenance: There was a positive change for most nutrient elements, except total nitrogen and available phosphorus. Levels of organic carbon and the exchangeable cations (K, Ca, Mg, Na) showed a positive balance for all sites. Deposition of fine soil material during flooding and incorporation of rice straw during puddling are contributory factors in the improvement of cations and total carbon.

Income Estimates: On the average, after a high initial investment in developing "sawah" fields, inputs requirements are brought to the barest minimum in subsequent years through increased efficiency. Cost of production per ha ranged from US $324 to US $ 428. With reducing production cost and increasing grain yields, revenue increased tremendously. Net revenue for the year 2004 therefore ranged from US $1284 – US $1547 among farmer-groups. This seems to suggest that rice cultivation under the "sawah" system is a viable alternative and a more reliable means of reducing rural poverty in so far as effective and efficient marketing mechanisms are put in place.

The study concluded that the "sawah" system has brought marked improvement in rice yields over the study period. This resulted in increased income for rural rice farmers, created rural employment and thereby reduced poverty in the rural communities.

Mean paddy yields from farmers-groups using the Sawah Technology

	Paddy grain yield (t/ha)				
Farmer-group	2001	2002	2003	2004	2005
Adugyama - A	4.0	4.7	3.8*	5.0	4.5*
Adugyama - B	4.4	4.8	5.5	5.5	4.8*
Biemso - A	4.8	4.7	4.8	5.5	-
Biemso - B	4.7	5.7	5.9	6.5	5.4
Biemso - C	-	4.5	5.4	5.5	5.5

Initial paddy yield under traditional system: 1.0 t/ha * fields partially destroyed by late floods

Changes in soil (0-30cm) nutrient levels under "sawah" rice cultivation (2001– 2005)

Parameter/Site		Adugyama A	Adugyama B	Biemso A	Biemso B	Biemso C	Mean % Change
Total C (g kg^{-1})	Initial level	13.7	13.2	11.8	8.1	11.1	
	% change	3.20	2.95	3.20	4.10	2.80	+ 3.20
Total N (g kg^{-1})	Initial level	1.30	1.30	1.20	1.10	1.40	
	% change	- 3.10	0.77	- 5.80	- 5.40	- 4.30	- 3.60
Available P (mg kg^{-1})	Initial level	3.30	3.80	4.50	4.70	3.10	
	% change	15	- 83	-30	- 84	- 62	- 49
Exch. K {Cmol (+) kg^{-1}}	Initial level	0.10	0.16	0.05	0.06	0.03	
	% change	38	29	16	31	100	+ 43
Exch. Ca {Cmol (+) kg^{-1}}	Initial level	8.80	7.30	2.90	3.20	3.80	
	% change	45	39	14	10	22	+ 26
Exch. Mg {Cmol (+) kg^{-1}}	Initial level	2.20	1.70	0.90	1.40	1.20	
	% change	6	3	12	7	7	+ 7
Exch. Na {Cmol (+) kg^{-1}}	Initial level	0.06	0.26	0.25	0.25	0.77	
	% change	40	18	41	36	7	+ 28

3.3: Review of Policies on Rice Production in Ghana

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The role of policies and production systems on rice production in Ghana are reviewed. Rice is one of the major staple foods in the country and perhaps the most widely consumed cereal. For over 10 years running about 60% of the rice consumed is imported (Table 1). This does not only exert more strain on the country's foreign exchange earnings but defeats the country's idea of becoming self-reliant in rice production in the near future.

Policies have significantly influenced rice production in Ghana. Favourable policies on subsidies for both fertilizer and machinery brought about large-scale rice production between 1960-1970 in the country. Through such favourable policies, the country achieved self-sufficiency in rice between 1974-1975. However, a shift from subsidies to a full liberalization system in the 1980s resulted in significant changes in the production of the crop.

Irrigated rice, upland rice and rice grown in the valleys are the three (3) major systems of rice production in the country. About 16% of total production is obtained from irrigated rice. An average yield of 4.5 t/ha is achieved under this system and is the highest among the three systems. Upland rice, where yields are generally low (1.0t/ha), is grown almost throughout the whole country and contributes only 6% to total rice produced. Most of the rice produced is from the inland valleys, which contributes 78% of total production, with an average yield of 2.2 t/ha. Under the “sawah” technology (bunded, levelled and irrigated rice field) practised within a limited area in the Ashanti region, farmers obtain an average yield of 5.0 t/ha.

Therefore, favourable policies when put in place coupled with proper and effective management as experienced under the “sawah” method of production will ensure increased and sustained rice production in Ghana. With proper orientation and the right policies, the country can become self-sufficient and a probable rice exporter in the near future when the “sawah” technology is adopted as a catalyst.

Table 1. Mean rice production and importation between 1995-2002

Production (000 mt)	‘95	‘96	‘97	‘98	‘99	2000	‘01	‘02
Paddy	221	215	197	-	210	249	253	280
Milled	-	129	118	-	125	150	152	168
Imported	-	204	186	-	226	170	304	325
Total	-	333	304	-	351	320	456	493
% Imported	-	61.3	61.2	-	64.4	53.2	66.7	65.9

Source: MOFA 2003b

Good water management, fertilization and use of improved varieties will ensure better rice production in the country. The ‘sawah’ technology (banded, levelled and irrigated rice fields) was introduced in the Ahafo Ano South district in the Ashanti in 1998 through CSIR-JICA project. Under the "sawah" technology rice yield of 4.0 t/ha and above are easily attainable under farmer’s condition. The influence of the “sawah” technology on rice production is demonstrated from the results presented in Tables 3a and b. Buri et al (2006), showed that mean rice yield increased from 1.0 t/ha to over 5.0 t/ha under farmer’s condition. Under better management paddy yields in Ahafo

Ano South district is more than double what was obtained in the other districts except Atwima.

Under better policy orientation the country has the capacity to be self sufficient in rice production. Improvement and better management of inland valleys seems to be the key to making Ghana self sufficient in rice.

Table 2. Typology of rice production systems and their contributions to total production in 2002

	Irrigated	Upland	Inland Valley	Total
Area (ha)	10,200	18,750	93,750	122,700
Paddy Yield (t/ha)	4.5	1.0	2.4	
Production (t)	45,900	18,750	225,000	289,650
% of Total Production	16	6	78	

Source: MOFA 2003a and Agrey-Fin 1999.

Rice production in selected districts in Ashanti region

District	Area (ha)	Paddy Yield (t/ha)	Production (Metric Tons)
Amansie East	232	1.36	325
Amansie West	96	1.45	152
Ahafo Ano North	89	1.60	145
Ahafo Ano South	486	5.30*	2,642
Sekyere West	28	2.30	60
Sekyere East	44	1.60	63
Afigya Sekyere	34	1.25	45
Atwima	1,425	2.90	4,246
Offinso	110	1.25	143
Kwabre	16	1.00	21

Source: MOFA 2001 * Farmers introduced to '"sawah" Technology'

4.0: Evaluation of Sustainable Rice-Based Cropping Systems in the Inland Valleys Under "Sawah" System.

In an effort to validate the results obtained in 2005, the above experiment was repeated in 2006 at Potrikrom. The overall goal is to contribute to food security and poverty reduction by increasing rice production to the level of self-sufficiency Specifically, it seeks to develop of appropriate technologies for sustainable rice-based cropping system under rain-fed lowland conditions. It is expected that at the end of the project**,** improved pre-rice and post-rice based cropping systems involving legumes and vegetables would be developed. Results so far obtained from this activity are presented below for 2005. Minor season crop for 2006 is yet to be harvested.

Grain yield

Yield of main rice crop for the three varieties were 5.97, 5.39 and 6.97 t/ha for Sikamo, Digang and ITA 324 respectively. The ratoon also yielded 0.87, 0.76 and 0.94 t/ha for Sikamo, Digang and ITA 324 respectively. The main goal of obtaining higher rice yield was observed with all the three varieties yielding more than 5t/ha. The ratoon, which used residual moisture and took a shorter period, to mature yielded an average of approximately 1t/ha for all the varieties, which is equivalent to the main rice yield of the traditional farmers (1-1.6t/ha). The significant improvement in yield of rice and the interventions introduced is encouraging and its effect in combination with the post-rice crops will be highlighted.

Conclusion:

The rice-based cropping systems over the study period has shown efficient use of resources for increased crop production per unit area per unit time, thereby increasing profitability. This leads to wealth creation and poverty alleviation. This system is also environmentally friendly since it allows the farmer to stay on a particular land for years, thereby conserving our natural resources, especially the forest. The system also leads to improvement in the physico-chemical properties of the soil since the residue of the legumes after harvesting can be ploughed back into the soil to increase the organic matter content, hence improving the nutrient status of the soil.

Yield of rice (2005)

Variety	Yield of main rice (t/ha)	Yield of ratoon rice (t/ha)
Digang	5.97	1.09
Sikamo	5.39	0.63
ITA 324	6.97	0.68

Yield of cowpea (2005)

Cowpea Varieties	Yield of cowpea after main rice (kg/ha)			Yield of cowpea after ratoon rice (kg/ha)		
	Digang	Sikamo	ITA 324	Digang	Sikamo	ITA 324
Asetenapa (IT86-1957)	586.96	780.19	477.85	1093.8	704.9	391.3
IT87D-2075	706.5	888.48	636.47	1158.6	1581.3	701.69
Soronko (TVX2724-01F)	721.40	666.67	476.24	1207.7	1313.6	773.75

Yield of okra (2005)

Variety	Yield (kg/ha)
Asontem	938.7

5.0: Continuation Of The Preparation Of The Guide/Manual For Inland Valleys "Sawah" Development And Rice Cultivation.

Work on the manual continued during the year. Introductory and protections chapters which were hither to lucking a well developed frame work are now taking shape and hopefully the manual would be completed before the end of year 2007

6.0: Training of farmers and Ministry of Food and Agriculture (MoFA)) extension staff.

Staff of the project was also engaged in the training of extension staff of MoFa and selected farmers on rice cultivation in conjunction with IVRDP and NERICA project. Topics such as land selection, good land preparation, general agronomy and crop protections were extensively discussed

7.0. Visits to Project Site.

During the year, the number of external visitors also visited the project sites to have a view of what is happening on the field in terms of "sawah" development, its adoption by farmers and its general impact on income generation. Some of these visitors included experts from JICA. MoFA etc.

8.0: THE WAY FORWARD/ACTIVITIES FOR YEAR 2007.

(1). A major problem identified during the year was poor land preparation due to both lack of proper machinery and technical know-how and back stocking for the "sawah" system. A greater part of activities for the year will be devoted to training of farmers on land preparation and back stocking of established project fields and farmers. In possible collaboration with the Inland Valley Rice Development Project (IVRDP), demonstration sites would be established for the practical on-the-job training of farmers and extension on proper land preparation, machinery handling, effective nutrient and water management. Such demonstration sites would serve as focal points for the effective transfer of the "sawah" technology to rice farmers, who are yet to be fully introduced to the technology. Based on the availability of funds, demonstration and/or training sites may be set up at two locations in each of the five regions the IVRDP is currently operating.

Back stocking of the project at sites within Adugyama and Biemso would also be another major activity. As a way of sustaining the momentum for the rapid adoption of the technology, already established fields at the above sites would be back stocked and farmers continued to be assisted with the requisite technical know how. This requires the acquisition of both field machinery (power tillers and water pumps) for effective fieldwork and other logistical support for effective and timely delivery of required services. The project proposes to purchase at least two power tillers and water pumps for farmers use. These items may be sold to promising farmer groups (particularly farmer-groups at Adugyama and Biemso I) who have shown total commitment to the adoption of the "sawah" technology. This could be done under the project on hire purchase (credit) basis.

(2) Work will continue on the manual/guide on “sawah” deveopment, for its early completion. Some chapters would be upgraded with the necessary information while others would be re-organised, while we wait for any inputs from our Nigerian colleagues. Not much information on certain areas was provided in the first draft. Work to continue to fine tune the information to bring it up too the standard of complete manual/guide

(3) Under nutrient and water management systems, work on the effect of different environments in comparison with the “sawah” system, on rice growth and yield will be repeated as last year field work was significantly affected by drought. A second experiment on Phosphorous adsorption studies will be started in early April in the green house.

(4) Studies on the hydrological characteristics of the rivers within the project catchment area will also be continued but on a limited scale for the validation of results so far obtained.