PROJECT CONCEPT AND OVERVIEW

CONCEPTUAL FRAMEWORKS OF THE PROJECT

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Inland valley systems and hydromorphic fringes cover about 50 million hectare in West Africa, of which about 10 million hectare have the potential for small scale rice farming. In Ghana the potential area for inland Valley is estimated to be 700,000 hectares or one million if flood plains are included.

Rice is cultivated under three main systems, namely rainfed upland, irrigated and rainfed lowland (inland valleys) conditions. Production under rainfed upland conditions has been very risky due to unreliable rainfall, shallow and erodible soils of low fertility. Production under big irrigation schemes has not been very encouraging. However, the numerous small inland valleys found scattered across the country where the water management is the main problem, offer the best rice ecology. There are four key concepts that support this.

Key Concept 1: The Sawah Hypothesis

1.1 Sawah hypothesis

The green revolution laid the foundation for the rapidly growing economies of Asia today. The layouts of groups of sawahs in the watershed were adapted to the local topography for efficient irrigation and drainage. Why has the green revolution not yet occurred in West Africa and Ghana in spite of its success in Asia in the 1960's? The main cause of the present agricultural and environmental crises in West Africa is the general under development of lowland agriculture. Environmentally creative technology, such as sawah farming in lowlands is not traditionally practiced in sub-Saharan Africa or in Ghana. Sawah is one of the prerequisite for realizing the green revolution as well as for preserving and even restoring ecological environments. Irrigation and drainage without sawah farming technologies has proved inefficient or even dangerous because of the negative impact on accelerating erosion. Thus, the development of irrigation has been slow. In the absence of water control, fertilizers cannot be sustained. High yielding varieties never perform high yielding. Soil fertility cannot be sustained. Therefore 'green revolution' has so far not been realized.

1.2 Sawah and Irrigation

Another frequent source of misunderstanding in West Africa is the term 'irrigated rice'. In Asia, the meaning of this term is clear, as the sawah is prepared first by farmers before completing the government assisted irrigation system. However, there are many irrigation systems without proper sawah preparation in West Africa. In the past, research on water control of inland valleys concentrated on irrigation and drainage systems, such as the central-drain system, the interceptor-canal system, the head-bund system and head-dyke system. The contour bund system, however, may be more difficult to construct and manage by local farmers than the sawah system. It may be difficult to share land and irrigation water fairly for local farmers by using the contour bund system, which may be more suitable for large-scale rice farming such as in the United States of America and Australia.

Generally speaking, the construction cost of sawah is far higher than that of irrigation facilities in terms of labor and amount of soil moved. Out of the total cost, 50-70% should be allocated for sawah construction and 30-50% for irrigation and drainage. Therefore in order to achieve sustainable development, sawah systems need to be constructed with the active participation of farmers. The key element is the sawah. For sustainable irrigation systems in inland valleys, the sawah technology should first be extended to the farmers.

Key Concept 2: Geological Fertilization Theory for the Integration of a Watershed

2.1 Geological Fertilization Theory

Fertile soils and ample water cycling secure an abundant food supply and rich human life on the earth. The distribution of fertile soils, and hence the distribution of population in the world, is related to the amount and quality of geological fertilization processes. Four geological fertilization processes can be identified, i. e.

i. the lowland soil formation process,
ii. the volcanic ash soil formation process,
iii. the loess soil formation process, and
iv. the dynamic equilibrium between soil erosion and formation.

The lowland soil formation involves the transportation and sedimentation of eroded upland topsoils by surface run off and by river water. This process is very important to obtain fertile lowland soils. Small scale examples are the valley bottom soils as shown in Fig 1. The large scale examples include the formation of fertile deltas, such as Nile, Ganges and many Asian deltas. In the sawah based farming system this geological fertilization process can be enhanced. The long term sustainability of sawah farming can be attributed to this process.

2.2 Integrated Watershed Approach

The sustainable productivity of sawah is more than 10 times greater than that of upland rice fields because of geological fertilization process and the well-known bio-physico-chemical processes of inundated sawah soils as described by Kyuma and Wakatsuki (1995). Sustainable productivity of 1 ha of Sawah may be equivalent to more than 10 ha of upland fields. This value was estimated by assuming that the mean yield of upland rice without fertilizer application is 1 t/ha and the mean yield of sawah rice without fertilizer application is about 2 – 2.5 t/ha. To sustain the yield, upland fields have to lie fallow (3-year cultivation and 12-year fallow, for example). On the other hand the lowland sawah rice can be cultivated continuously for many more years. Thus sustainable productivity of sawah is 10-12.5 times higher than

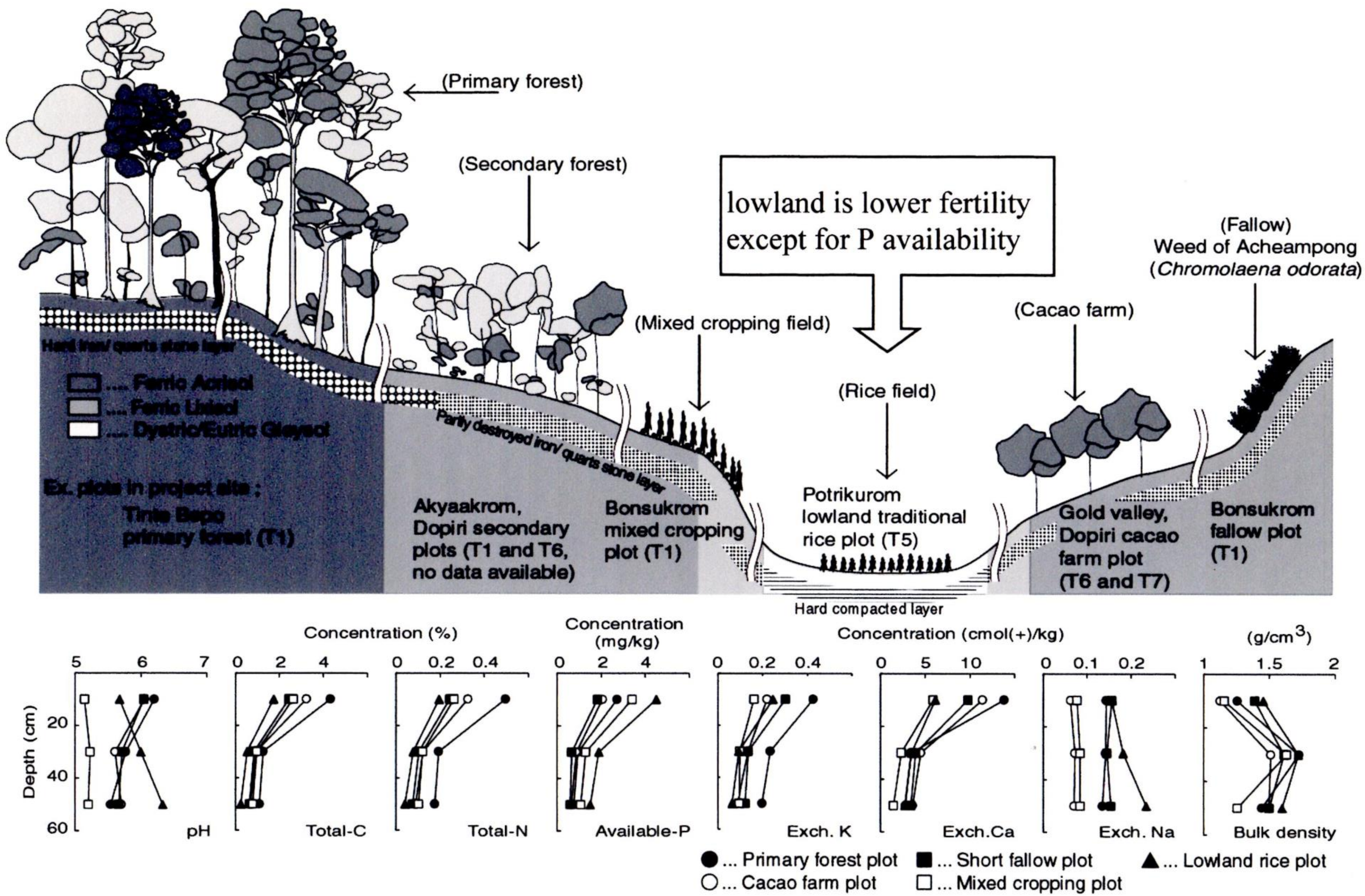

Fig. 1 . Typical soil type, land use (vegetation) and topography in benchmark inland valley watersheds. Profile characteristics of nutrients and bulk density are also shown in five land uses.

that of upland rice field, i.e., 12.5 = (2-2.5/1) x (15/3), productivity ratio (t/ha): Lowland sawah/upland rice = 2.5/1, and sustainable cropping intensity ratio (fallow period): lowland sawah rice/upland rice = 5/1.

A sustainable watershed should exhibit a dynamic equilibrium between soil formation and erosion. If the rate of soil formation far exceeds those of soil erosion, old leached soils like Oxisols may develop, and if erosion is not compensated for by soil formation, soil degradation and eventually desertification will occur. The earth's mean rate of soil formation was estimated at 0.7 ton/ha/year. Cool temperate granitic watersheds showed a rate of 0.02 tons/ha/year. Andesitic watersheds in West Sumatra, Indonesia showed a rate of 1.8 ton/ha/year.

Although the rates of soil formation in West Africa have not been measured, if one estimates a value of 1 ton/ha/year in total watershed, then 5% of lowland areas can receive fertile topsoils eroded from 95% of upland areas at the rate of about 20 tons/ha/year. The sawah system may contribute to the trapping of such eroded top soils to maintain the lowland soil fertility (Geological fertilization process No. (1) and (4) as shown in Fig 1.

2.3 Restoration of low fertility soils of inland valleys in West Africa

Issaka and Wakatsuki (1997) and Buri and Wakatsuki (1996) showed the general fertility and geographical distribution of soils of inland valleys and flood plains in West Africa. The general fertility was compared to those of Tropical Asia (Kawaguchi and Kyuma 1977) and Tropical America (Tanaka et al 1986). The results were summarized in Table 1. The total carbon and nitrogen content were low for West Africa and Tropical Asia. The mean values of available phosphorus suggest that the phosphorus status of West Africa is very low throughout the region. Base status such as exchangeable calcium and potassium and effective cation echange capacity of inland valleys of West Africa are characteristically low in majority of plant nutrients. For effective and sustainable crop production, new farming systems that are both soil restoring and enriching must be developed. As discussed above, the African adaptive sawah-based farming systems by small-scale farmers is one of the most promising systems.

Table 1. Mean values of soil fertility properties of inland valleys (IVS) and flood plains (FLP) of West Africa in comparison with lowland topsoils of tropical Asia and Japan (Hirose and Wakatsuki 1997)

Location	Total	Total	Available	Exchangeable Cation (Cmol/kg)				Sand	Silt	Clay	CEC
	C(%)	N(%)	P(ppm)	Ca	K	Mg	ECEC	(%)	(%)	(%)	Clay
IVS	1.3	0.11	8.7	1.89	0.25	0.25	4.20	60	23	17	25
FLP	1.1	0.10	7.3	5.61	0.49	2.69	10.31	48	23	29	36
T. Asia*	1.4	0.13	18	10.4	0.4	5.5	17.8	34	28	38	47
Japan	3.3	0.29	57	9.3	0.4	2.8	12.9	49	30	21	61

*Kawaguchi and Kyuma 1977

Key Concept 3: Sawah and Forestry Ecotechnology Development

3.1 Definition of Ecotechnology

The focus of research activities is to develop suitable Ecological Engineering Technologies (Eco-Technologies) for integrated watershed/rural development by increasing sustainable productivity and at the same time improving the total water cycling in a given watershed. Eco-technologies should be adaptive to indigenous farming systems and rural village society. Various areas of benchmark watersheds, from 100 to 10000 ha, which is located 40-50km northwest from Kumasi, has been selected for basic agro-ecological survey. Within these watersheds, various sites for sawah, including Adujama, Potrikrom, Biemtetrete, and Biemso No. 1 and No. 2 villages were selected for detailed survey and intensive field testing.

The term, Ecological Engineering Technology (Eco-Technology), is defined here as a ecology-based sustainable farming technologies viable to local socio-cultural systems to increase farming productivity and to improve the environment. The ecotechnology developed in this project should be adoptable to be used by local farmers to control water and to conserve water and soil. Leveling, bunding, and construction of canal and head dyke are the example of such ecotechnologies, which can be practiced as an extension of agronomic practices using locally available tools and materials. Forestry technology, such as nursery preparation and management, contour bunding and planting of the useful trees, regeneration of the water and soil conservation, and forest establishment for carbon sequestration against global warming are the examples of the ecotechnology which this project are going to develop. The ecotechnology will be the key technology to attract local farmers active participation for the improvement of basic agricultural infrastructure, such as irrigation and soil conservation measure. The ecotechnology will be able to integrate partly between agronomy and agricultural engineering.

3.2 Regeneration of Africa and the earth through the sawah and the forest based ecotechnology in 21st century

In tropical environment and ecology, sawah based farming systems have fully proved to be long term sustainable. Since sustainable productivity of one hectare of Sawah is equivalent to more than ten hectares of upland fields, development of 1 ha of sawah makes available the field for the afforestation in the degraded upland field in Africa. The total potential area for new sawah development in Africa is estimated to be 20 million ha. Thus, if we can develop 20 million ha of sawah in the next 50-100 years, we can open the afforestation area of 200 million ha, the forest can fixed carbon dioxide one billion ton annually in next 50-100 years which is roughly equivalent to reduce 10% of the present global carbon emission. Since it is estimated that such carbon fixation can sell no less than 100 dollars per ton in quite near future, global market price will be no less than 100 billion dollars annually in the next 50-100 years.

Key Concept 4. Field Work Principle: Participatory Approach for Ecotechnology Research and Development and Extension

4.1 Field Work and Ecotechnology Research and Development

Farmers field and forest are the place where major research activities for ecotechnology development and extension are done. Although the results of experimental fields and laboratory works at the research institutes will be applied, field-work should come the first.

4.2 Participatory approach and the ecotechnology development and extension: Ecotechnology comes the first, then participatory approach.

Various water management ecotechnologies will be researched and developed in collaboration with farmers, designed based on the local ecological and socio-economic conditions, constructed or practiced with the farmers' participation, and tested by ecological and socio-economic view points. In this joint study project, researchers proposed the possible various ecotechnology options to farmers. This is expecially necessary for our two main target fields, sawah based ecotechnology in lowland and forestry based ecotechnology on the upland. Field ecotechnology development comes first, then participatory approach follows. The participatory approach in this joint study project applied this principle. Farmers' participation at various steps of the ecotechnology research, development, design, construction and practices, testing and evaluation were essential. Therefore the farmers participated in this project was not only beneficial but we also worked as partners. At the same time the farmers participation was like on the job training (OJT) and furthermore an extension.

The main goal of the project is presented in Fig. 2.

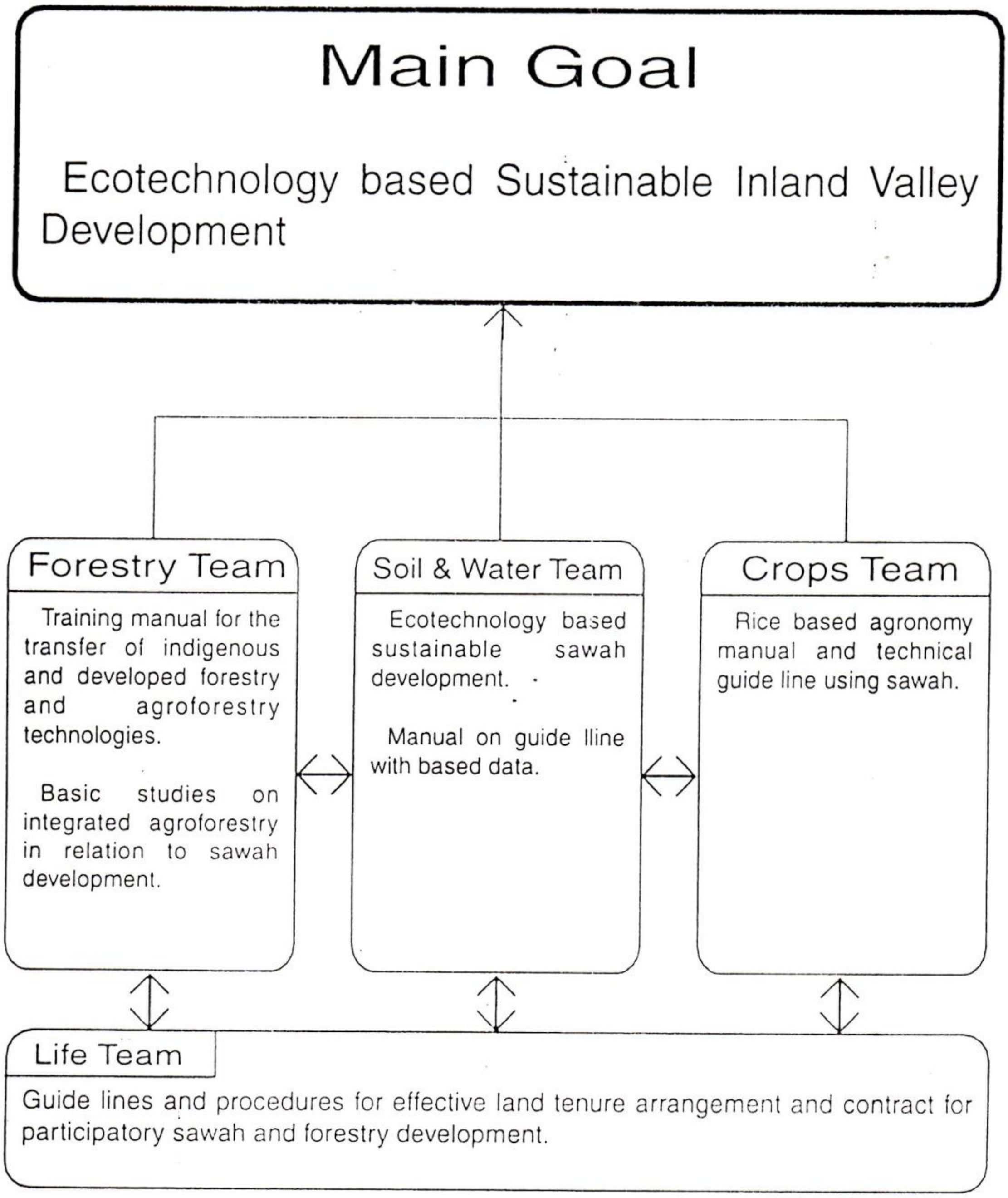

Fig. 2 Main goal of the project.

PROJECT OVERVIEW
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Introduction

Rice is an important food crop ranking next to wheat in terms of imported food crop. Since the self-sufficiency rate of local rice production is less than 40% scarce foreign exchange is utilized to meet the growing total consumption. It is estimated that within the next ten years, consumption of rice would reach between 400,000 – 480,000 metric
tons. This would require that local rice production should be increased to more than 600,000 metric tons, if self-sufficiency as envisaged under the nation's Vision 2020 is to be attained.

In Ghana, rice is produced in all the ten regions covering the major ecological zones. Four main rice growing systems available are:

i) Rainfed upland
ii) Rainfed lowland/hydromorphic iii)
iii) Inland valley swamps and valley bottoms and
iv) Irrigated paddies.

The first two ecologies account for nearly 75% of production area, the inland valley swamps (IVS) represent 23% and the irrigated paddies only 2% of rice production area.

With the increasing awareness of the limited potential for intensification of rice production in the uplands the thrust of rice research sine 1989 has been on the sustainable development of profitable technologies and an enabling policy environment that would enable rice farmers to utilize the IVS for rice and rice-based cropping systems. This would reduce the pressure on the rapidly degrading uplands. The IVS including the valley bottoms and flood plains constitute an important agricultural hydrological asset at the local, regional and national level that can contribute to future food security and poverty alleviation. There is approximately 1.0 million hectares of inland valleys in the country. Considering the success of the Green Revolution in South-East Asia and their experience in the development of paddy fields, using the integrated watershed management approach, assistance was sought from the Japanese Government to assist in developing simple low cost and environmentally friendly technologies for managing our inland valleys.

In August 1997, the Governments of Ghana and Japan through the Council of Scientific and Industrial Research (CSIR) and Japan International Cooperation Agency (JICA) signed a joint technical agreement establishing the Project on Integrated Watershed Management of Inland Valleys in the Republic of Ghana.

Project Objective

The main objective is the development and testing of environmentally friendly and sustainable technologies based on integrated watershed management and participatory approach for the production of rice and rice-based crops, animals and fish by resource- poor farmers cultivating the inland valleys.

Study Framework

To achieve this objective there is the need to gain an in-depth understanding of such dynamic processes as water and nutrient fluxes, land cover and landuse dynamics and socio-economic changes at the watershed level. Studies are therefore being carried out in forestry, soil and water management, crop production and socio-economics, which will all, lead to finding an option balance between the different use functions. Technologies developed would thus be sustainable. The studies, located at Adugyama, Potrikrom, Biemso No1 and Biemso No2 all in the Ahafo Ano South District (Fig.1), are organized along the following four main themes:

1. Soil and Water

- Water balance studies
- Design, construction and testing of SAWAH systems.
- Water table monitoring along strategic transects.
- Land use monitoring.
- Fertility and water quality monitoring.
- Soil characterization.

2. Forestry

- Integrated agro-forestry for sustainable development in small inland valleys.
- Development of community and private nurseries.
- Reforestation for timber production and environmental amelioration.
- Woodlots for firewood and charcoal production.

3. Crop Production

- Screening crop species and varieties for adaptability to Sawah conditions.
- Development of appropriate and sustainable rice and rice-based cropping system for the Sawah.

4. Life

- Baseline survey on landuse system, major farming, forestry, and water-borne diseases.
- Baseline survey on marketing, preservation and post-harvest issues of rice production.
- Socio-economic monitoring and evaluation of Sawah technologies.
- Adoption and impact analysis of Sawah technologies.

Technology Transfer

Technology transfer activities would be conducted by all members from Soil and Water, Forestry, Crop production, and Life teams.

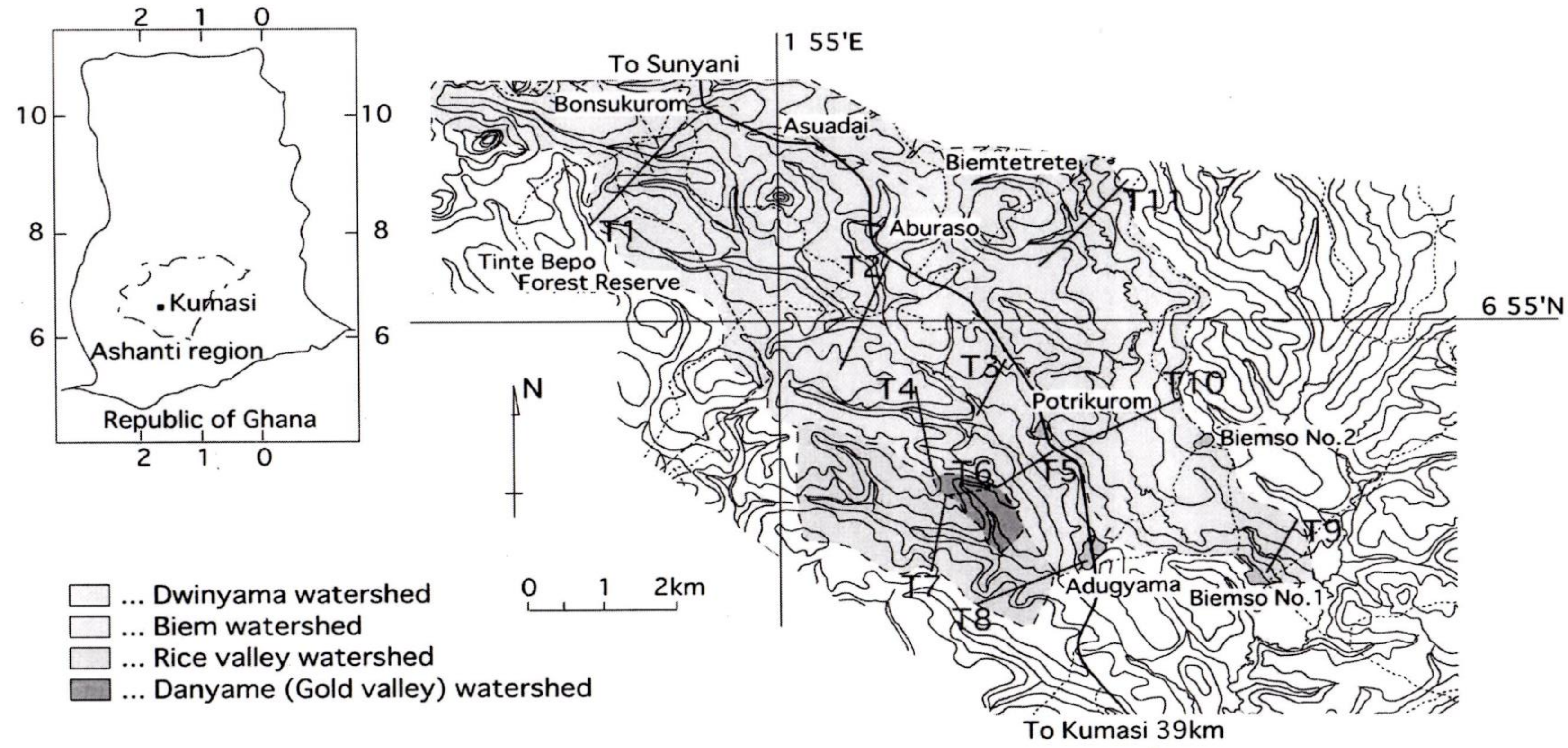

Fig.1 **Project Area showing sawah demonstration sites.**

Major achievements.

- The main thrust has been the selection, design and construction of different Sawah systems at Adujama, Potrikrom and Biemso.
- Farmers in these villages have been introduced to improved crop production practices resulting in rice yields of more than 3 tons/ha.
- Cultivation of cowpea after rice under Sawah appears promising.
- Plantation of different timber species has been established.

Informal studies on the traditional farming systems and land use have been carried out at Adujama and Biemso No.1. There has also been marketing studies and socio-economic analysis, all of which is on going and would be continued in the next quarter of the year.

Future Thrust (2000-2001)

- Comparative studies of the different Sawah systems at Adujama, Potrikrom and Biemso with the traditional system. All activities will be started simultaneously for effective comparison.
- Hydrological monitoring of the different Sawah systems.
- Physical and chemical monitoring of soils under Sawah and traditional systems.
- Determination of nutrient fluxes from the uplands to the valleys.
- Comparison of the various agronomic packages under different Sawah and traditional systems.

Socio-economic evaluation of Sawah and traditional farming systems.

- Established of community nursery at Biemso and Adujama.
- Development of new sites if requested by farmers.
- Report writing and publication of final Project Report.
- Development of training manual on Sawah technology.