KINKI UNIV. JAPAN

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"SAWAH" ECO-TECHNOLOGY




PRINCIPLES AND PRACTICES

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FOREWORD

In sub-Saharan Africa (SSA), even though there have been research concepts to improve natural resource management (NRM), there has been no clear research concept on how to improve natural resources such as soil and water conditions at the farmers field level. The "Sawah" eco-technology is one of such missing concepts to improve natural resources management in majority of African rice farms. It can accelerate improvements in effective natural resources management, minimize environmental degradation and increase soil productivity in majority of African conditions. In order to apply these scientific technologies, farmers' have to develop typically refined rice growing environments referred to as "Sawah" or develop similar alternatives which can conserve soil and control water. Essential components of such land development are: (i) demarcation by bunding based on topography, hydrology and soils, (ii) leveling and puddling to control and conserve soil and water, and (iii) water inlets and outlets. The above parameters are typical characteristics of "Sawah" fields. The essence for this is to avoid too much water deposited at one side of the field to the disadvantage of other parts of the field.

The "sawah" eco-technology can improve fertilizer and irrigation efficiency. Thus it can improve water shortage, poor nutrition especially for nitrogen and phosphorous supply, neutralize acidity as well as alkalinity, and improve micronutrient supply. With this, improved varieties can perform well to realize green revolution in Africa. The "Sawah" system of rice production therefore seeks to improve on lowland rice production by helping to effectively manage land, control water and nutrients to boost local rice production. If appropriate lowlands are selected, developed and soil and water managed properly, then the application of improved agronomic practices such as System of Rice Intensification (SRI) under the "Sawah" system, can result in paddy grain yields exceeding 10 t ha^{-1}. Use of the technology has increased rice production from about one ton per hectare under the current traditional system to over six tons per hectare at several locations across Ghana and Nigeria. It is also environmentally friendly and it minimizes erosion, reduces land degradation and increases nutrient-use-efficiency.

At the 1st International workshop on "Sawah" rice farming in SSA, participants were convinced that (i) the demand for rice will continue to rise in the immediate, medium and long term and that large amounts of foreign exchange will continue to be used on rice imports by countries of the sub-region, (ii) that Africa, and in particular West Africa, has large stretches of lowlands which can be used for rice production across most agro-ecological zones that can significantly reduce imports and create employment particularly for the youth, (iii) that there is the urgent need for the adoption of improved and sustainable technologies for the rapid expansion of local rice production in the sub-region, recommended that there was the need to build the capacity of extension workers and “Sawah” farmers by providing them with good training and working materials/documents which will offer Agricultural Ministries and other stakeholders in the rice industry of individual countries a better understanding of the technology and which can also be used to strengthen and/or expand farmer education on the eco-technology. This document is therefore in fulfillment of that recommendation. It provides the basis and principles of the "sawah" system. It also defines effective and efficient pathways for its application and adoption. Finally, the manual outlines field observations and experiences particularly in Ghana and Nigeria which can be shared by farmers, field extension staff and scientists not only within these countries but across other countries as well. This is a technology that has the greatest potential to galvanize rice farmers, minimize environmental degradation, improve productivity and accelerate the processes of the rice green revolution in Africa.

PROFILE OF AUTHORS

Toshiyuki WAKATSUKI is a Professor Emeritus who obtained his Ph. D in Agriculture in 1977 at the Kyoto University in Japan. He thought in several universities in Japan either as a full time lecturer or visiting Research Associate. His field of specialization is African "Sawah" development, Soil Science and Eco-technology while his major interests are implementation of "Sawah" eco-technology innovation to realize green revolution in Sub- Saharan Africa. His teaching experience spanned several years and covers the following: Emeritus Professor, Faculty of life and Environment Science, Shimane University (2008-present); Professor, Faculty of Agriculture, Kinki University (2004-March 2013); Professor, Faculty of life and Environment Science, Shimane University (1995-2003); Associate Professor., Faculty of life and Environmental Science, Shimane University (1981-1995); Research Associate, Faculty of Agriculture, Kyoto University (1979-1980).

T. Wakatsuki was not only a teacher but also a Researcher whose research career and experience also span over several decades, part of which covers the following: Project leader of MEXT/JSPS assisted grant-in-aid Specially Promoted Research on “Materialization of West African rice green revolution by "Sawah" eco-technology and the creation of African Satoyama systems” (2007-2011); Project leader of JSPS assisted Grant-In-Aid of Basic Scientific

Research (S) on "Watersheds Ecological Engineering for Sustainable Increase of Food Production and Restoration of Degraded Environment in West Africa" (2003-2007); Project leader of JSPS assisted Grant-In-Aid of Basic Scientific Research (A) on "Ultimate Decomposition Rates of Organic Waste and Purification function of Soil Ecosystems" (2001-2002); Project leader of JSPS assisted Grant-In-Aid of Basic Scientific Research (A) on "Land tenure and Agro-silvo-pastoral systems in West African small Inland valley watersheds" (1999-2001); Project leader of MOFA commissioned research on development assistance through FASID assisted research on "Comparative studies and evaluation on Asian collaborative "Sawah"-based Rice Development Projects in West Africa" (1998); Project leader on JICA/CSIR-CRI joint study project on "Integrated watershed management of Inland Valleys in Ghana and West Africa: Eco-technology Approach" (1997-2001); Project leader of MEXT assisted Grant-In-Aid of Scientific overseas research on "Indigenous farming adaptive "sawah" and agro-forestry systems' (1996-1997); Project coordinator of MEXT assisted Grant-In-Aid of Scientific overseas research on "Regeneration of Agro-Forest-Ecosystems in Sub-Saharan Africa" (1993-1995); Project leader of MEXT assisted Grant-In-Aid of Scientific research on "Rates of Rock Weathering and Soil Formation" (1992-1994); JICA expert at International Institute of Tropical Agriculture (IITA) on "West and Central Africa wide lowland rice soils and rice farming system survey" and "On farm research on the 'Sawah' system to intensify sustainable rice production at Bida, Nigeria" (1986-1989).

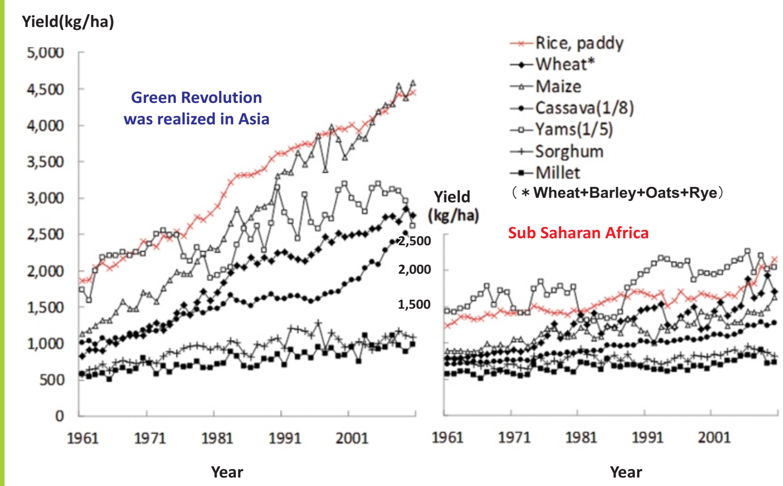
Mohammed Moro BURI is currently a Principal Research Scientist and Co-ordinator of the Ghana "Sawah" Project. He works for the Soil Research Institute (SRI) of the Council for Scientific and Industrial Research (CSIR), Ghana. He obtained his B. Sc. (Agriculture) degree from the Kwame Nkrumah University of Science and Technology, Ghana and M.Sc. (Natural Resource Science) from the Shimane University in Japan. He obtained a Ph. D. in Bioenvironmental Science from the Tottori University also in Japan in 1999. Dr. Buri has conducted extensive research with a variety of interdisciplinary teams on soil resource management, water management, environmental related problems and crop (rice, maize, cassava, yam, potato, and cowpea) production across the different agro-ecological zones in the Ghana and beyond. His research areas of interest include resource management (soil/water), soil fertility, plant nutrition and general agronomy. He has worked and continues to work with several International Organizations (AfricaRice, IITA, IWMI, JIRCAS, and JICA); Universities in Japan (Kinki Univ., Shimane Univ. Tsukuba Univ. United Nations Univ.); the Ministry of Food and Agriculture, Ghana and sister Institutes of the Council for Scientific and Industrial Research (CSIR) also in Ghana. Dr. Buri has been a major contributor to developing and demonstrating the "sawah" eco-technology on rice production in Ghana. He has made a significant contribution to training young scientists from Nigeria on sustainable management of inland valleys under the UNU-ISP (Tokyo) Training Program. He was the leader of the team that published the first book on the "Sawah" system of rice production and a backbone of the team that organized the first international workshop on Sawah Eco-technology and Rice Farming in Sub-Saharan Africa. With several years of experience on "sawah" system development and training of field technical staff and farmers, Dr Buri has assisted in "sawah" technology transfer to Togo and Benin. He provided consultancy services towards the effective, efficient and practical execution of the "Sawah", Market Access, and Rice Technologies for Inland Valleys (SMART-IV) Project in Togo and Benin which is being executed by Africa Rice. Nationally, he is a member of the team working in collaboration with Ministry of Food and Agriculture, on scaling out of the "Sawah" system for rice production across Ghana.

Ademiluyi Yinka SEGUN, a royal from the family of Ademakinwa Ademiluyi, had his basic education at Ibadan and Ikirun. He earned a Bachelor degree in Agricultural Engineering from the University of Ilorin and M. Sc. in the same field from the University of Ibadan, both in Nigeria. He obtained a Ph.D. in Agriculture from Kinki University, Japan. His tireless efforts and studies on the use of medium and intermediate technologies for field operations drew the attention of the Federal Government of Nigeria through the Ministry of Agriculture (where he is serving currently) to nominate him as a consultant on the use of Draught Animal Power (DAP) for Agricultural Production in Nigeria. He was trained at Beijing, Chinese Academy of Agricultural Mechanization Sciences (CAAMS) on the operation and maintenance of Agricultural Machinery in China where he developed an unparalleled interest in Single Axle Tractor (Power Tiller). He brought his experience to bear on "Sawah" Eco-technology for Rice Farming (SERIF) project where he played leading role as the Nigeria National Coordinator. Since becoming a National Coordinator, he has worked to scale up the “Sawah” eco-technology to six geo-political zones of Nigeria. Working in collaboration with World Bank Fadama III Project and Commercial Agricultural Development Program (CADP), over 2000 farmers have adopted “Sawah” eco-technology for rice production.

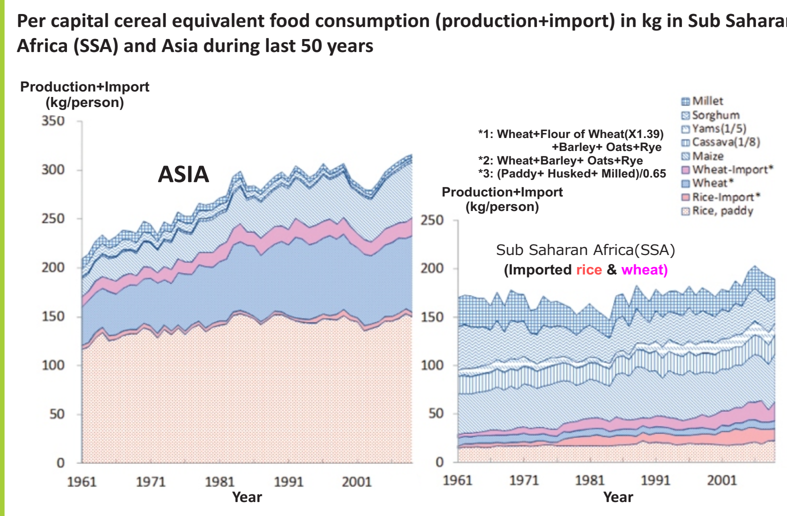
CHAPTER 1

INTRODUCTION

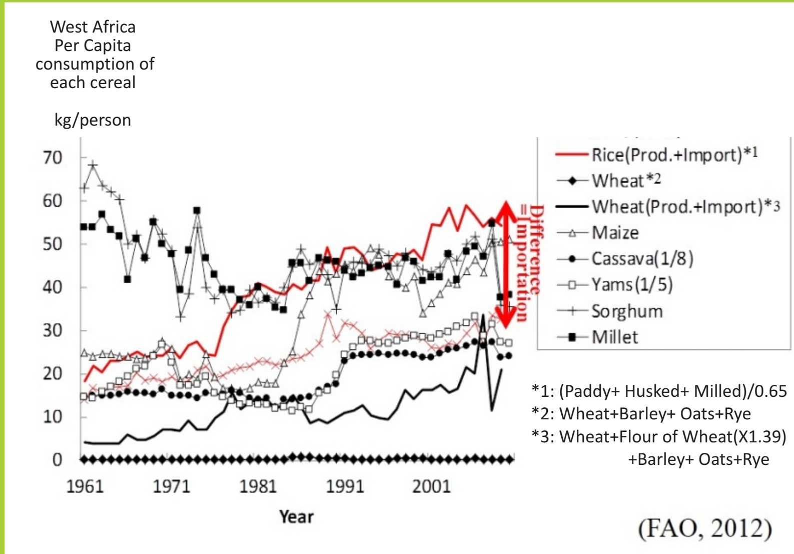
An understanding of the current global trend of activities that affect the rice industry is key to identifying major constraints based on site and the laying of solid foundations towards solving or mitigating the effects of such constraints, in order for any effective change and impact to be made.



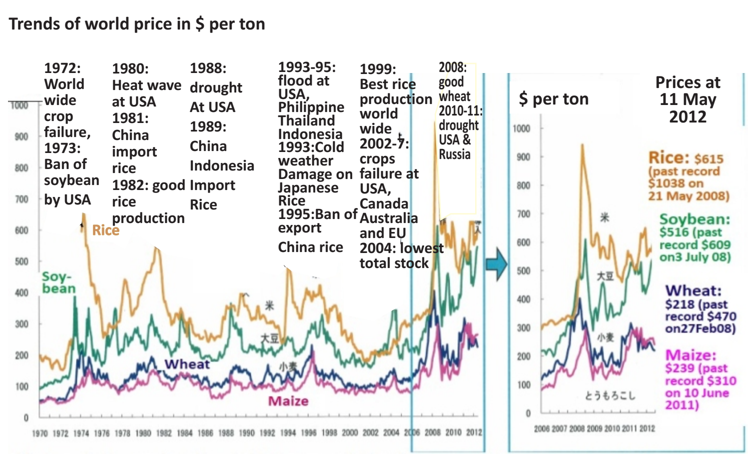
Comparative yield trends of five major cereals, Yam and Cassava between Asia and Sub Saharan Africa (SSA) during 1961-2010 show No green revolution in SSA (FAO 2012). Data of Yam and Cassava were divided by 5 and 8 respectively to calculate cereals equivalent.



Both SSA and Asia produced about 200kg of per capita cereal food equivalent in 1960s. However, 50 years later, that of Asia increased to above 300kg, while SSA remained stagnant at less than 200 kg. Both cassava(108%) & yam(167%) increased. While both millet (73%) & sorghum(70%) decreased, maize (120%) & rice(140%) increased. Rice consumption sharply increased(186%). Hence, its importation of 383% was similar to wheat (428%). SSA, however, has a high potential of rice production



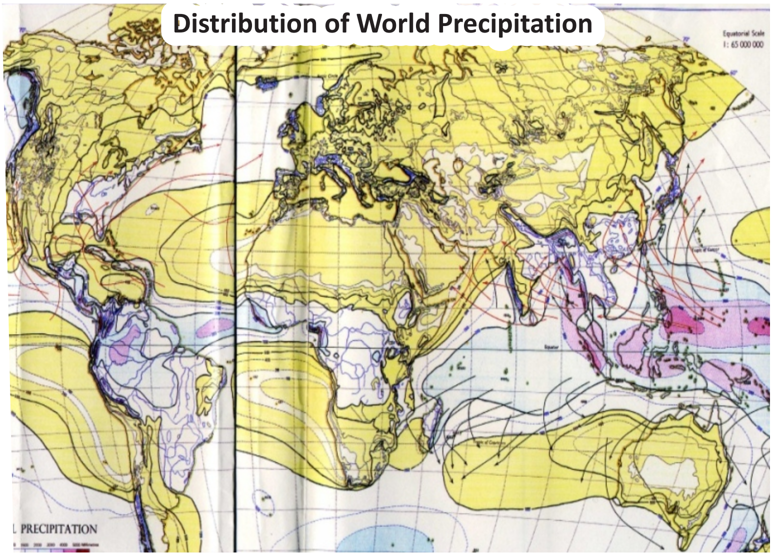
Per Capital consumption of Paddy in West Africa increased abruptly from 21 to 56 kg and importation uptl from 5 kg to 24k during 1961-2010. Recent steep rise of paddy price induced social unrest. However West Africa has a huge potential of paddy production and even exportation to Asia in near future



Note: Prices of wheat, Maize, and Soybean are prices at both the first and the last Friday of each month. Rice price is at both the first and the last Wednesday of each month.

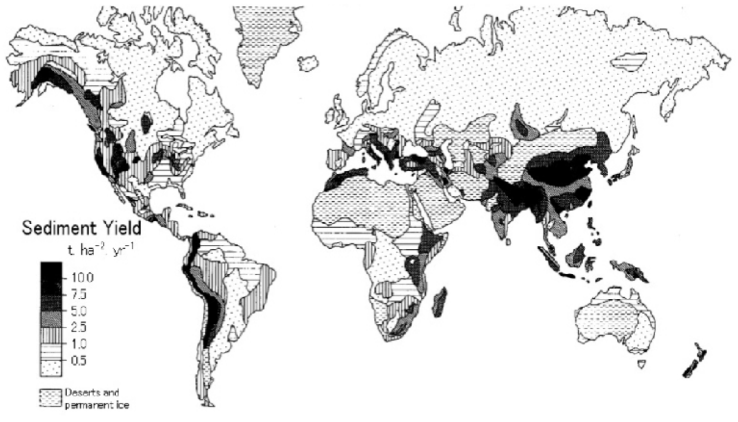
Trends of world trading prices of rice at Thai (milled 2[nd] class FOB) and of soybean, wheat and maize at Chicago commodity exchange during 1961-2012. *(Source - Ministry of Agriculture, Forestry and Fishery, Japan).* Note : Prices of wheat, maize, and soybean are prices at both the first and the last Friday of each month. Rice price is at both the first and the last Wednesday of each month

Distribution of World Precipitation



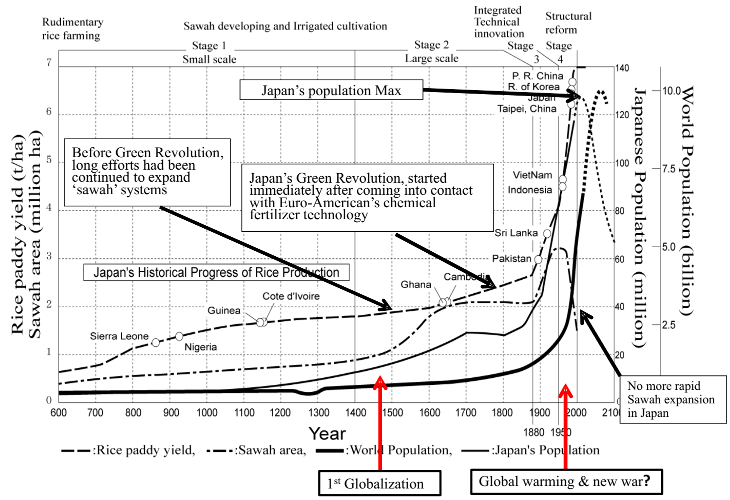
Water (quality and quantity) is very essential for effective and sustainable crop production. Water scarcity therefore calls for adoption of effective and efficient utilization methods

Rate of soils erosion in the world (Walling1983)



Can watersheds of SSA sustain Sawah system? High rate of soil erosion and lowland sawah soil formation can be compensated by high rate of soil formation in Asia. However soil formation, soil erosion and hence lowland soil formation are very low (only 10-20%) in comparison with Asian watersheds

Population, rice yields & "sawah" area of historical path in Japan in comparison with Asia & Africa (Takase & Kano,1969, modified)

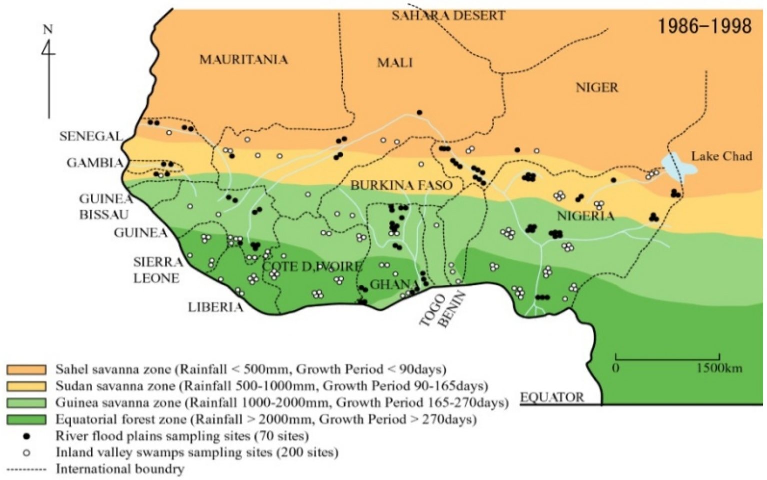


Japanese Experiences has shown that farmers' "sawah" fields are the most important infrastructure to be developed under the green revolution. Hence the development of farmers' fields is the first key step under the green revolution.

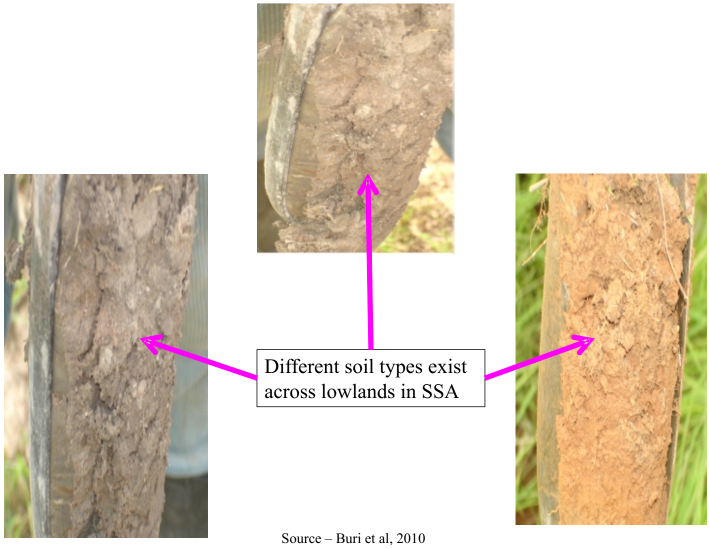
Distribution of lowlands and potential irrigated sawah in SSA (Hekstra, Andriesse, Windmeijer 1983 & 1993, Potential Sawah area estimate by Wakatsuki 2002)

Classification	Area (million ha)	Area for potential sawah development
Coastal swamps	17	4-9 millon ha (25-50%)
Inland basins	108	1-5 million ha (1-5%)
Flood plains	30	8-15 million ha(25-50%)
Inland valleys	85	9-20 million ha(10-25%)

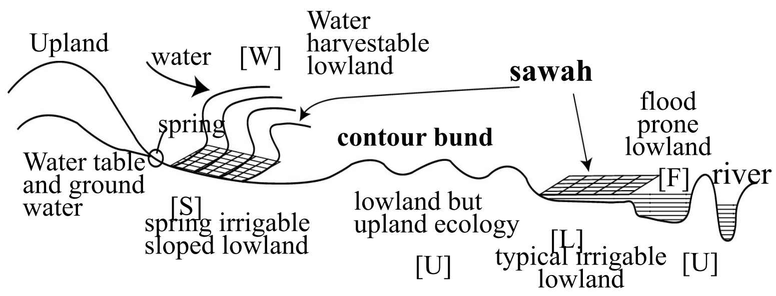
In SSA, estimated total maximum "sawah" area is 20 million hectors. Even though priority is given to inland valleys because of easier water control, some flood plains can also be given the same high priority. Examples are Sokoto & Kebbi where personal pump irrigated "sawah" is efficient



West Africa map showing selected sampling sites of lowland soils where detailed studies on the characteristics of both Inland valleys and flood plains across the sub-region have been studied (*Buri, Issaka and Wakatsuki et al)*



Lowlands (mainly inland valleys and flood plains) in Sub Saharan Africa are composed of heterogeneous soils that require different soil and water management options. The development of site specific management options will ensure their sustainable use.



Lowland sawah development priority

[S] > [L] > [F] > [W] > [U]

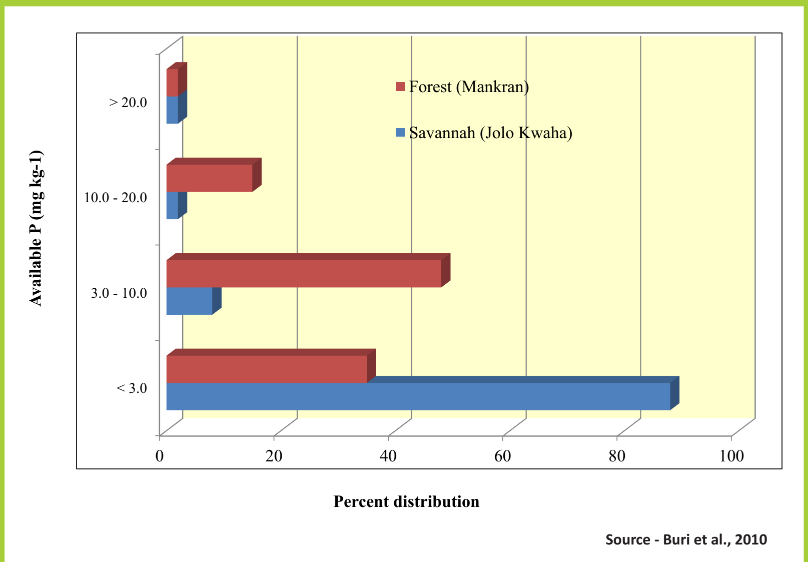
Irrigation options: Sawah to sawah/contour bund water harvesting, spring, dyke, river, pump, peripheral canal, interceptor canal, tank

As a result of variability in ecology, vegetation and rainfall, SSA has very diverse nature of lowlands that require Large Scale Action Research and On-the-Job training on Site Specific "Sawah" Development and "Sawah" Based Rice Farming

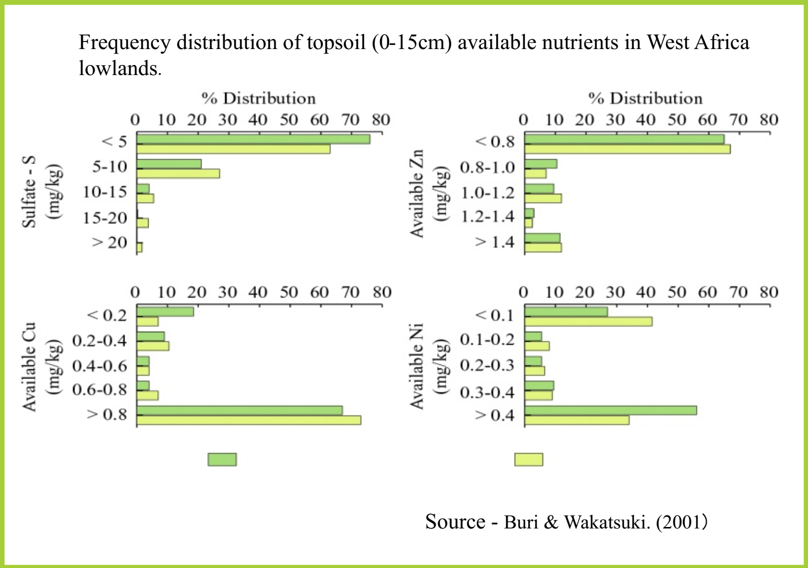
Mean values of fertility properties of inland valleys (IVS) and flood plains (FLP) of West Africa in comparison with lowland top-soils of tropical Asia and Japan

Location	Total C (%)	Total N (%)	Available P (mgkg^{-1})	Exchangeable Cation (cmol/kg)				Sand (%)	Clay (%)	CEC /Clay
				Ca	K	Mg	eCEC			
IVS	1.3	0.11	9	1.9	0.3	0.9	4.2	60	17	25
FLP	1.1	0.10	7	5.6	0.5	2.7	10.3	48	29	36
T. Asia*	1.4	0.13	18	10.4	0.4	5.5	17.8	34	38	47
Japan	3.3	0.29	57	9.3	0.4	2.8	12.9	49	21	61

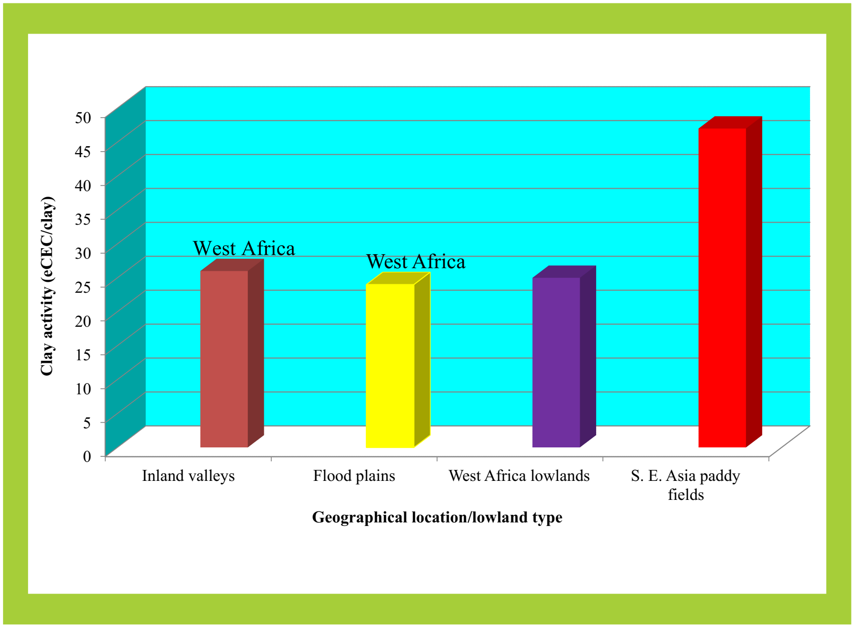
Studies have shown that soils of lowlands of SSA (particularly West Africa) are low in plant nutrients required for obtaining optimum crop yields. Lowland soils of the sub-region when compared to other similar areas are relative deficient in soil nutrients.



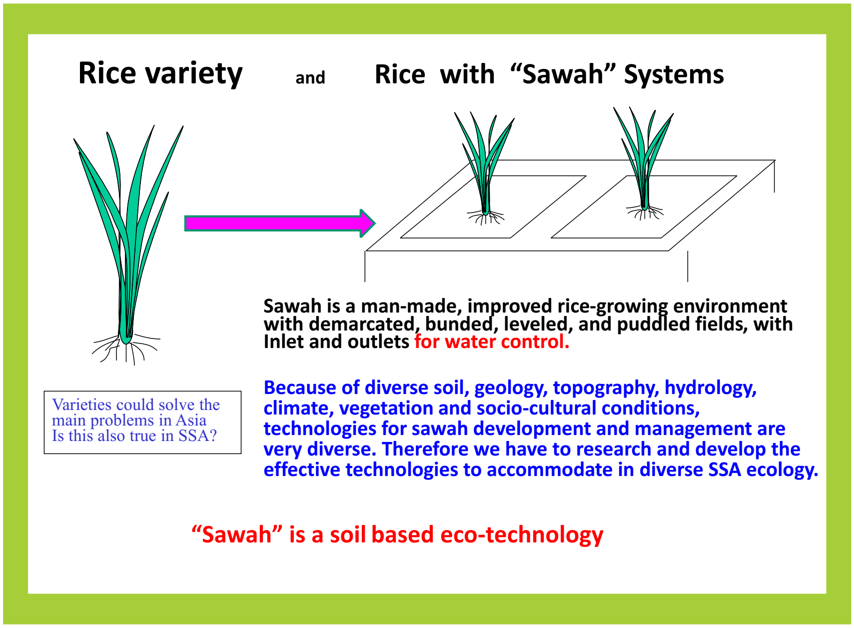
Available P distribution in Ghanaian Soils. Soil phosphorus is a major limiting nutrient to crop production in SSA not only within the lowlands but also in the uplands as well.



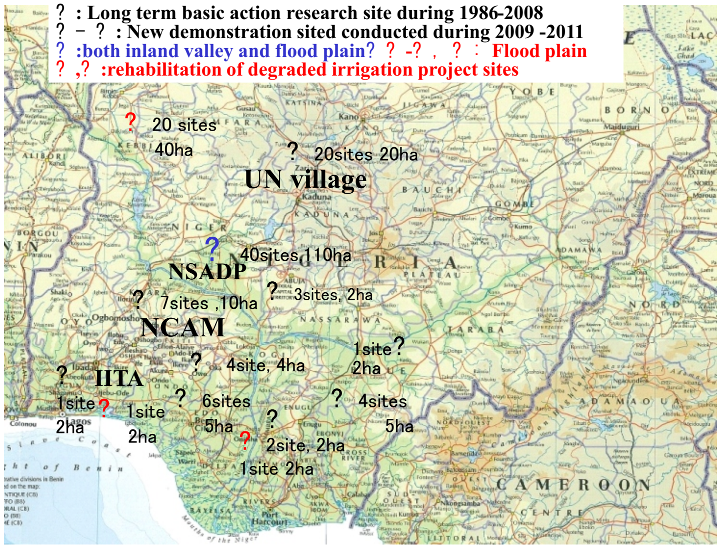
Lowland soils of the sub-region are very deficient in most secondary and micronutrients notably Sulfur and Zinc which are very critical for rice nutrition and hence grain yield.



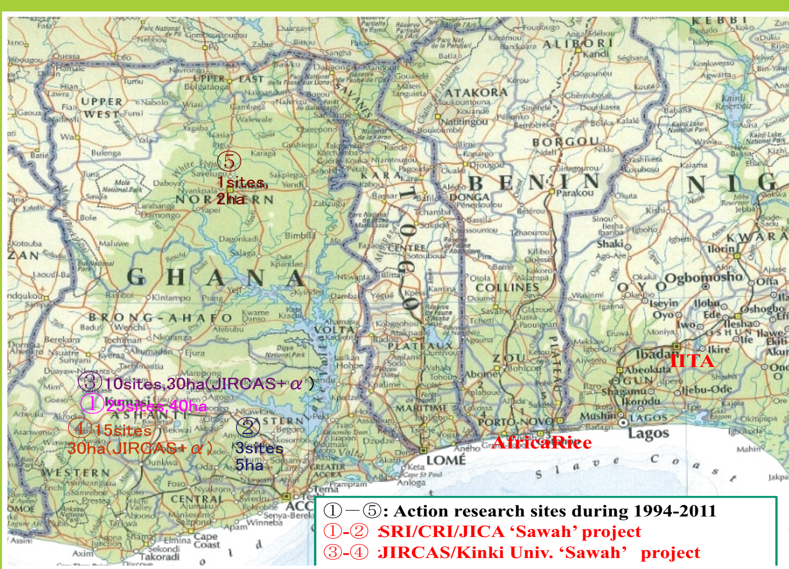
Clay activity is a good indication of how active soils are in terms of nutrient supply. Lowland soils of SSA are low in clay activity due to high weathering and the dominance of low activity clay minerals



Under the prevailing condition as spelt out earlier, there is the urgent need therefore to provide an improved environment (eco-technology) if the full potential of improved rice varieties (biotechnology) are to be realized. Higher yielding rice varieties require an improved growing environment ("Sawah" systems) to give off their high yield potentials. In effect, there must be a balance in bio-technology and eco-technology for effective and sustained rice production



Map of Nigeria showing areas where action research and on-the-job training has been conducted on "Sawah" System Development. So far action research and demonstration have been conducted at 100 sites covering 200ha in Nigeria including both inland valley and flood plains



Map of Ghana showing areas where action research and on-the-job training has been conducted on "Sawah" System Development. Many farmers have been given on-the-job training on "sawah" system development in the country. Currently "sawah" rice yields of 6-8 t ha-1 are very common. In addition, demonstrations and on-the-job training have been successfully conducted for technical staff of the SMART IV Project of AfricaRice