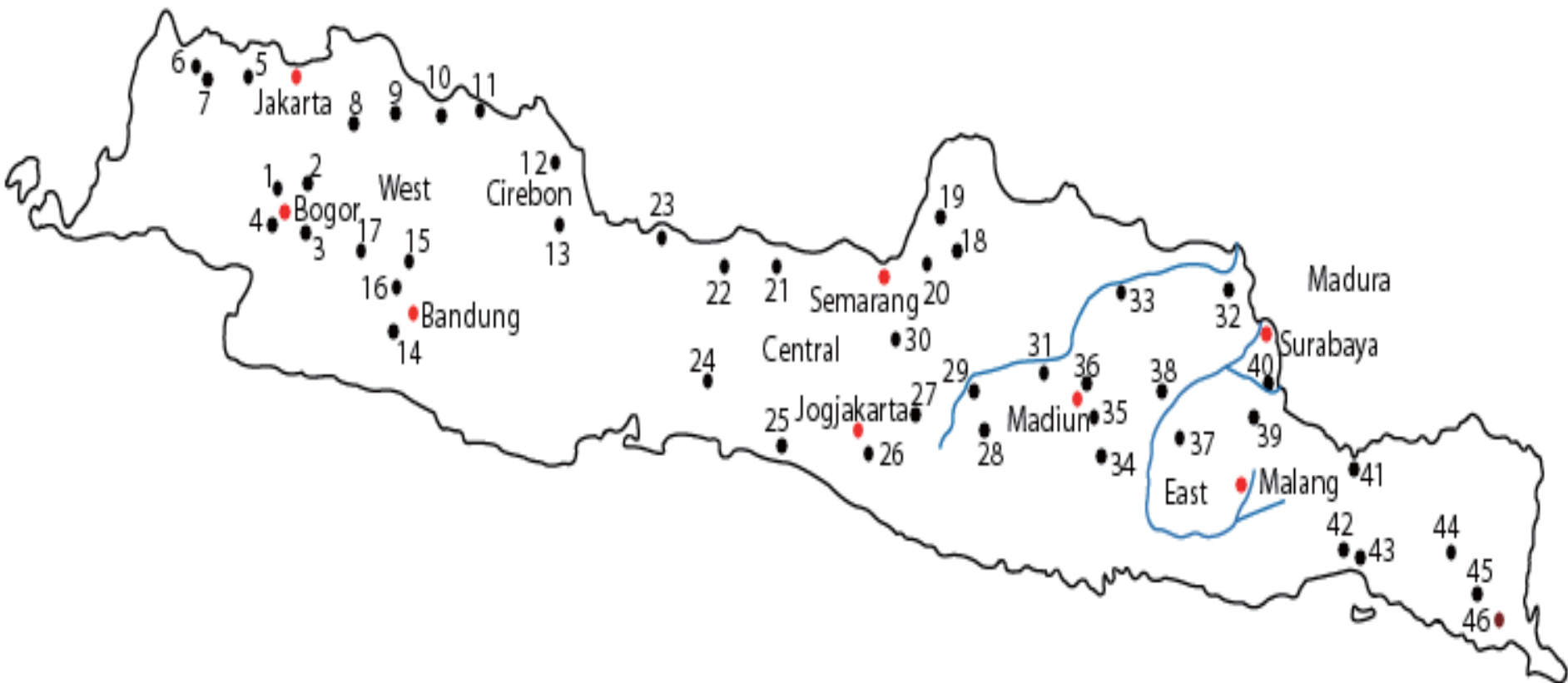




**Sawah soil carbon change of Java, Indonesia, during 1970-2003, the Green revolution period (Darmawan et al. 2006)**



**Prof. Kyuma  
Revisited his  
1970 sampling  
site in 2003**

**In 2003, Dr. Darmawan  
collected sawah soils from  
the same sites where  
Kyuma surveyed in 1970**



**In 2003, Dr. Darmawan collected sawah soils from the same sites where Prof Kyuma surveyed in 1970**



**Table 3** Changes in total carbon and total nitrogen (Mg ha<sup>-1</sup>) content in the 0–20 cm and 0–100 cm soil layers in seedfarms and non-seedfarms from 1970 to 2003 in Java, Indonesia (Darmawan et al. 2006)

	Seedfarm				Non-Seedfarm			
	0–20 cm		0–100 cm		0–20 cm		0–100 cm	
	1970	2003	1970	2003	1970	2003	1970	2003
<b>Total carbon (Mg ha<sup>-1</sup>)</b>								
<i>n</i>	18	18	18	18	22	22	22	22
Mean	34.50	39.24	92.68	112.83	29.77	41.37	79.60	114.86
Standard deviation	9.95	9.70	39.47	40.91	10.88	15.12	28.07	40.50
Mean change		4.74		20.15		11.60		35.26
% change		13.7		21.7		39.0		44.3
<i>t-test</i>		*		***		***		***
<b>Total nitrogen (Mg ha<sup>-1</sup>)</b>								
<i>n</i>	18	18	18	18	22	22	22	22
Mean	3.16	3.95	9.34	12.03	2.94	3.98	8.93	11.44
Standard deviation	1.07	0.89	4.01	4.10	1.15	1.24	3.16	3.30
Mean change		0.79		2.69		1.04		2.51
% change		25.0		28.8		35.4		28.1
<i>t-test</i>		**		***		***		***

*n*, number of sampling sites. \**P* < 0.05; \*\**P* < 0.01; \*\*\**P* < 0.001

**Both C & N increased 30% per 30 years during Green Revolution**

**Table 1. Research, technology development, innovation and dissemination in the area of eco-technology are just emerging, although its philosophy is to study the past to learn new things, i.e., **learning from history**「温故知新」 Agriculture needs Good Environments and Good Varieties. Both Biotechnology and Ecotechnology have to be researched, developed and innovated in good balance**

## **Bio-technology :**

**To improve varieties through breeding, i.e., Genetic improvement. Target is DNA improvement.**

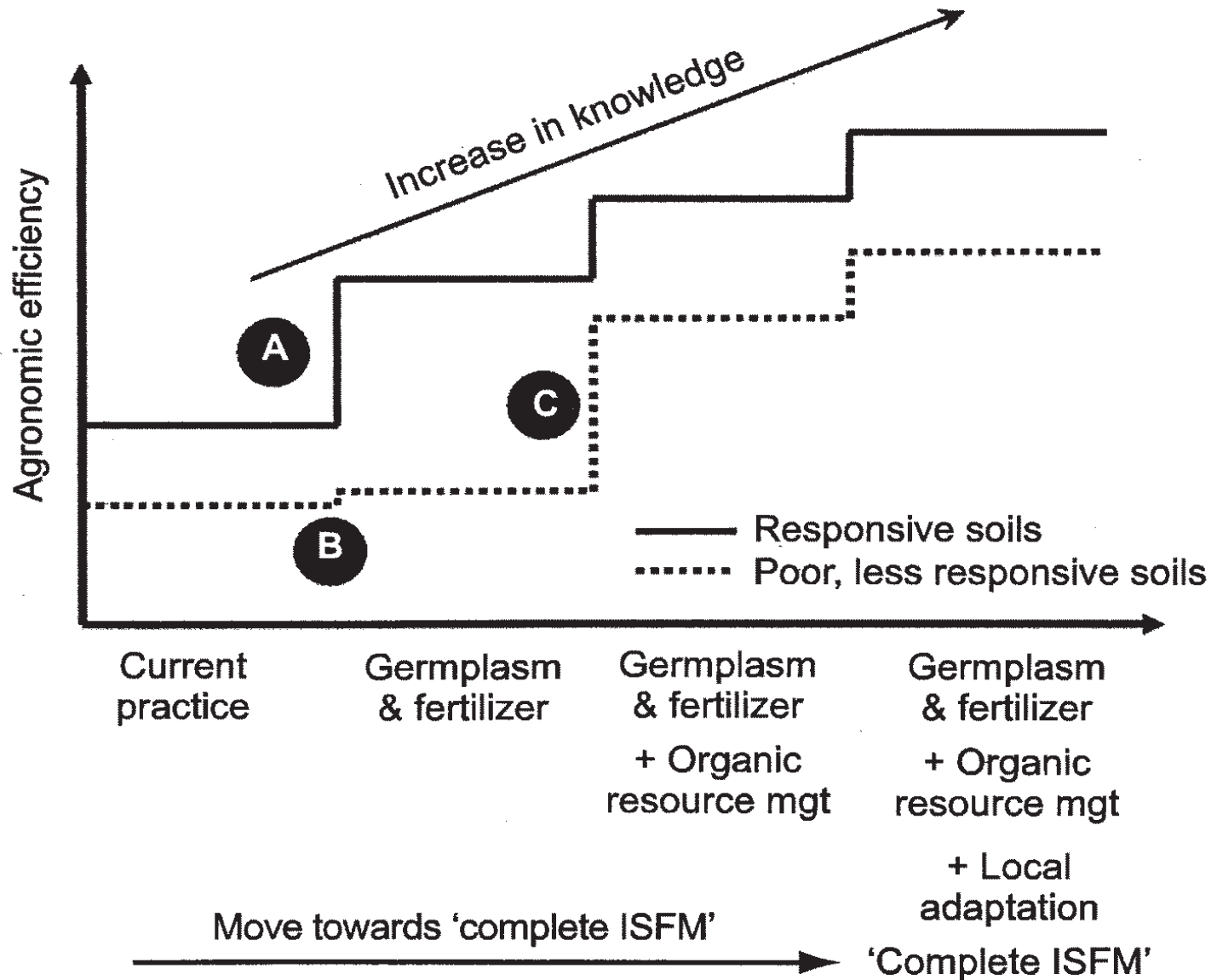
**Operational platform is Cell of organisms**

## **Eco-technology :**

**To improve growing ecology through sawah research, i.e., Improvement of water cycling and soil condition.**

**Target is soil and water. Operational platform is sawah in watersheds.**

# Integrated soil fertility management (ISFM)



(Vanlguwe, Bationo, Sanginga et al., 2010)

**Figure 11. Concept of Integrated Soil Fertility Management can not work without proper platform like sawah**

Weeds are stronger: upland rice, Bida



No eco-technology measures



Nupe's indigenous partial water control system



Inland Valley, Sierra Leone



Once Sawah systems are developed by farmers' self-support efforts and water is controlled, majority of HYV can produce higher than 5 t/ha

**Table 2. Mean gain yield of 23 rice cultivars in low land ecologies at **low (LIL)** and **high input levels (HIL)**, Ashanti, Ghana (Ofori & Wakatsuki, 2005)**

Entry No. Cultivar		← ECOTECHNOLOGICAL YIELD IMPROVEMENT						
		<u>Irrigated Sawah</u>		<u>Rainfed sawah</u>		<u>Upland like fields</u>		
		HIL	LIL	HIL	LIL	HIL	LIL	
		(t/ha)		(t/ha)		(t/ha)		
<b>BIOTECHNOLOGICAL IMPROVEMENT</b>	1	WAB	4.6	2.9	2.8	1.6	2.1	0.6
	2	EMOK	4.0	2.8	2.9	1.3	1.4	0.5
	3	PSBRC34	7.7	3.5	3.0	2.1	2.0	0.4
	4	PSBRC54	8.0	3.7	3.8	2.1	1.7	0.4
	5	PSBRC66	5.7	3.3	3.8	2.0	1.8	0.4
	6	BOAK189	7.0	3.8	3.7	2.0	1.4	0.3
	7	WITA 8	7.8	4.2	4.4	2.1	1.8	0.5
	8	Tox3108	7.1	4.1	4.0	2.3	2.3	0.6
	9	IR5558	7.9	4.0	3.8	2.0	1.8	0.5
	10	IR58088	7.7	4.0	3.7	1.8	1.4	0.3
	11	IR54742	7.7	4.3	4.0	2.2	1.9	0.4
	12	C123CU	6.9	4.1	4.2	1.9	2.0	0.4
	13	CT9737	6.5	4.0	4.0	1.7	1.9	0.6
	14	CT8003	7.3	3.8	3.8	1.7	2.0	0.5
	15	CT9737-P	8.2	4.0	4.3	1.8	1.2	0.5
	16	WITA1	7.6	3.6	3.3	1.8	0.9	0.3
	17	WITA3	7.6	3.5	4.1	2.0	1.3	0.5
	18	WITA4	8.0	4.1	3.7	2.1	1.5	0.3
	19	WITA6	8.0	3.5	4.0	2.3	1.4	0.3
	20	WITA7	7.3	3.7	3.8	2.2	2.0	0.4
	21	WITA9	7.6	4.4	4.5	2.8	2.0	0.6
	22	WITA12	7.6	4.0	3.8	1.9	1.8	0.4
	23	GK88	7.5	3.8	3.5	2.0	1.8	0.5
<b>Mean (n=23)</b>		<b>7.2</b>	<b>3.8</b>	<b>3.8</b>	<b>2.0</b>	<b>1.7</b>	<b>0.4</b>	
Range		(4.0-8.2)	(2.8-4.4)	(2.8-4.5)	(1.3-2.8)	(0.9-2.3)	(0.3-0.6)	
SD		1.51	0.81	0.81	0.45	0.44	0.12	

Because of cost of green revolution technology, yield must be higher than 4t/ha



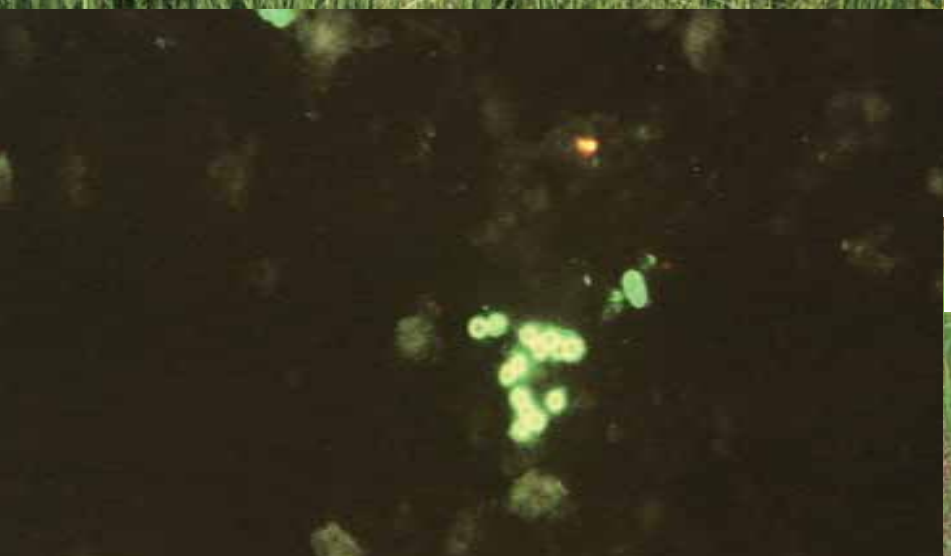
**Sawah and traditional non sawah rice ,  
Pampaida, UN millennium village, Zaria**



**Poor tillering and aggressive  
weed in non sawah field**



**Submerged sawah:  
Multi functional  
ecosystems of  
various interaction  
between rice, algae,  
fish, goose,  
microbes, & others**

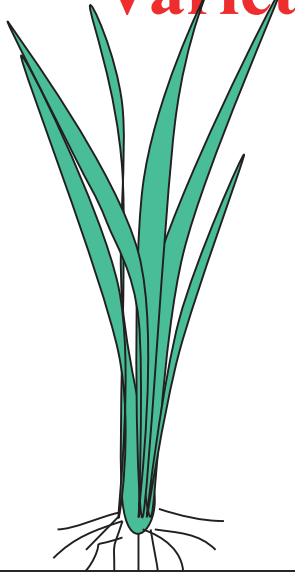


**Left :nitrogen  
fixing Azola**

**Azotobacter : Chemoautotrophic  
Nitrogen fixing bacteria in Sawah  
(SSSA Slide collection)**

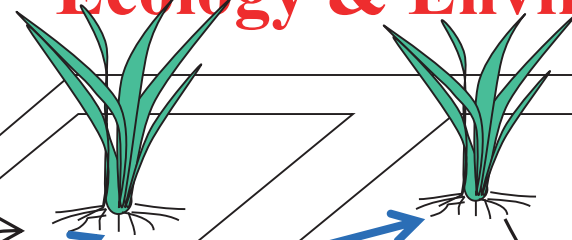
# Bio-technology and Eco-technology

**Breeding to improve Variety**



**Sawah to improve Ecology & Environment**

**Water in (irrigation)**



**Water out (drainage)**

Sawah is a man-made, improved rice-growing environment with demarcated, banded, leveled, puddled fields and smoothed surface

Varieties could solve **the main problems** in Asia. Is this also true in SSA? **No! , last 40years experiences**

**Good Yield**

**Good Tillering & Grain**

**Good Puddling Soft & low Bulk density topsoil**

**Good Sawah**

**Good weed competition**

**Good rooting, nutrient supply & Water saving**

**Good Water control**

**Fig 12. Rice (variety) and environment (Sawah) improvement. Both Bio & Eco-technologies must be developed in appropriate balance**

# **Table 4. Biotechnology and Sawah Eco-technology Options and Complementation for Rice Production**

## **(1) Water shortage and Flood damage**

**Biotech:** Genes of deep rooting, C4-nature, Osmotic and flood tolerance

**Ecotech:** Sawah based water harvest in watersheds. Bunding, leveling, puddling, with various irrigation and drainage. Flood control systems, aerobic rice.

## **(2) Poor nutrition, acidity and alkalinity**

**Biotech:** Gene of N fixation, P and various micronutrient transporters.

**Ecotech:** Sawah based method to increase N fixation and P, Si, K and Zn etc. availabilities. Geological fertilization and watershed agroforestry (Satoyama systems). Mixed, organic and natural farmings

## **(3) Weed, Pest and disease control**

**Biotech:** Genes of various resistance, rapid growth, C4 nature

**Ecotech:** Sawah based weed management through water control and line transplanting. Good leveling. Sawah based silica and other nutrients supply to enhance immune mechanisms of rice. Sawah based mixed cropping, Sawah based duck, fish and rice and other rice farming.

## **(4) Global Warming**

**Biotech:** Ultra high yield varieties

**Ecotech:** Carbon sequestration by Sawah systems through the control of oxygen supply, use of Biochar, and organic farming. System rice intensification and other ultra high yield agronomic practices

## **(5) Food quality and Biodiversity**

**Biotech:** Golden rice, other vitamin rice gene

**Ecotech:** Fish, duck and rice in sawah systems. Satoyama agroforestry systems

# **Table 5. Multi Functionality of Sawah Systems**

## **I. Intensive, diverse and sustainable nature of productivity**

- (1) Weed control**
- (2) Nitrogen fixation ecosystems: 20 to 200kgN/ha/year**
- (3) *To increase Phosphate availability: concerted effect on N fixation***
- (4) pH neutralizing ecosystems: to increase micro nutrient availability**
- (5) *Geological & irrigation fertilization: water, nutrients and topsoil from upland***
- (6) Various sawah based farming systems.**
- (7) Fish and rice, Goose and sawah, Birds and sawah, Forest and Sawah**

## **II. To combat Global warming and other environmental problems**

- (1) **Carbon sequestration through control of oxygen supply.** Methane emission under submerged condition. Nitrous oxide emission under aerobic rice**
- (2) *Watershed agroforestry, SATOYAMA, to generate forest at upland and to conserve bio-diversity***
- (3) Sawah systems as to control flooding by enhance dam function through bund management**
- (4) Sawah system as ground water recharge system and to soil erosion control**
- (5) Denitrification of nitrate polluted water**

## **III. To create cultural landscape and social collaboration**

- (1) *Terraced sawah as beautiful cultural landscape***
- (2) Fare water distribution systems for collaboration and fare society**



**Sawah rice farming:  
Ecotechnology for  
Food, Environment,  
Landscape, and  
Culture(Multi-  
functionality) (World  
Heritage, Ifugao  
people,  
Philippine,Koudansha  
Co. Ltd, 1998)**

**Sawah is ecotechnology based Multi-Functional constructed Wetland:  
Production, Environment, and Cultural landscape (JICA sawah project, 2001)**

Termite mound



**Inland valley, Ashanti, Ghana, 2001**

**Japanese Inland Valley system  
(SATO-YAMA ): Integration  
of Forest, Pond & lowland Sawah  
in watersheds**



**Sawah is Multi-Functional  
Wetland: Rice, Algae, and  
Microbes' Complex Ecosystems**



Primary  
Forest

“YAMA”

Secondary  
Forest

Cocoa  
Plantation

“SATO”

Rice  
'Sawah'  
Field

Through fall, decomposition of litter, mineralization,  
erosion and transport of dissolved nutrients and nutrients releases to  
fertilize inland valley at the lower slope (Si, N, P, K, Ca, Mg)

Figure 10. One Example of Africa SATO-YAMA Concept Map by Dr. Owusu, FoRIG, Ghana which is a watershed agro-forestry applicable to Cocoa belt region in West Africa.



# Kumasi, Gold valley Site, Non Sawah and Cacao farm



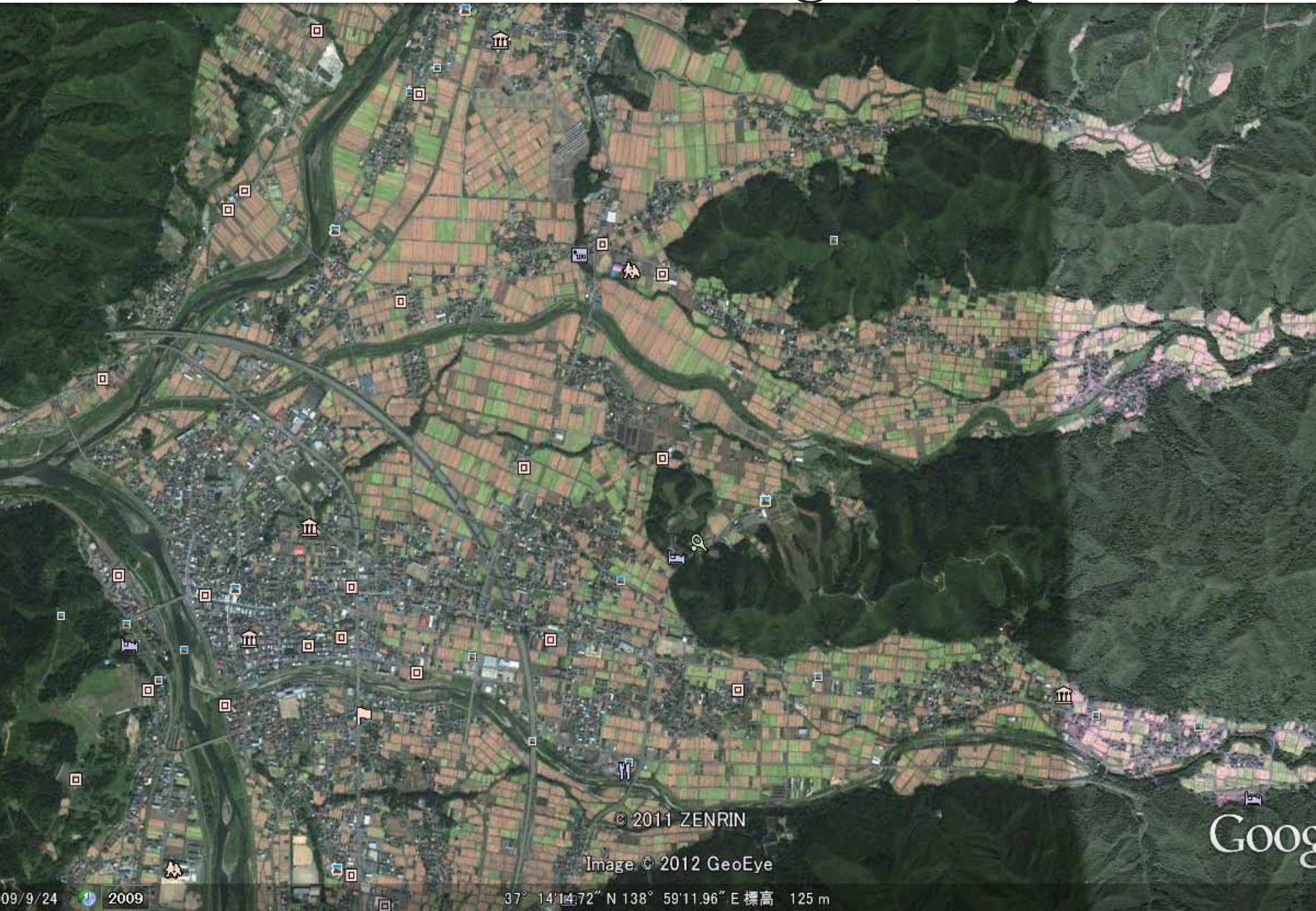
# Kumasi, Tawiah Site, Terraced sawah and Cacao and citrus farm



**Kumasi, SRI assisted Baniekrom Site, lowland sawah, oilpalm, Cacao in opposite side and access road & citrus farm in front side (August 2013)**



# Minami Uonuma, Niigata, Japan



© 2011 ZENRIN

Image © 2012 GeoEye



**Mt, Oscar's Sawah rice and Cacao farm, at Afari, Kumasi, Ghana**



# Thanks

A group of approximately 20-30 people, including men, women, and children, are walking along a narrow dirt path that runs through a vast, lush green paddy field. The field is filled with tall, healthy rice plants. In the background, there are several trees and a clear sky with some light clouds. The overall scene is bright and vibrant, suggesting a healthy and productive agricultural environment.

**Traditional Nupe's  
Paddy fields  
Nigeria**

**New Sawah  
Field**