Site specific sawah development & management by farmers' self-propelling efforts: Action research in Ghana & Nigeria for demonstration of Sawah hypothesis (1) & (2), 22-26 March, 2010, at the 2nd Africa Rice Conference, Bamako, Mali

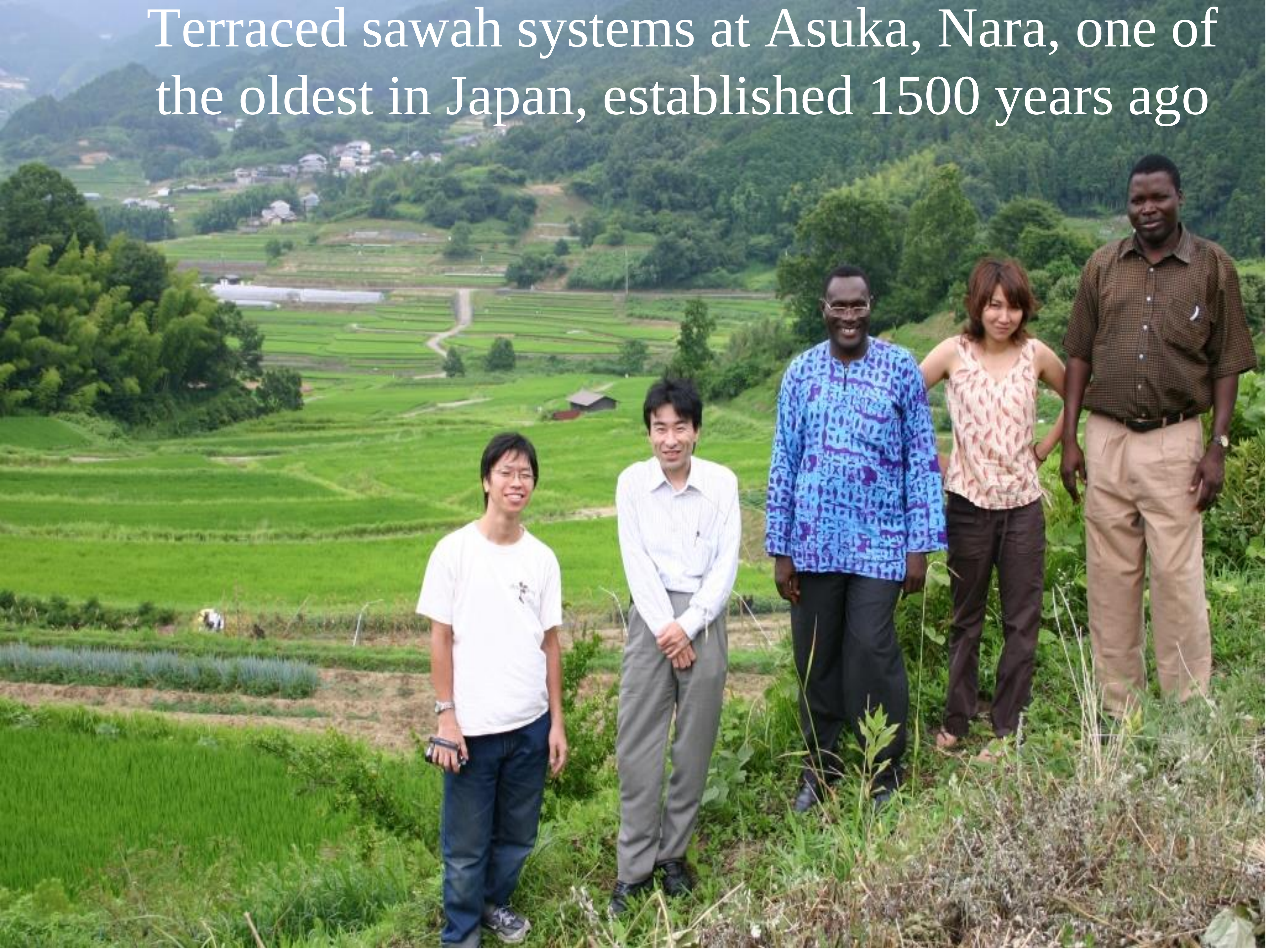
Wakatsuki(Kinki Univ), Buri(SRI), Bam(CRI, Ghana), Oladele ,Imolehin(NCRI, Nigeria)

African farmers can develop their personal irrigated sawah systems by themselves to realize green revolution and Africa's rice potential

Sawah systems developed by China Farmers

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

Terraced sawah systems at Asuka, Nara, one of the oldest in Japan, established 1500 years ago

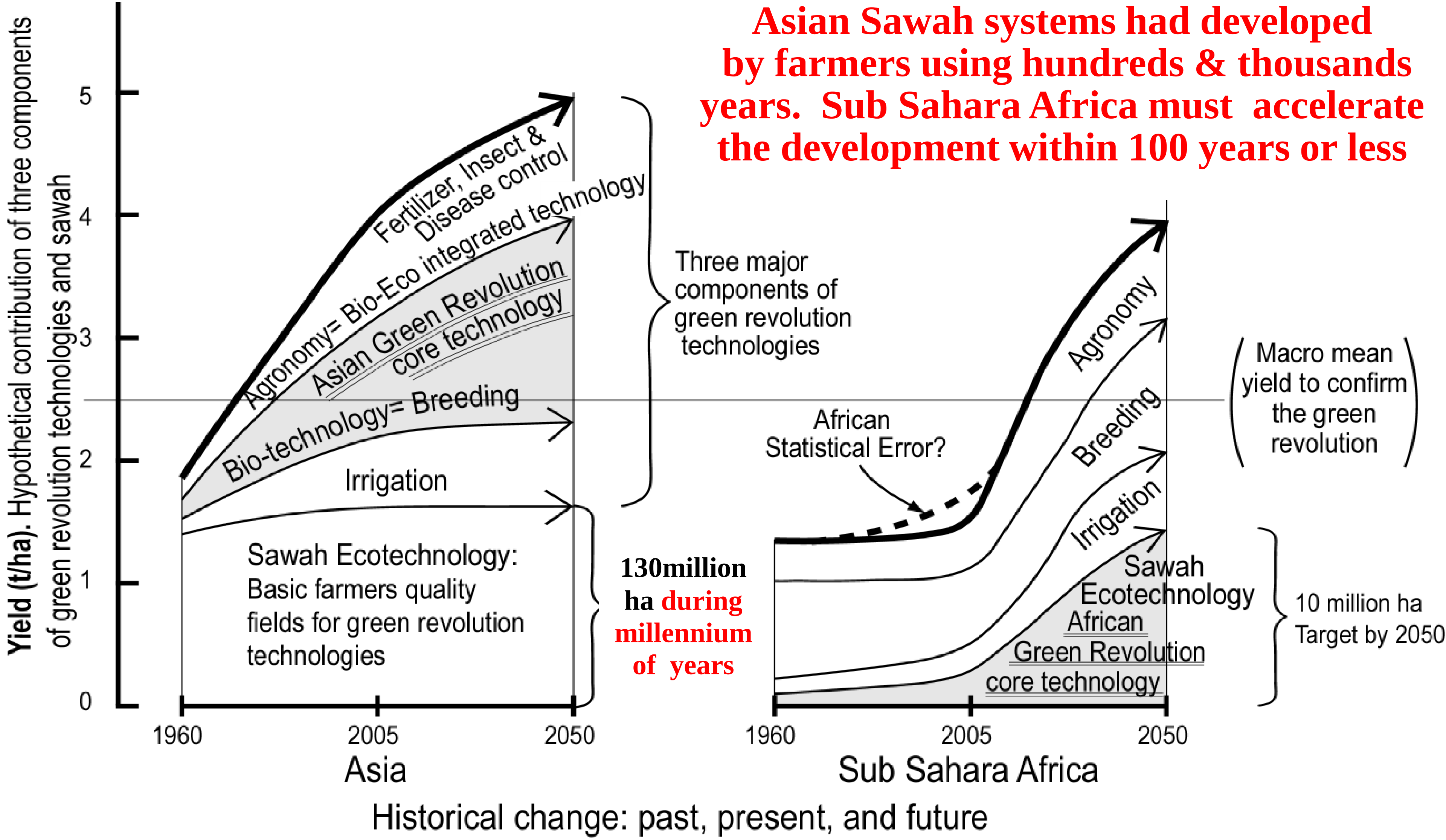


Sawahs of Madagascar have thousands years of history with the migration of "old" Indonesian,
Sawah systems are the base of "SRI" and "Aerobic rice"

Sawah of Bangkok Plain, March 08 .

Even very flat flood plain, good & closed bunding, leveling and puddling are the essence of sawah for control water

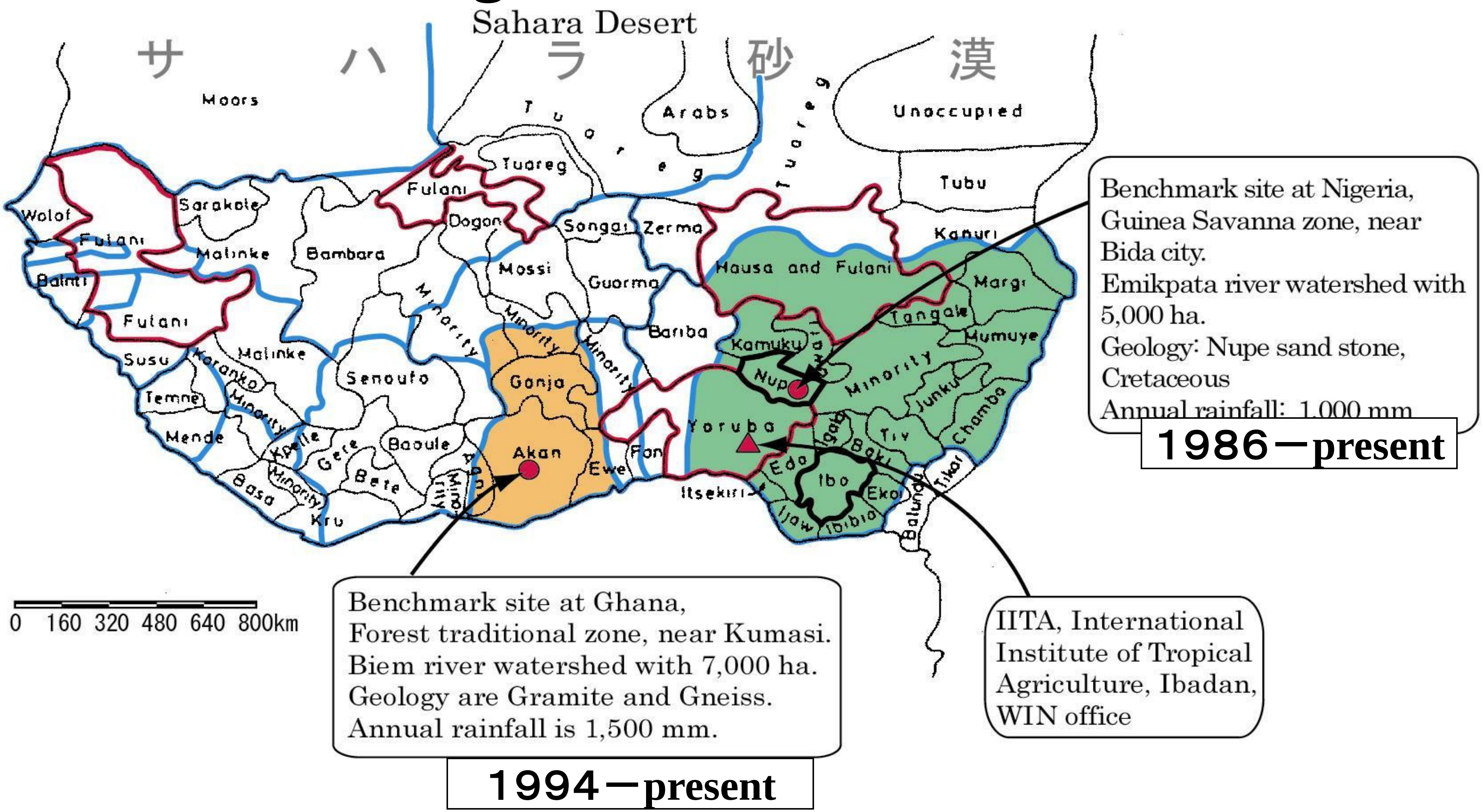
Asian Sawah systems had developed by farmers using hundreds & thousands years. Sub Sahara Africa must accelerate the development within 100 years or less



Sawah hypothesis (I) for Africa Green Revolution:

hypothetical contribution of three green revolution technologies & sawah system development during 1960-2050. Bold lines during 1960-2005 are mean rice yield by FAOSTAT 2006. Bold lines during 2005-2050 are the estimation by the authors.

Experiences and examination of Sawah hypothesis I & II through long term massive action researches in Ghana and Nigeria

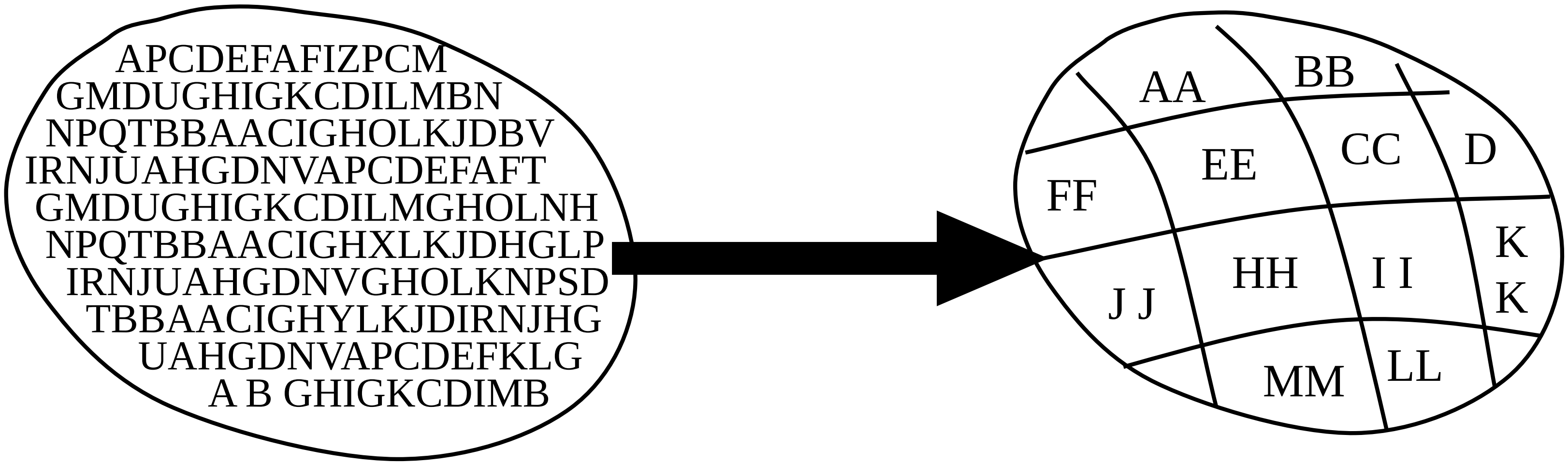


Core benchmark sites with various sized watersheds in Ghana & Nigeria. The action research sites were expanded in 2008 and 2009.


New Sawah project
Sokwae Inland valley
site of CRI, Aug.08

Farmers' Paddy Fields: Diverse and mixed up environment.No clear field demarcations

Sawah based eco-technology can improve rice ecology, especially for water control. Green revolution technology of fertilizer, irrigation and HYV are useful.



Fertilizer, Irrigation, and HYV are not effective No Green Revolution possible

Sawah based Farming system

Fig. Sawah hypothesis (I): Farmers Sawah should comes the first to realize green revolution. Successful Integrated Genetic and Natural Resource Management needs classified demarcated land eco-technologically

Sokwae Sawah development
by CRI sawah team, June 2008

Sokwae Sawah development by farmers July 2008

Sand bag weir by farmers and SRI Sawah team, Aug.2009, Nsutem, Ghana

Levelling & Soil movement by power tiller, which is extended agronomical works by farmers themselves.

Ghana-Sokwae,Kumasi, CRI sawah Staffs and farmers, Aug. 2008
Rice yield was more than 4t/ha, thus green revolution was realized.
2 ha in 2008, which was expanded to 6 ha by January 2010

Mr. Tawiah developed about 4ha sawah by Sep. 07 surrounding his 1.5ha of fish pond. Total paddy production was more than 20ton annualy, which gave gross revenue about $10,000. Power tiller loan is $1500 per year for four years

Mr. Tawiah and his rice grown on sawah about 4ha developed by himself, with CRI/SRI, and JIRCAS scientists, August 2009

Table. Estimated Revenue of farmer groups under the "Sawah" System (By BURI SRI, based on 2007 before 2008 food crisis)

Farmer-group	Paddy Grain yield (kg/ha)	Gross Revenue (US$/ha)	Production Cost** (US$/ha)	Net Revenue (US$/ha)
Adugyama*	4334	1712	428	1284
Biemso – A*	4675	1847	350	1497
Biemso – B*	4736	1871	324	1547
Biemso – C*	4675	1847	349	1498
Traditional	900	355	150	205

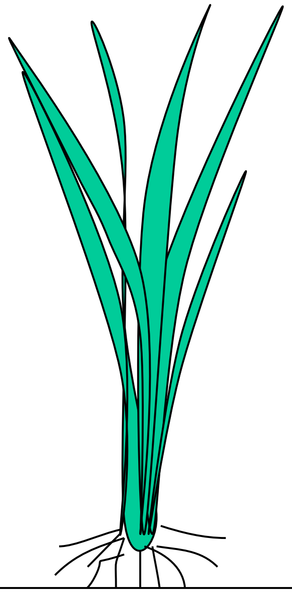
***5ha sawah give about $7000 revenue in 2007 price. After 2008 food crisis the revenue will be more than 30% up, $10,000.**

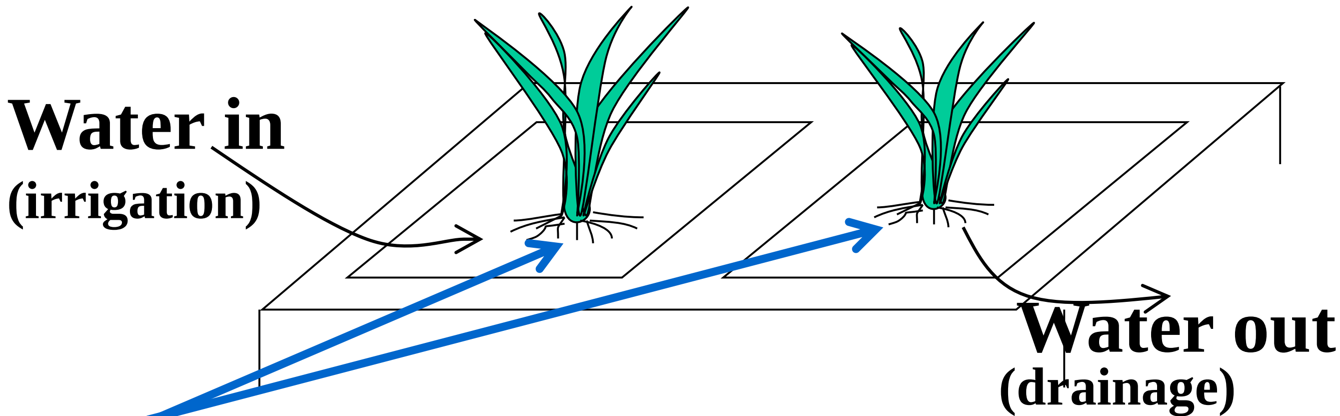
****The production cost does not include sawah development, which will be 2000-4000$/ha including machine and running cost.**

One powertiller can develop 1-3 ha per season and 10ha per 5 years of durability. One power tiller can cultivate 10 ha sawah per season & 5years of life. The machine cost is $3000-7000 (Asian price is about $3000)

Bio-technology and Eco-technology

Rice variety and Rice with Sawah Systems





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

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

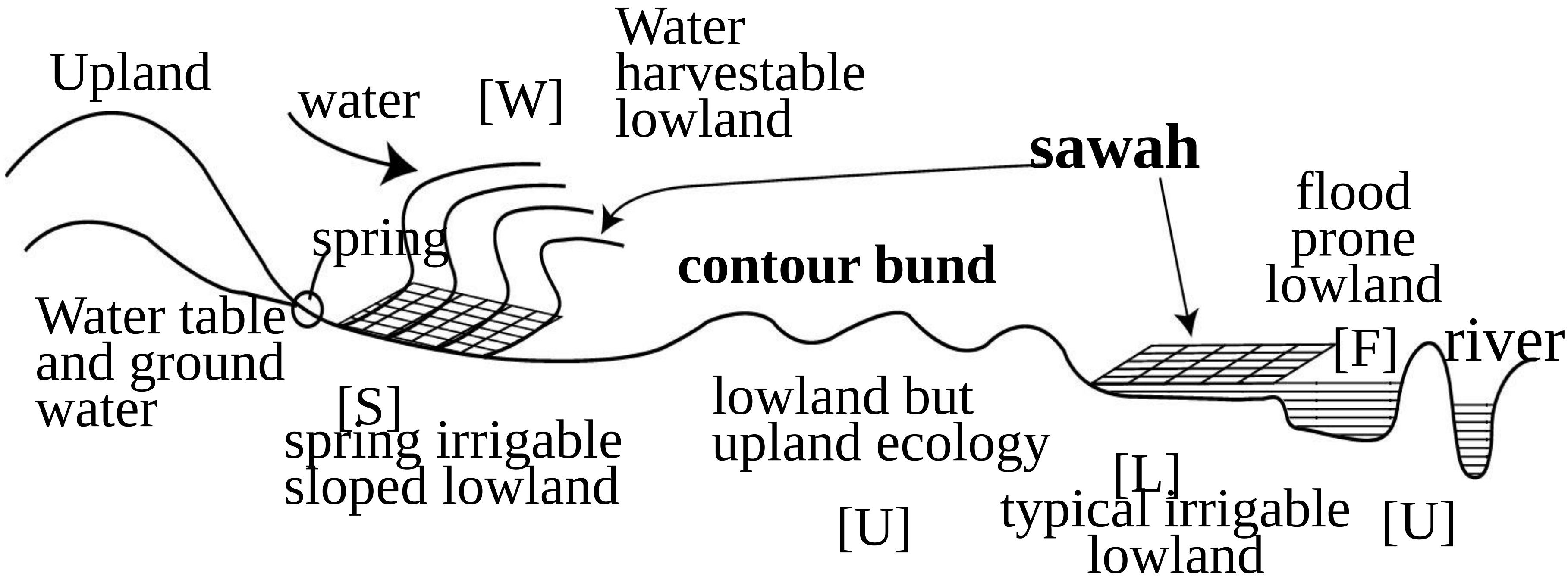
Good Sawah → Good Puddling Soft&low Bulk density topsoil → Good Tillering & Grain → Good Yield

Good Sawah → Good Water control

Good Puddling Soft&low Bulk density topsoil → Good rooting, nutrient supply & Water saving

Good Tillering & Grain → Good weed competition

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



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

Lowland sawah development priority

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

Fig. : Very Diverse Nature of African Lowlands Need on Large Scale Action Research and On The Job training on Site Specific Sawah Development and Sawah Based Rice Farming

Table: Necessary Technologies and Socio-economic conditions to be researched on Site Specific Sawah Development & Management by Farmers' Self-Propeleld Efforts

Sawah approach: farners' personal rice irrigation scheme with 0.5-10ha area

(1) Site Selection and Sawah system design

(2) Development skills and cost ($/ha)

(3) Farmers Group Quality

(4) Agronomic Sawah system management

(5) Land Tenure Arrangement for sustainable sawah development

(6) Training

(1) Site Selection and Sawah system design

(a) Water sources for site selection (>10liter/sec, > 5months)

Stream/River, Spring, Seepage, Flood, Rainfed

(b) Topography and soil for site selection

Potential area

Slope and surface roughness

Soil

(c) Socio-economic for site selection

Participating farmers

Land tenure

(d) Sawah system design

Sawah layout and total potential area

Mean sawah size(ha)

Water intake, distribution and control

Spring and sawah to sawah & diversion canal

Stream/Seepage and sawah to sawah & diversion canal

Simple dyke& diversion canal

Weir & Canal

Fish pond or dam lake

Pump

Interceptal canal

Contour bud system

Flood control by drainage/dam

Drought control by pond/waterharvest

Soil movement(t/ha)

Contour bund system

Flood control by drainage/dam

Drought control by pond/waterharvest

Soil movement(t/ha)

At first local farmers never know sawah technologies, they know site specific hydrological conditions which are the most important for site selection

On the job collaboration between farmers and Scientists, engineers, as well as extension office is essentially important

(2) Development skills and cost ($/ha)

(a) Skils for development

- Skill for power tiller operations
  - Plowing and Puddling
  - Soil Moving
  - Surface leveling & smoothing
  - Skill for power tiller management

(b) Cost ($/ha) or (Cedi/ha)

- Power tiller for development
- Powertiller spare parts
- Fuel for development
- Bush clearing destamping
- Bunding and surface teatment
- Canal construction
- Dyke construction
- Additional hired labours
- Tools and materials
- Scientist and engineers cost
- Extension officer cost
- Farmers' training

Action research and on the job training of site specific sawah development and management

(1) Cots of Power tiller for Sawah development: at least 10ha per one power tiller ($5000/10ha)

(2) Cost of scientists, engineers, extension officers, and leading farmers

(3) Target cost: 2000-4000/ha

(4) Agronomic Sawah system management

Rice mono cropping
Rice and other 2nd season cropping
Rice double cropping
Overall Water Control
Water sources
Water distribution
Leveling & smoothing
Bunding
Puddling
Weed control
water consumption (ton/season)
water requirment(mm/day)
Water quality
Soil fertility
Fertilzation(N-P2O5-K2Okg/ha)
Variety
Yield (ton/ha)

(1) Immediate target
Paddy yield >4t/ha

(2) 3t/ha is not enough to sustain sawah development

(3) >5t/ha will accelerate Sawah development

(4) Basic research on sustainable paddy yield >8t/ha is important

(3) Farmers Group Quality

Leader and group collaboration

No. of farmers

Ethnic composition

Skills and incentives

Gender composition

(6) Training

Trainer

Trainee

International scientists

National scientists

Extention officers

Leading farmers & farmers

To train
(1) Sawah farmers who can develop Sawah and manage Sawah based rice farming by themselves,

(2)Leading sawah farmer and farmers' group who can train another new sawah Farmer and farmers' groups

On the job field training on sawah ecotechnology to researchers, extension officers & leading farmers are the most important

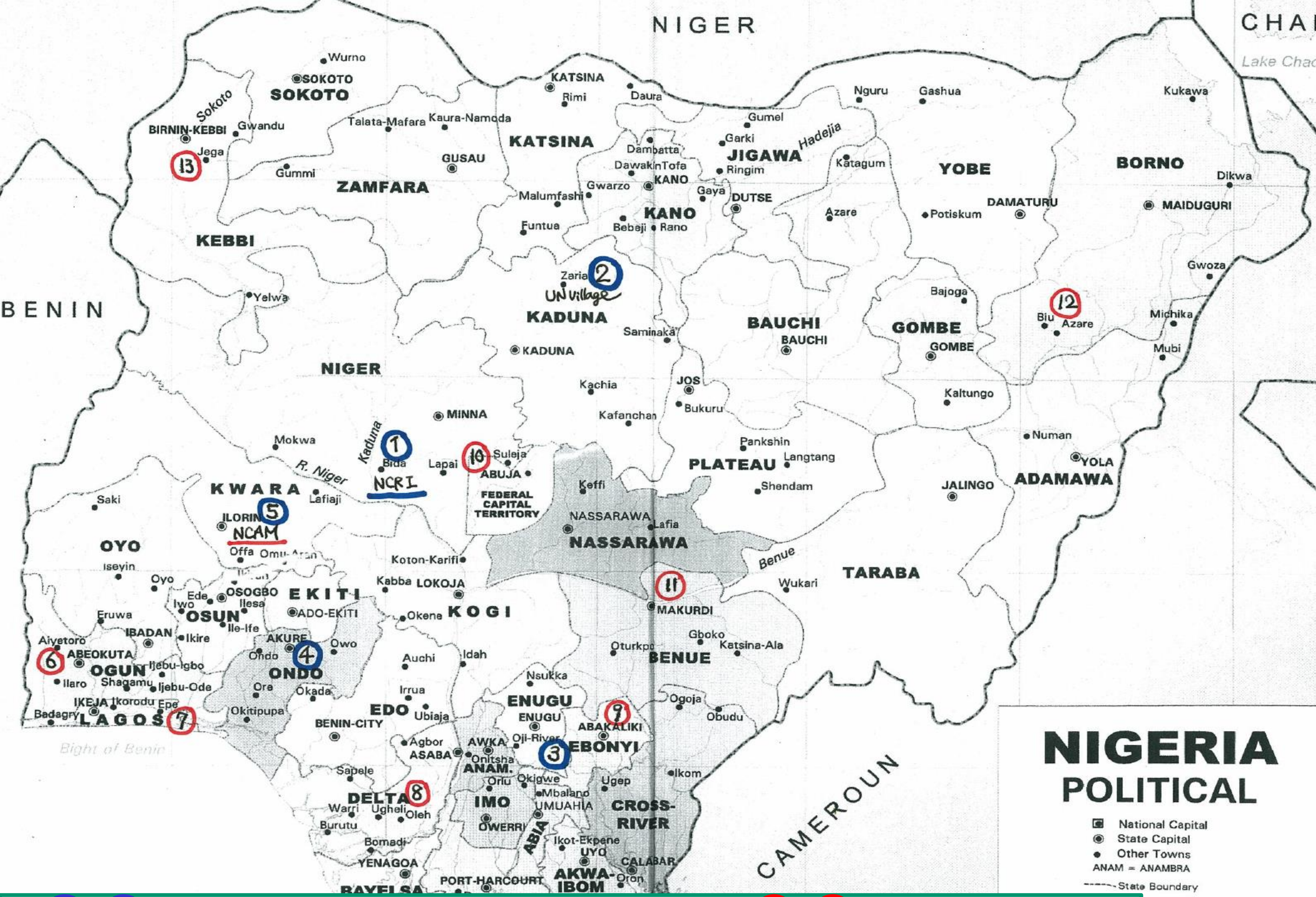
Ejiti Sawah village,
Bida, Nigeria, Sep 09

On the job training at Shabamaliki village, Bida, Nigeria, Sep 09

On the job training at Shabamaliki village, Bida, Nigeria, Sep 09
Paradoxically, leading farmers can master the skill within one to two seasons, but extension officers needs more than three seasons

Farmers' to farmers sawah technology transfer, SRI site, Ghana, Jan 2010

Mr. Tawiah trained another farmer to develop 3ha of sawah using small spring water source. Only local farmers know such water source.



①-⑤: Action Research Sites by 2009, ⑥-⑬: New sites in collaboration with NCAM/NCRI and Fadama III in 2010

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 and 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%)

Priority target is the inland valley because of easier water control

Max 20million ha (Estimated sawah area came from the relative amount of water cycle in Monsoon Asia, which has 130 million ha of sawah)

Road Map to Realize Africa Rice Green Revolution through Site Specific Sawah Technology by Million Farmers' Self-Support Efforts

- **1986-2003 : (10 sites, 10ha of sawah) : Achieved**

  Baisc research on Site Specific Sawah development by farmers' self support efforts at Bida, Nigeria and Kumasi, Ghana

- **2004-2008: (50 sites, 100ha of sawah): Achieved**

  Basic Action research on Site Specific Sawah development by farmers at Bida, Zaria, Akure, and Ilorin, Nigeria and Kumasi and his surroundings, Ghana

- **2009-2013: (250 sites, 1000ha of sawah): Immediate Target for Action Research for Dissemination of Sawah Technology**

  by Kinki Univ/NCAM/FadamaIII, JIRCAS, SMART-IV and JICA-CARD; Large scale Action research on Site Specific Sawah development by farmers at Nigeria, Ghana, Togo, Benin & others

- **2014-2025: (5000 sites or more, 25,000ha of Sawah):**

  Africa wide dissemination of Site Specific Sawah development by farmers self-support efforts

- **2025 and after: African wide spontaneous sawah expansion and the Realization of African Rice Green Revolution: Realization of African Rice Potential**

Comparison between Biotechnology and Sawah based Ecotechnology, which must be integrated

(1) Water shortage : **Bio-technology**:Genes for deep rooting、C4-nature、and Osmotic regulation. **Eco-technology** of Sawah based soil and water management, bunding, leveling, puddling, surface smoothing with various irrigations, Aerobic rice, System rice intensification

(2) Poor nutrition, acidity and alkalinity:Gene of Phosphate and micronutrient transporter. **Eco-technology** of Sawah based N fixation, increase P availability and micro- as well as macronutrient. Geological fertilization and watershed agroforestry(SATOYAMA systems), organic matter and fertilization. Bird feculent are rich in P.

(3) Weed control:Gene of weed competition, rapid growth.

Eco-technology of Sawah based weed management through water control, and tans-planting. Leveling quality and surface smoothing of sawah are important. Duck and rice farming.

(4) Pest and disease control: Resistance genes. **Eco-technology** of Sawah based silica and other nutrients supply to enhance immune mechanisms of rice. Mixed cropping.

(5) Food quality: Vitamine rice gene. **Eco-technology**: Sawah based nutrition control. Fish, duck and rice in sawah systems

Macro-scale watershed eco-technological mechanisms to support Sawah hypothesis II: Geological Fertilization of eroded top-soils and accumulation of nutrient rich water in lowland Sawah

Sustainable green revolution by sawah and SATOYAMA systems for combating Global warming: (1) efficient use of water cycling and conservation of soil fertility, (2) Ecological safe carbon sequestration by CDM, Bio-char and humus accumulation in sawah Soil layers, which will eventually transfer to sea floor, and (3) increase soil productivity by bio-char and humus accumulation

Micro-scale eco-technological mechanisms to support Sawah hypothesis II: Enhancement of the availability of N, P, K, Si, Ca, Mg, and micronutrients and quality carbon accumulation

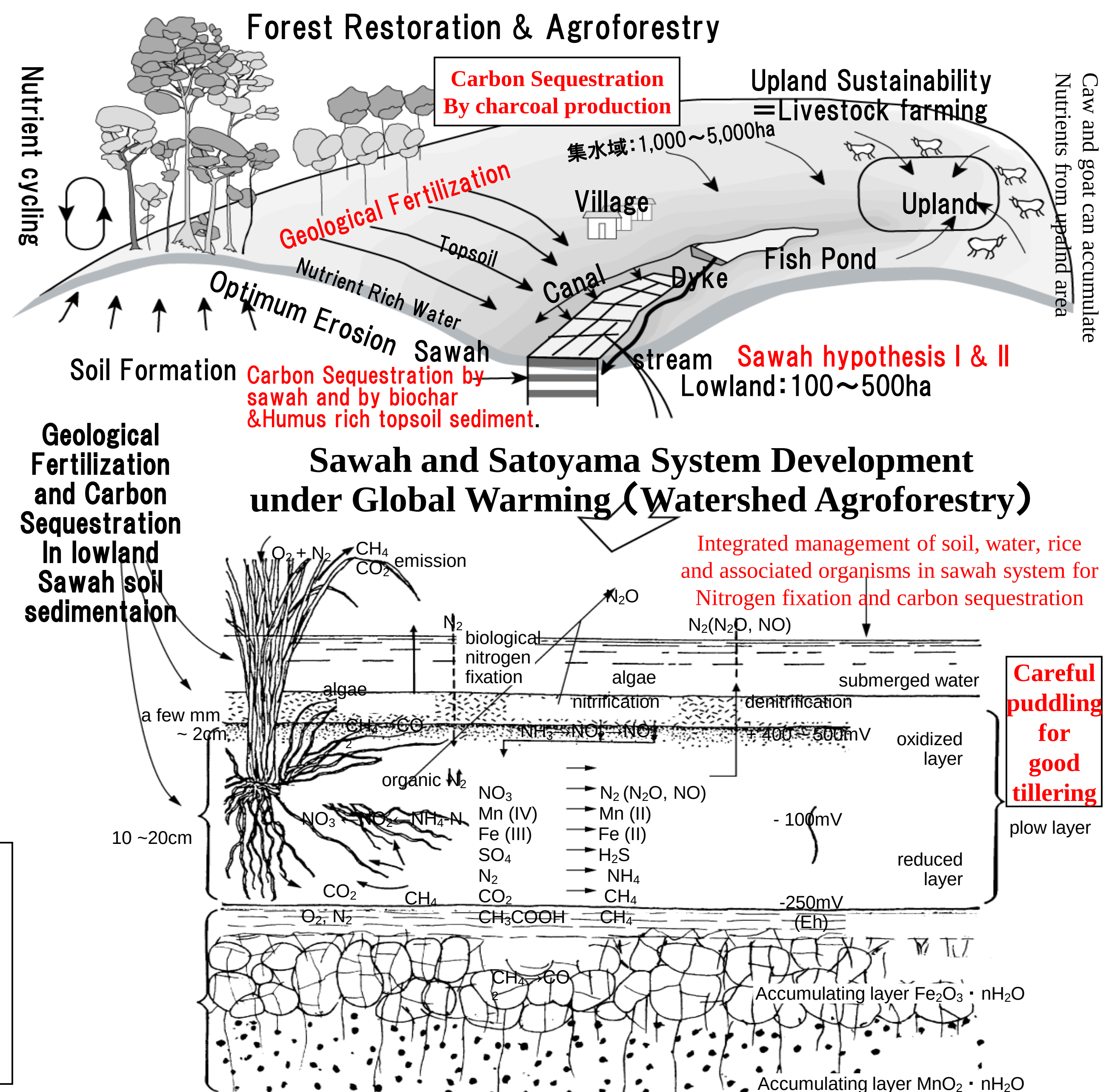


Fig. Sawah hypthesis (II) and creation of African SATOYAMA watershed systems to combat food crisis and global warming


Nupe's rudimentary Sawah system
THANK YOU FOR LISTENING

Comparison of large scale, small scale, traditional and site specific sawah ecotechnology approach in inlnd valleys of Ghana & Nigeria

	Large Scale Development	Small Scale Development	**Sawah eco-technology approach**	Traditional System
Development cost per hectare	20,000-30,000 US$ / ha	20,000-30,000 US$ / ha	**2,000-4,000 US$/ha**	20-30 US$ / ha
Economic returns of rice and vegetable etc	1,000-2,000+ US$ / ha	1,000-2,000+ US$ / ha	1,000-2,000+ US$ / ha	100-300 US$ / ha
Running cost including machinary	Medium to High (300-600$/ha)	Medium to High (300-600$/ha)	Medium (200-300$/ha)	Low (10-20$/ha)
Farmers participation	Low	Medium to High	High	High
Project ownership	Government	Goverment	Farmer	Farmer
Adoption of Tecnology	Long, Difficult	Short, relatively easy	Medium to short, needs intensive demonstration and On the Job Training (OJT) programme	Low technology transfer
Sustainable development	Low	Low to Midium	High	Medium
Environmental effect	High	Medium	Low	Medium

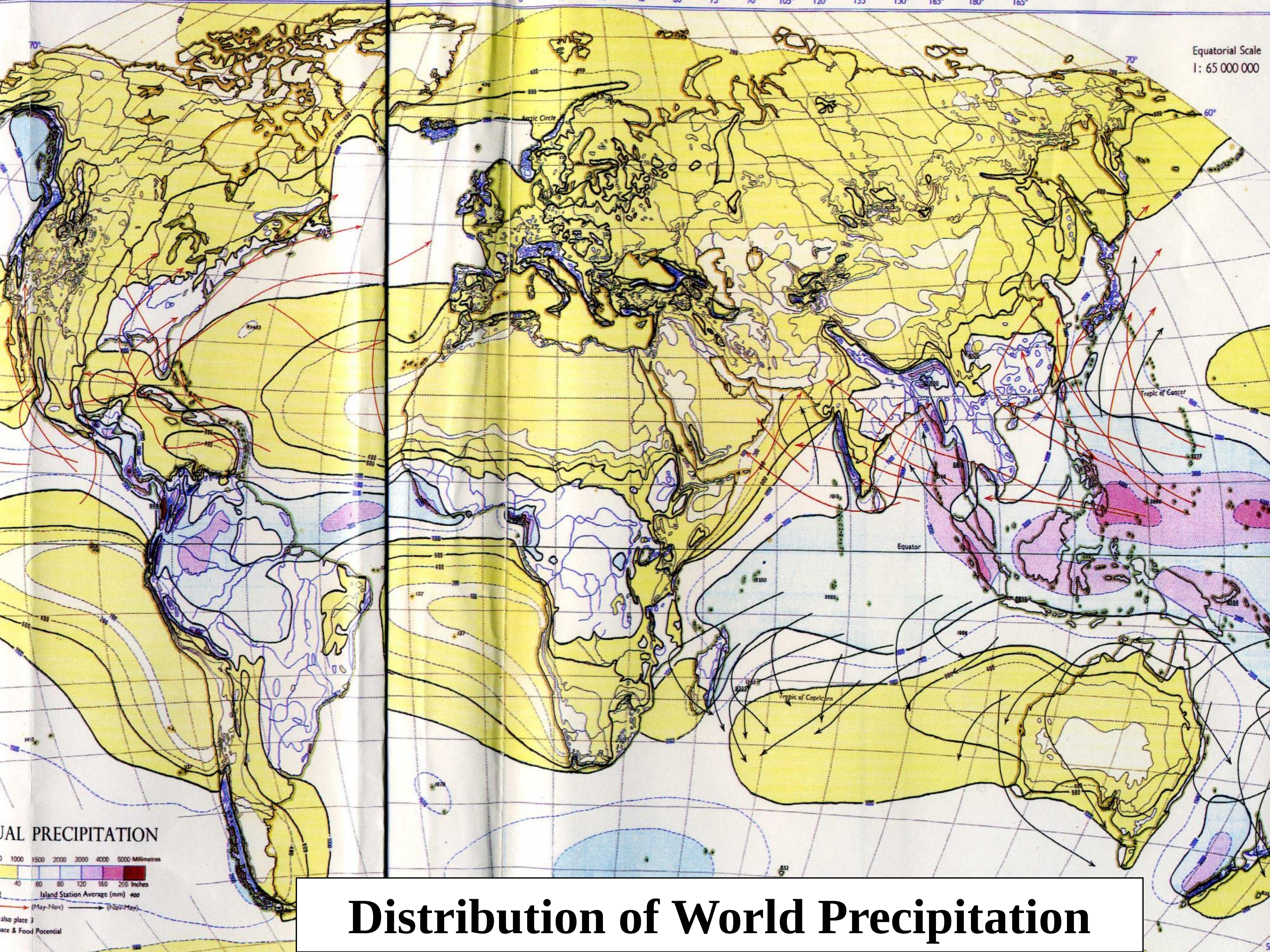
Heavy machine use
Contractor based

Power tiller (sometimes animal traction) use.
Farmer based development
Extended agronomy

No proper English/French &local language in Sub Sahara Africa to describe eco-technological concept and term to improve farmers'rice fields
Sawah (in Indonesian) or SUIDEN (in Japanese)

Suiden（Japanese） =SAWAH（Malay-Indonesian）

	English	Indonesian	Chinese（漢字）
Plant Biotechnology	Rice	Nasi	米，飯，稲
	Paddy	Padi	稲，籾
Environment Ecotechnlogy	(Paddy)?	Sawah	水田



Distribution of World Precipitation

Can watersheds of in SSA sustain Sawah system? High rate of soil erosion and lowland sawah soil formation can be compensated by high rate of soil formation:Ecological Balance is a Key

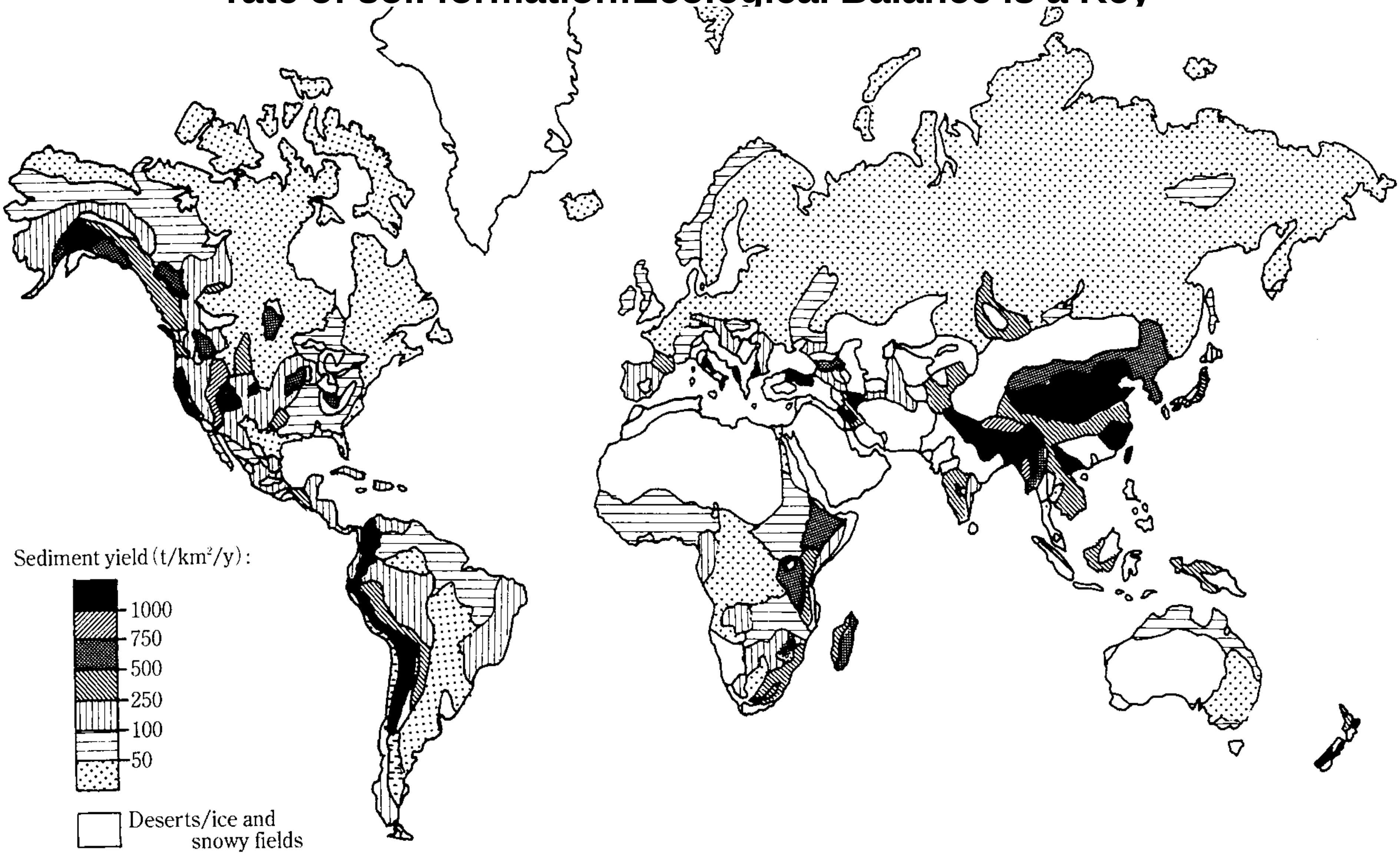


Fig. 1-26 Yearly soil erosion (t/km²/y) in the world (Walling, 1983; quotation in Lal 1988, "Soil Erosion Research Method")

Cost Effectiveness of Power Tiller Based Sawah Rice Farming

1. Power Tiller cost:$3000 in Bangkok
   $3000-8000 in Nigeria/Ghana

2. Power Tiller life time:
   10ha sawah development/one power tiller
   25ha-100ha sawah rice farming/one power tiller

3.Paddy yield in sawah: 4-6ton/ha
   Paddy yield in traditional:1-2ton/ha
   Power Tiller cost:
   Sawah development:$500-600/ha
   Sawah rice cultivation:$100-200/ha
   (For the first 5yrs of sawah development:$600-800)

4.Gross revenue and gross cost :
   Sawah based farming : Revenue: $2400-3600/ha,
   Production cost:$500-600/ha
   (For the first 5yrs of sawah development:$1100-1400)
   Traditional farming : Revenue: $600-900/ha,
   Production cost:$200-300ha

Japanese Inland Valley (SATO-YAMA systems): Integration of Forest, Pond and lowland Sawah in watersheds

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

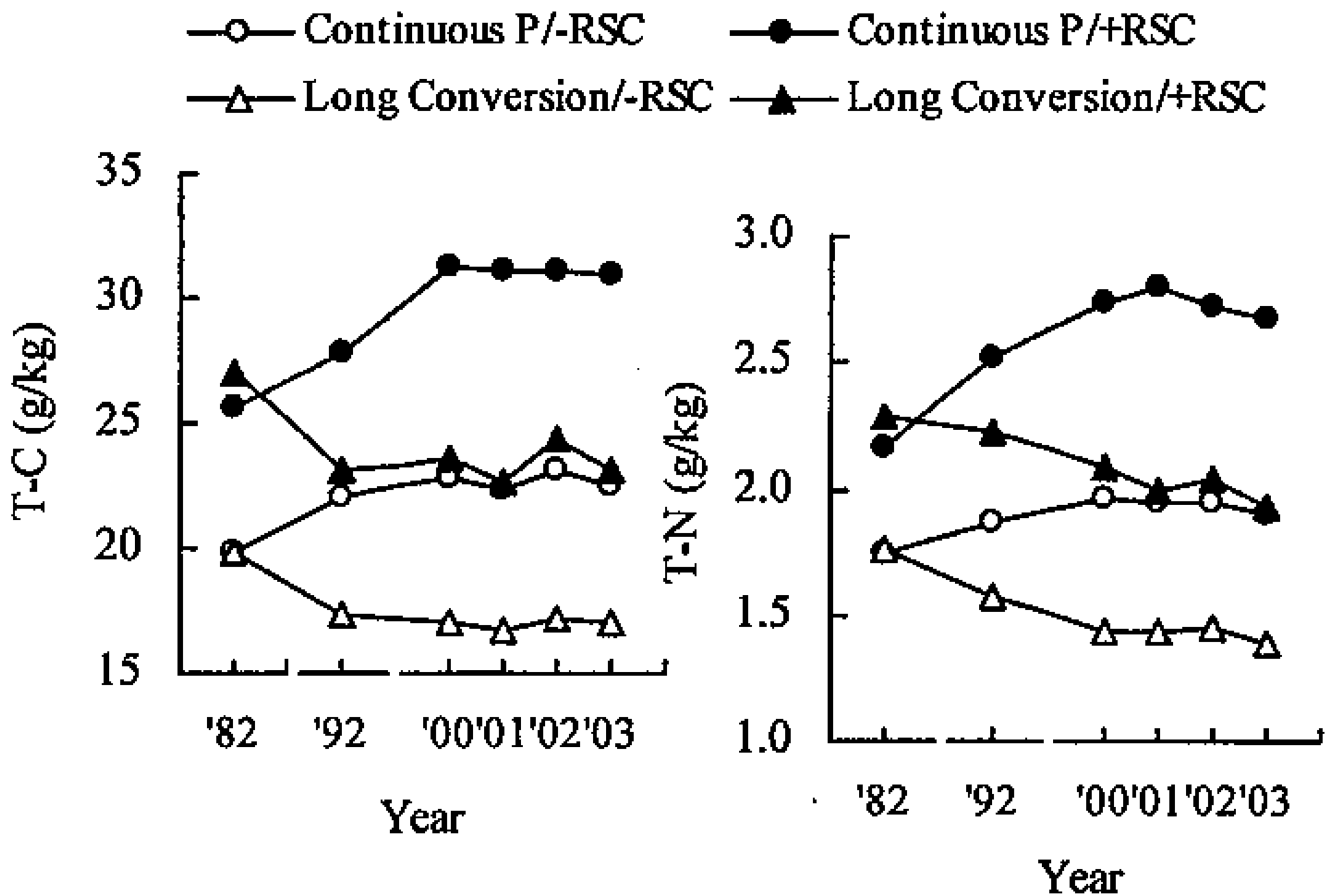


Fig. 5 Changes in total C and N contents of the soil in long-term upland conversion system. P, paddy; RSC, rice straw compost.

100gCO_2/m_2
is equivalent to
0.27ton C/ha
200g of CO_2
is equivalent to
0.54 g of C

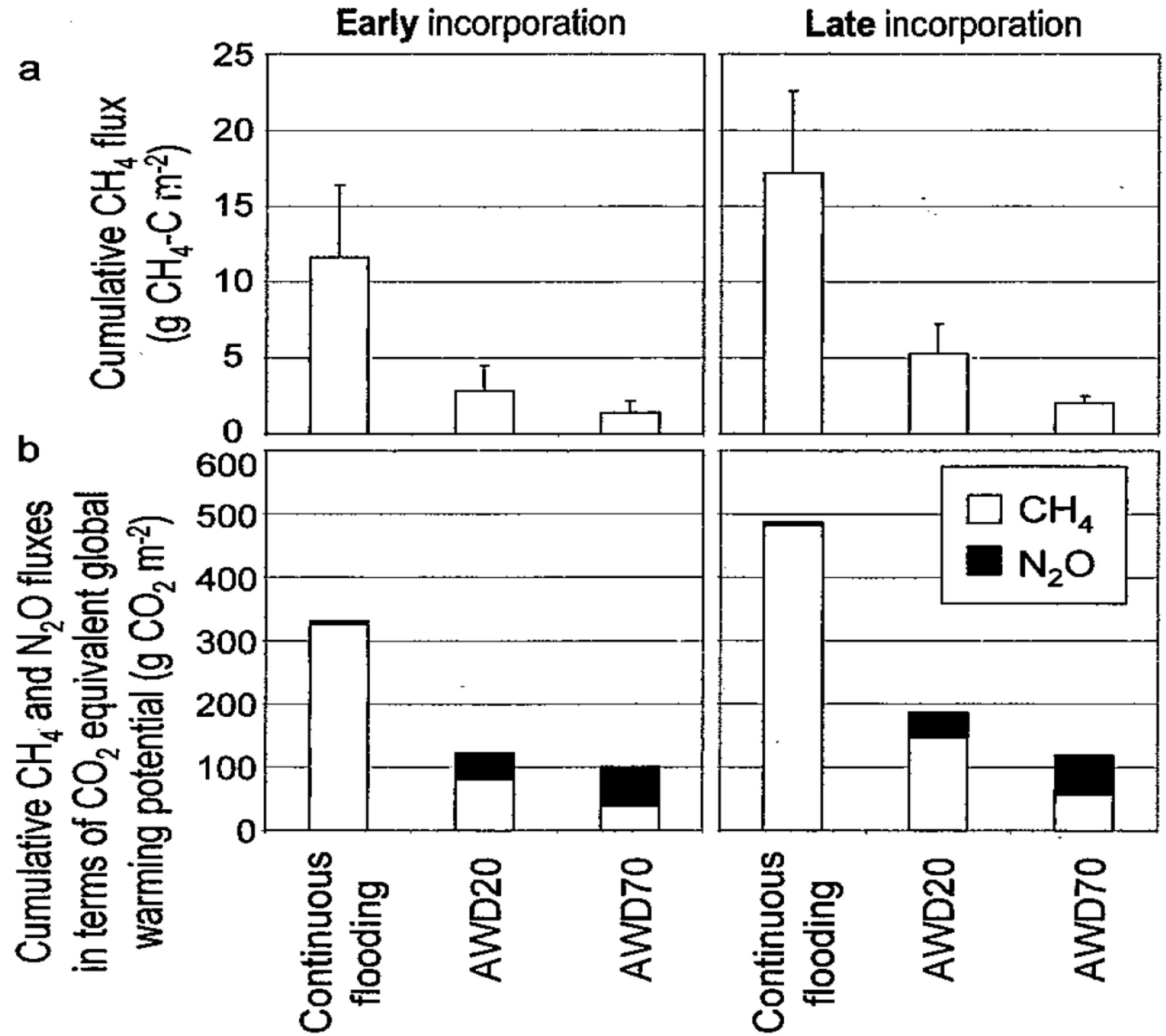


Figure 1. Cumulative CH_4 flux (a) and cumulative CH_4 and N_2O fluxes in terms of CO_2 equivalent global warming potential (b) during rice cropping period (January 29, 2007 (transplanting) – May 8, 2007 (harvest around this date); the conventional cropping period in dry season in the region). Bars indicate S. E. (only for **a**) (n = 3).

AWD20: irrigation under water potential-20kP(=2-3 days after water saturation)
AWD70:intermittent irrigation under water potential at-70kP(close to upland)