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)
Terraced sawah systems at Asuka, Nara, one of the oldest in Japan, established 1500 years ago
Sawahs of Madagascar have thousands of 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.
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.

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

Sawah Ecotechnology: Basic farmers quality fields for green revolution technologies

130 million ha during millennium of years

10 million ha Target by 2050

Historical change: past, present, and future
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.

Fig. Sawah hypothesis (I): Farmers Sawah should come 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.
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 annually, 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)

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

*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 & 5 years of life. The machine cost is $3000-7000 (Asian price is about $3000).
Sawah is a man-made, improved rice-growing environment with demarcated, bunded, leveled, puddled fields and smoothed surface. Both Bio & Eco-technologies must be developed in appropriate balance. Varieties could solve the main problems in Asia. Is this also true in SSA? No!, last 40 years 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. Rice (variety) and environment (Sawah) improvement. Both Bio & Eco-technologies must be developed in appropriate balance.
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: farmers’ 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 (>10 liter/sec, > 5 months)
   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 bund 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 ($/ha)
   (a) Skills for development
       Skill for power tiller operations
          Plowing and Puddling
          Soil Moving
          Surface leveling & smoothing
       Skill for power tiller management
   (b) Cost ($/ha) or (Cedi/ha)
       Power tiller for development
       Powertiller spare parts
       Fuel for development
       Bush clearing destamping
       Bunding and surface treatment
       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) Costs 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
(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

(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 requirement (mm/day)
Water quality
Soil fertility
Fertilization (N-P2O5-K2O kg/ha)
Variety
Yield (ton/ha)
(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
Extension 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.
Action Research Sites by 2009, New sites in collaboration with NCAM/NCRI and Fadama III in 2010
## Distribution of lowlands and potential irrigated sawah in SSA

<table>
<thead>
<tr>
<th>Classification</th>
<th>Area (million ha)</th>
<th>Area and potential sawah development(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal swamps</td>
<td>17</td>
<td>4-9 million ha (25-50%)</td>
</tr>
<tr>
<td>Inland basins</td>
<td>108</td>
<td>1-5 million ha (1-5%)</td>
</tr>
<tr>
<td>Flood plains</td>
<td>30</td>
<td>8-15 million ha (25-50%)</td>
</tr>
<tr>
<td>Inland valleys</td>
<td>85</td>
<td>9-20 million ha (10-25%)</td>
</tr>
</tbody>
</table>

Priority target is the inland valley because of easier water control. Max 20 million 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

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 hypothesis (II) and creation of African SATOYAMA watershed systems to combat food crisis and global warming
THANK YOU FOR LISTENING

Nupe’s rudimentary Sawah system
| Comparison of large scale, small scale, traditional and site specific sawah ecotechnology approach in inlnd valleys of Ghana & Nigeria |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| Development cost per hectare                   | Large Scale Development | Small Scale Development | Sawah eco-technology approach | Traditional System |
| 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 machinery                | 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        | Government        | 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)

<table>
<thead>
<tr>
<th>English</th>
<th>Indonesian</th>
<th>Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Biotechnology</td>
<td>Rice</td>
<td>Nasi</td>
</tr>
<tr>
<td>Paddy</td>
<td>Padi</td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>(Paddy)</td>
<td>Sawah</td>
</tr>
</tbody>
</table>

Suiden （Japanese） = SAWAH （Malay-Indonesian）
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.
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.
100g CO₂/m² is equivalent to 0.27 ton C/ha
200g of CO₂ is equivalent to 0.54 g of C

Figure 1. Cumulative CH₄ flux (a) and cumulative CH₄ and N₂O fluxes in terms of CO₂ 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-20kPa (≈2-3 days after water saturation)
AWD70: intermittent irrigation under water potential at -70kPa (close to upland)