Sawah technology training and demonstration at Haraze, border town of Central Africa Republic, and Tissi, border of Sudan, and Baga Sola, Nigeria, June 2015 to April 2017

On the job training has expanded to the staffs of AfricaRice, Togo and Benin on various skills of sawah eco-technology (Afari, Ghana, Nov.2011)

International workshop on sustainable sawah development by farmers' self-support efforts was organized at Kumasi, Ghana in collaboration with Agric. ministries of Ghana & Nigeria, JIRCAS-Japan, AfricaRice and our Sawah project. Now leading farmers can develop 5-10ha of new sawah fields within 1-2 years and produce 20-50 ton of paddy per year (Nov. 2011)

Small pump based Oasis type sawah development at savanna floodplain performed paddy yield 7t/ha at Jega, Kebbi state, Nigeria(May 2011)

8. Case study on Sawah Technology Dissemination in the South Nkwanta District, Volta Region, Ghana

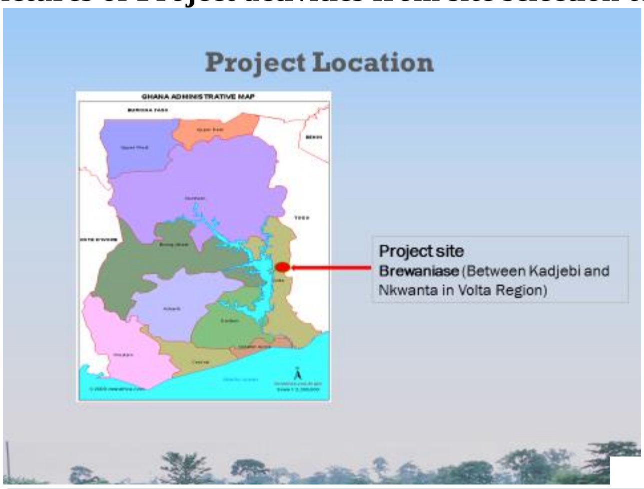
(Introduction)

Lowland area in Ghana estimated to be 800,000 hectares, offers huge potential for intensive and sustainable rice production due to relatively good hydrological condition. This ecology is however prone to flooding, surface run-off leading to soil erosion and therefore soil fertility challenges. There is also the issue of drought in the event of low and erratic rainfall situation leading to poor crop performance and at times complete crop failure. However, lowland rice farmers in the Northern Volta region cultivate rice mostly under rainfed conditions with little or no bunding and leveling. Since the field condition usually alternate between flooding and drought condition, added plant nutrients are prone to leaching, surface run-off or poor uptake, hence low utilization efficiency.

It is believed that suitable growing environment and appropriate management practices are pre-requisite to increased productivity of lowland rice production. Therefore, to address the rice production challenges facing farmers in the northern part of Volta Region of Ghana, innovative technology called Sawah - based farming system was introduced in 2016.

This African adaptive irrigated *sawah* rice farming system is a type of lowland rice cultivation technology developed in a lowland ecology of Ghana to manage challenges such as flood and drought situations faced by rice farmers in the inland valleys and flood plains. This technological innovation involves using simple agricultural machinery (Power tiller) and tools such as mattocks, pick- axes, soil chisels, machetes and hoes, through farmer participatory approach, to construct leveled fields with bunds and inlet and outlets canals for irrigation and drainage. To avoid heavy movement of top soil from higher spots to lower portions of the field, leveled rice basins are developed by resorting to contour bunding of the valleys or flood plains which are mostly sloping. The simple structures constructed by this practice turns to prevent erosion, and thus conserve soil and water for intensive and sustainable rice-based farming practices.

(Pictures of Project activities from site selection to harvest)



Hands-on training in field lay-out and bund construction

Bund Construction in progress

Using power tiller to prepare field for planting

Rice Nursery Preparation

Rice Nursery Preparation

Lifting

Lifting seedlings for transplanting

Hands - on - training in transplanting

(Training methods and Activities)

For the construction of suitable structures to conserve soil and water, irrigation systems, mechanized land preparation techniques and good agricultural practices (GAP) in rice production, FAO's Farmer Field School (FFS) approach was employed. This involved class room instruction and on-the-job or hands - on field training for a group of farmers and Agricultural extension agents (AEAs) on the following activities;

i. *Sawah* system design, i.e., *sawah* layout by bunding - necessary flood and drought control measures, as well as path to facilitate movement of power tiller and people
ii. Design of water intake, storage, distribution and drainage and the installation of water intake and drainage systems, including surface pond (dugout), water pumping system and dyke/weir gravitational water use systems
iii. Basic power tiller operations and management,
iv. Skills for bunding, leveling, puddling and construction of irrigation/drainage canals
v. Good agronomic practices - rice seed selection, nursery preparation and transplanting, management of soil fertility, weeds, pests, birds and rodents
vi. Skills of harvesting, threshing, and winnowing and storage

(Results)

The use of sawah rice farming system resulted in increase of rice yield from 2.2 MT per hectare (as pertained in traditional lowland farming practice) to 6.3 MT per hectare. Additionally, farmers gained skill in establishing bunds and canals around rice fields. Also, technical know-how was gained in puddling and levelling of fields, resulted in reduction in water run-off. Rain harvesting in the farmers' rice fields greatly enhanced due to the dug-out and the bunded fields. Farmers established rice nurseries very well on their own, gained skill in transplanting of rice in puddled field and sowing of dry seeds of rice either by dibbling or broadcasting. They also developed the know-how in measuring right amount of fertilizers (NPK) and application in the rice field. Farmers were able to identify and removed rice off-types at some stages of growth. Through the training farmers could harvest, threshed their rice timely. They also adopted good drying technique to ensure uniformity in drying to enhance milling quality.

9. Cost effectiveness of the *Sawah* Eco-technology

Cost-effective *sawah* development is critical (Table 4, 5 and 6). Although the cost of applying the *sawah* technology is less than 10% of the cost of traditional contractor based ODA-style irrigation schemes (Table 2), the initial *sawah* development relies heavily on use of a power tiller, which makes up 50% of the development cost.

Table 4. Cost and income (US$) of new sawah development (Nigeria and Ghana, 2013).

Activity	Cos/income elements, performance or durability of Agric. Machineries	Spring-based (slope 1.5%)	Floodplain -like (mean slope 1%)	Stream dike-based (slope 1%)	Pond-based (mean slope 1%)	Pump-based (mean slope 1%)	Non-sawah (mean slope 2%)
A. Sawah development activities (first year only, per ha)							
Clearing, Bunding	30–50 work-days†	200	150	150	150	150	75
Plow, Puddling, leveling	14-21 days powertiller operation	300	250	250	250	250	NA
Pumping cost	Minimum 3 ha/year‡	NA	150	NA	100	250	NA
Powertiller cost §	2–3 ha/year, 6–15 ha/life	700	600	600	600	600	NA
Canal	$1000 for 100 m per ha	100	50	200	200	100	NA
Dike/weir	$450 for 20 m×5 m×3 m per 3 ha	NA	NA	150	NA	NA	NA
Flood control	$700 for 150 m×2 m ×2 m per 3 ha	NA	300	100	NA	NA	NA
Pond construction	$1500 for 20 m×20 m ×2 m per 3 ha	NA	NA	NA	500	NA	NA
Personnel cost for on the Job training ($/ha)		**Scientists/engineer ($1000/ha) , Extension officer ($500/ha), Leading farmers($250/ha)**					
Cost including training cost		2300-1550	2500-1750	2450-1675	2800-2050	2350-1600	75

† 1 work-day costs $3.5.
‡ Pumping machine: $500-1000 of two sets for 1ha irrigation, 30% $150-300 for spare parts, 3-5 years of life
§ Power-tiller cost: $5000 for 3–7-year life, 20% depreciation, 20% spare parts; initial sawah development claims heavy load on power-tiller, which comprises 50% of cost of development.

Table 5. Cost and income (US$) of sawah-based rice farming in the first development year and total cost (Ghana and Nigeria, 2013).

Activity	Cost/income elements, performance or durability of Agric. Machinery	Spring-based (slope 1.5%)	Floodplain-like (mean slope 0.5%)	Stream dike-based (slope 1%)	Pond-based (slope 1%)	Pump-based (mean slope 1%)	Non-sawah (slope 2%)
B. Sawah-based rice farming cost (first year only, per ha)							
Nursery, seed	3 work-day, 60-90kg	90	90	90	90	90	130*
Water management	20–50 work-days†	50	50	50	50	150	NA
Transplanting	30 work-days	100	100	100	100	100	NA
Weed control Herbicide	10-14 work-days	100	100	100	100	100	100
Fertilizing	6 work-days	200	200	200	200	200	NA
Bird-scaring Harvesting Winnowing	30-40 work-days 30-40 work days	75 200	75 200	75 200	75 200	75 200	75 75
Threshing,	20-25 work-days†	100	100	100	100	100	50
Sawah-based rice farming cost except for OJTCB training		915	915	915	915	1015	450
Total cost in the first year except for training cost		2215	2415	2365	2715	2365	525
Yield	4–5 t/ha	4.0	4.5	4.5	4.5	5.0	1.5
Gross income	$500/t of paddy	2000	2250	2250	2250	2500	750
Net income		-215	-165	-115	-465	135	225

† 1 work-day costs $1.5-3.5, *direct sowing and/ or dibbling

Although sawah approach gives sustainable low-cost personal irrigated sawah system development, which costs about 10% of ODA-based irrigated sawah development, there may need to be special subsidization to encourage sawah development by farmers in the first year.

Table 6. Cost and income (US$) of sawah based rice farming (Nigeria and Ghana, 2013).

Activity	Cost/income, work days, performance machinery	Spring-based	Floodplain-like	Stream dyke	Pond-based	Pump-based	Non-sawah
C. Sawah-based rice farming cost (subsequent year, per ha)							
Pump	2–10days ($15/day)	NA	75	NA	50	200	NA
Power-tiller, Plow, Puddling	10 days per powertiller 10 ha/year, life 5–7 years	150	150	150	150	150	NA
Maintenance, canal,dyke,pond	15% of new construction	50	100	100	150	50	NA
Water management	20–50 work-days ($3/work-days)	50	50	50	50	25	NA
Transplanting, Seed, nursery	30-40 work-days	150	150	150	150	150	200*
Weeding, Herbicide	10-14 work-days	100	100	100	100	50	100
Fertilizing	6 work-days	200	200	200	200	200	NA
Bird-scaring	30–40 work-days	75	75	75	75	75	75
Harvesting, winnowing	30–40 work-days	200	200	200	200	200	75
****Harvester**	6–10 work-days	200	200	200	200	200	NA
Threshing	20-25 work-days†	100	100	100	100	100	40
Sawah-based rice farming cost with and without harvester		**1075-975**	**1200-1100**	**1125-1025**	**1225-1075**	**1200-1100**	**490**
Yield	**4–7 t/ha**	**4-5**	**4-6**	**4-5**	**4-5**	**5-7**	**1-2**
Gross income	**$500/t paddy**	**2000-2500**	**2000-3000**	**2000-2500**	**2000-2500**	**2500-3500**	**500-1000**
Net income		**925-1525**	**800-2900**	**875-1475**	**775-1425**	**1300-2400**	**10-510**

† 1 work-day costs $1.5-3.5. In case of Non-Sawah, threshing day is less than half, because of lower yield
*** Including annual land clearing. direct sowing and/ or dibbling need 3-6 times higher seed rate than transplanting**
**** if harvester available we can save $100 if quality sawah area is available larger than 25ha**

10. The roadmap for Rice Green Revolution by Sawah Technology

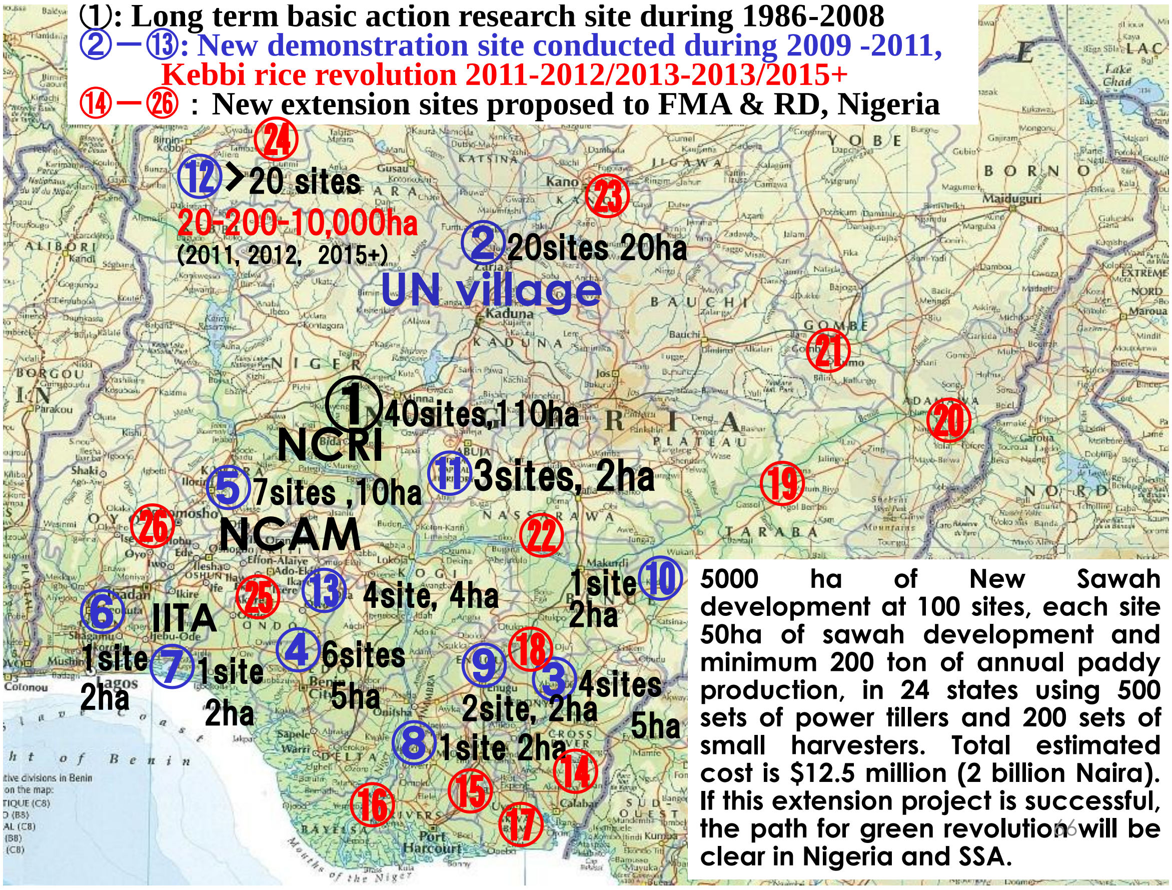


Table 7. Road map and summary data on past various irrigation projects in SSA by Contractor development and possible dramatic reform by Sawah Technology

1. Lower Anambra, Nigeria : Total 22 billion Yen, ≒$100million, 17 billion was Yen loan. Huge pump irrigation of 3850ha developed by Japanese companies, full mechanization during 1981-1989. JICA grant for technical cooperation,1989-1993. High development cost $30,000/ha, Malfunction of both irrigation & mechanization since 1993. Both management and endogenous development are difficult.

2. Mwea, Kenya: 3000ha of new irrigation and 5860ha of rehabilitation during 2011-2016, 14 billion Yen loan, including planning consultant cost 0.7billion Yen in 1993-1996. Technical cooperation in 1989-1998 with 4billion Yen grant for rehabilitation of 5860ha. High development cost >$20,000/ha and management. Difficult endogenous development

3. JICA/MoFA Sustainable Development of Rain-fed Lowland Rice Production Project. Even though results from this project look encouraging with yields of over 5t/ha recorded, it is on a micro-scale where demonstration sites are only micro-plots (0.1ha) with high cost. Net returns will therefore be very low and its economic impact negligible. Scaling up using sawah ecotechnology and effective collaboration in technology transfer is necessary to achieve the desired results

The target of improvement of ODA projects by the application of Sawah Technology

4. Proposal FMA&RD 1billion Yen, ≒$15million, loan for 5000 ha of irrigation development within 5 years by Sawah Ecotechnology : 100-500 core sites, each 50-10ha sawah development. Total 5,000ha, 20,000ton of annual paddy production, which is equivalent to $10million/year, within 5 years. 700 sets of powertillers $ 3 million, 170 sets of small harvesters $ 2 million, Development logistics $ 2.5 million, Farmers training $ 2.5 million, Youth training $2.5 million, Vehicle $ 1.5 million, Project management & consultancy $ 1 million. Development cost <$3000/ha. Since the core sites attract 3-5 new sites, then new sites expand to 1500- 2500 sites. Thus endogenous development expand with acceleration.

6. >100,000ha of Sawah development during 2017-2026: Africa wide dissemination.
7. >Millions ha of Sawah development during 2027-2050: African wide rapid expansion and Realization of African Rice Green Revolution

Therefore, apart from the importance of training power-tiller operators (Ademiluyi 2010), high-quality, durable, and low-cost power tillers are necessary. Once the *sawah* is developed, the power- tiller cost for rice farming will not be a major problem. Since farmers are well trained during the first year in difficult *sawah* development operations, *sawah*-based rice farming will be more sustainable than old-style ODA-based irrigation projects. Although the *sawah* technology provides sustainable low-cost personal irrigated *sawah* system development, there may be a need for special subsidization to encourage *sawah* development by farmers in the first year especially. However because of sustainability, power tiller and pump should be supplied to farmers as subsidized loan, 30 to 50% discount or less/more?. Payment will be done by paddy and repayment should be 3-5 years.
Asian farmers can buy similar power tillers for just $1,500–$3,500, whereas the commercial prices of power tillers in Ghana and Nigeria are $3,000–$5,000. Of course, if *sawah* developments are accelerated and power-tiller markets are expanding in the near future, power-tiller costs may decrease to the same price ranges obtainable in Asia, to $2,500-$3,500 (including shipping costs).

Kebbi state sawah rice revolution process 2011-2014:Fortunately and paradoxically, African lowland, especially inland valleys and flood plains, have quite adaptable topography and wide areas of virgin but bush land that could be used to rapidly develop *sawah* systems. Since rice farmers have to master a wide range of skills, including ecological engineering, intensive on-the-job training continuing for 5–6 months is very important. Once mastered, the skills can be transferred from farmer-to-farmer and *sawah*-to-*sawah* to scale up the success from Kebbi, Niger (Bida) and Kwara (Patigi) states in Nigeria and Ashanti in Ghana to the wider potential rice-growing areas in SSA to realize Africa's green revolution in rice cultivation. One of the factors working against the realization of a green revolution in Africa is the failure to scale up successful results of past agricultural research (Ejeta 2010). The *sawah* approach has arrived at a scaling-up stage to show a clear road map for rice green revolution in Africa (Table 7). Thus, our *sawah* approach becomes comparable to the research, development, and dissemination of good varieties.
As Kebbi state governor Alh SU Dakingari described as Rice Revolution (Dakingari 2013) and Kebbi state Fadama III facilitator, Mr. HM Yeldu (2014) reported that Sawah team hosted by NCAM demonstrated 20 ha of sawah development using two sets of power tillers and trained sawah technology in 2011/12. During 2013/14 wet and dry season, additional 22 new powertillers were bought by farmers to cultivated 326ha sawah and produced 2100 tons paddy (mean yield 6.45 t/ha). Based on this result, the Governor bought 1000 set of power tillers in June 2014 to supply farmers. If sawah development will be realized at the scale >10,000ha, Kebbi state will be pioneer of rice green revolution in SSA.

11. New Business Model of Sawah Technology for Africa Green Revolution Innovation

Summary**:** If we get US$18 million initial investment, of which US$14 million for *sawah* technology operation and US$ 4 million for On-the-Job Capacity building (OJTCB) including 10% miscellaneous cost, 5000ha irrigated *sawah* can be developed in 5 years, and annual paddy production reach to up to 30,000 ton (5t/ha, 20% of double cropping), which equivalent to $15million at the 6th year. The OJTCB trains 300 *Sawah* technology extension officers and about 3000 *sawah* rice farmers and youths, including 500 qualified lead farmers and youths, which will make ready to next scale up, i.e., 50,000ha of irrigated *sawah* development.

Phase I, duration of two years 2014-15, target 500ha irrigated sawah development, 20 sites, 25 ha each. OJTCB of 7-8 extension officer and 15 lead farmers/youths per site, total 150 extension officers and 300 lead farmers will be trained by 10 sawah teams. Each sawah team includes one sawah expert and 2-3 sawah technicians including power tillers operators/trainer.

(1) Targeted irrigated sawah development, 150ha at the first, and 350ha the second year.

(2) Produced paddy price in US$ per year in both wet and dry season (assuming to 20% of wet season sawah can cultivate in dry season) from 780 ha of sawah (150x1.2+500x1.2ha cultivation) with 3120 ton of paddy production, which give US$1.56 million.
(3) Total cost of Phase I is $3.3 million, of which $2.1million for 500ha sawah development including 10 sets of pickup trucks, 150 sets of motor bikes and 10 ha of seed farms, and $1.2 million for OJTCB of 150 Extension officers and 300 lead farmers. This cost is expected by investor. We estimate all necessary cost for sawah based rice farming to get 4-8 t/ha to be incurred $1000 per ha (Table 6). Rice farmer will pay this cost.

Phase II, duration three years 2015-17, target 1000ha new irrigated sawah development, 60 sites, 25 ha each, total 1500ha including the Phase I. OJTCB by extension officer and backstopping by NCAM, Nigeria or CSIR, Ghana, sawah team, total 700 lead farmers will be trained. Additional 150 extension officers will be trained by their colleagues of extension officers.

(1) Targeted irrigated sawah development and OJTCB are, 200ha, 200 lead farmers in the first, 300ha and 200 lead farmers in the second, and 500ha and 300 lead farmers in the third year respectively.
(2) Targeted establishment of new institutional organization: Sawah project at Federal Ministry of Agriculture and Rural Development (FMA&RD) to realize 3 to 5 million ha of irrigated sawah in Nigeria and Ministry of food and agriculture (MOFA) to realize half million ha of irrigated Sawah in Ghana.
(3) Total 12,960 ton of paddy in 3240ha of sawah cultivation, gives, US$6.5 million.
(4) Total cost of Phase II is $5 million, of which $3.4million for 1000ha sawah development including 40 ha of seed farms, and $1.6 million for OJTCB of 700 farmers. This cost is expected to also be incurred by investor. All cost estimate that is necessary for sawah based rice farming to get 4-8 t/ha will be paid by farmers.

Phase III, duration four years 2016-19, target 3500ha of new irrigated sawah will be developed, 100 sites, 50 ha each, total 5000ha including the Phase I and II. OJTCB by lead farmers and backstopping by extension officers and sawah teams, totalling 2000 farmers/youths will be trained.
(1) Targeted new irrigated sawah development and OJTCB are, 500ha, 500 lead farmers in the first, 1000ha and 500 farmers in the second, and 2000ha and 1000 farmers in the third year respectively. 5000ha in wet and 1000ha in dry season
(2) Sawah based rice farming will be practiced routinely at the third year in Phase III, i.e., after 5 years from the initiation of the project.
(3) Total 33,600 ton of paddy in 8400 ha of sawah gives US$16.8 million.
(4) Total cost of Phase III is $8.2 million, of which $7.1million will be required to develop 3500ha of sawah fields including 100 ha of seed farms, and $1.1 million for OJTCB of 2000 farmers and youths. This cost is expected to be incurred by investors. All cost estimate that is necessary for sawah based rice farming to get 4-8 t/ha will be paid by farmers.

Overall 10 years cost & benefit during the first 5 years including sawah development cost and OJTCB including additional 5 years for sawah farming stabilizing period.

I. Overall cost and benefit during the first 5 years including *sawah* development cost.

(1)Total production of paddy: 49680 ton/12420ha/5years= $25 million
(2)Total cost for both development and 50% of rice farming = $27 million, of which Government or investors will be responsible Sawah Development and Seed farm cost, 5000 (84 seed farm) ha=$13 million. OJTCB=$4million, Farmers will be responsible for rice farming cost, $10 million.
(3)Sawah rice farmers profit=$ 15 (25-10) million/12420ha=1208 $/ha

II. Overall cost and benefit during the next 5 years after the stabilization of *Sawah* based rice farming

If additional 5 years included, and yield increase to 5t/ha, total paddy selling is 5x5000x1.2x5x500 =$75 million, but total cost for rice farming=1100x5x5000x1.2= $33 million,
therefore *sawah* rice farmers profit= $42 (75-33) million/3000ha=$1400/ha

III. Overall 10 years cost and benefit of various rice sector businesses

(1) Farmers profit: $15 million in first 5 years+ $42 million in next 5 years= $57million/42420ha =1344 $/ha
(2) 3000 farmers/youths can be trained as professional rice farmers with annual profit of $7000 (in case 5ha is cultivated with 5t/ha model)
(3) Rice millers gross selling: 199,700tonx$75=$ 15 million /10 years
(4) Milled rice selling retailer: 15% of paddy selling: 199.7x500x0.15=$15 million per 10 years
(5) Power tiller market: 500 sets in 5000 ha development+350 sets for OJTCB+750 sets in 37420ha rice farming: 1600x1.5x3500= $8.4 million, 18 sets of pickup trucks:18x40000= $0.72 million
(6) *Sawah* irrigation and drainage engineering service at the first year development, ($450/ha)x5000= $2.25 million
(7) Powertiller assisted *sawah* development and cultivation service: ($250/ha)x42420=$10.6 million
(8) Agrochemical market:200x42420= $8.5 million
(9) Harvest, threshing and winnowing service labours =300x42420= $12.7million, or Harvester 200x42420= $8.5 million
(10) Research, Consulting and training services, and awards $ 4.6million, of which breakdown is
NCAM in Nigeria or CSIR institutions in Ghana = $0.76 million and establishment core seed farms.
Innovation award=5% of VAT increment= $0.73million for new research budget
National extension services= $0.76 million and establishment regional seed farms
Extension officers award=5% of VAT increment= $0.76 million for free use
Lead sawah farmers/Youths= $0.88million, Lead farmers/Youths award= $0.76 million for free use
(11) Government profit for various selling through VAT (15%) =115x0.15= $17.3million during 10 years
Initial Investment necessary is only $14 million for development and $4 million for OJTCB. This Investment cost will be obtainable as soft loan from IFAD, World Bank, USAID, or JICA Yen loan.
(12) After this project, FMA&RD in Nigeria and MOFA in Ghana will be able to expand 50,000 ha of new irrigated *sawah* program and farmers OJTCB during 2020-2025, the half million ha of new *sawah* development during 2025- 2030

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