Event report on Round-table "ZERO Malaria: What We Can Do from Japan"

"Rice Production and Malaria:
How to Evaluate 'Mosquito' in Agricultural Project"

Malaria No More Japan

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Executive Summary

The rice plants were swaying before the breeze. This is a traditional scenery in rural Asia. So that in Japan.
Historically in Japan, the status of a feudal lord was determined by the amount of rice that could be harvested in his domain. In Japan and Asian countries, rice cultivation has linked to life, and it has been a part of their culture.
On the other hand, in Africa, rice cultivation was imported as a monoculture policy by JICA and other international organizations after World War II. In this region, rice production is seen as food security and commodities rather than agriculture rooted in daily life and can be positioned in an economic context.
Wetland rice cultivation system was introduced in Africa, and economic development resulted in improvement of living, including sanitation and health management systems. It means that we need to consider the health of residents and the impact of changes in the environment caused by paddy rice production from the perspective of health agenda, at the same time as economic efficiency is being sought.
ZERO Malaria 2030 Campaign has implemented study sessions such as on "malaria countermeasures in Africa", "private sector investments on malaria in Asia", "climate crisis and malaria", integrating knowledge and innovation on malaria. This time in twice, it will be discussed how wetland rice production system in Asia and Africa are changing mosquito-borne infectious diseases including malaria, and the living environment of local residents, and about its transformation. It will be shared our knowledge and experience as to whether there are necessary measures and efforts that have already been implemented.
The evaluations of vector generation mechanism in paddy field are still divided, and it seems difficult to reach general conclusion at this stage. We expect the cogent discussions about the coexistence with malaria and rice production and the balance between these points.
Also, we discussed the comprehensive approach to evaluate rice-growing communities and their quality of life from the perspective of economic and social condition.

Event Outline

ZERO Malaria 2030 Campaign, has launched in 2017. The campaign members are from various malaria community members: from universities, from international organizations, from private sectors, and from national diet members.
Since its establishment, ZERO Malaria 2030 Campaign has organized events, lecture series, distribution goods to the persons in Asia and African countries through the Japan's youth volunteers.
Executive Committee of ZERO Malaria 2030 Campaign (secretariat: Malaria No More Japan) launched three round-table sessions "ZERO Malaria: What We Can Do from Japan".
Through discussion of several malaria-related themes, we aimed to establish a system for collaboration and coordination in terms of All-Japan efforts.

Organizer : Executive Committee of ZERO Malaria 2030 Campaign (secretariat: Malaria No More Japan), RBM Partnership to End Malaria
(*means the Committee members or the support organizations of this campaign)

Dates : 25 August 2020 & 10 September 2020, from 5:00pm to 7:00pm

Venue : Online conference system "Zoom"

Language : Japanese/English
-We arranged simultaneous interpretation for the session

MC : Dr. Masahiro Takagi (Board Member of Malaria No More Japan/ Professor Emeritus, Nagasaki University)

Moderator : Prof. Koji Tanaka, Professor Emeritus, Center for Southeast Asian Studies, Kyoto University

Keynote Speakers : -Dr. Toshiyuki Wakatsuki (Professor Emeritus, Shimane University)
-Mr. Kiyoshi Shiratori (Africa Rikai Project / Specially Appointed Professor of The Center for African Area Studies, Kyoto University)
-Dr. Jun Kobayashi (Professor, Department of Global Health, University of the Ryukyus) *only on Sept. 10th
-ZERO Malaria 2030 Campaign Executive Committee members, Malaria No More Japan Board Members, and other persons concerned attended the meeting. Basically, these series of sessions were organized as closed one, invitees only.

Second Session : Global Health Systems and Rice Production in Case of Malaria as an Indicator

<Event Outline>

Some research indicates the potential increase of malaria at the paddy rice field area . In Africa, wetland rice cultivation was introduced for economic development. On the other hand, however, it might be obstacle to the better livelihood in rural areas. In the session, we would like to discuss the economic development and income-generating project and its' coexistence with amelioration of health situation, by comparing the malaria cases in Asia and Africa.

4 : 45 pm ZOOM open

5 : 00 pm opening remarks by Dr. Takahiro Shinyo (Chairman, Malaria No More Japan)

5 : 10 pm Brief explanation about this study session from Malaria No More Japan (Dr. Masahiro Takagi, Malaria No More Japan)

5 : 15 pm Theme "Raising public health and awareness of paddy rice cultivation", moderated by Prof. Koji Tanaka, Kyoto University

5 : 25 pm Keynote speech

- "Possible pathways to reducing malaria transmission through endogenous development of sustainable sawah based rice farming in Sub-Saharan Africa (SSA)" by Dr. Toshiyuki Wakatsuki, Shimane University
- "How to evaluate variable environmental and economic factors in community-based malaria projects in Asia and Africa" by Dr. Jun Kobayashi, University of the Ryukyus

6 : 10 pm Discussion and Q&A

Problem presentation Mr. Kiyoshi Shiratori, mainly about the participatory rural development approach in the process of paddy rice cultivation.

- We use chat system for checking the questions and comments from the floor. Speakers and commentators use both Japanese and English.
- Our talking points are below ;
  1. The coexistence with infectious diseases. How to put the priority on prevention.
  2. Aid agency and workers tend not to connect the rural development and universal health coverage. How to develop the comprehensive approach to Japanese aid mechanism
  3. Utilizing the data and statistics.

6 : 50 pm Closing remarks and proposition to setup the working group

7 : 00 pm Close

Possible pathways to reducing malaria transmission through endogenous development of sustainable sawah based rice farming in Sub-Saharan Africa (SSA)

T. Wakatsuki (Shimane University), 10th of September 2020

1. **Endogenous sawah system platform development by sawah technology**
(1).Definition of *Sawah (SUIDEN)*, Paddy, Irrigation and Eco-technology
(2). 6 evolutionary stages and possible future sawah system platforms
(3). Sawah Hypothesis 1 for Scientific and 2 for Sustainable platform of rice cultivation
(4). Practices on Sawah Technology（アフリカ水田農法）for endogenous development of irrigated sawah system platform
(5). Nigeria Kebbi rice revolution, Ghana sawah project, AfricaRice-Smart inland valley, IOM Chad sawah project
2. **Possible pathways to reducing malaria transmission through endogenous sawah system platform development**

"Possible pathways to reducing malaria transmission through endogenous development of sustainable sawah based rice farming in Sub-Saharan Africa (SSA)"

Toshiyuki Wakatsuki (Professor Emeritus, Shimane University)

Wakatsuki : Thank you very much.

This time, I would like to talk more specifically about how we did Sawah (paddy field) development in Africa. The bottom line is that the past 50-100 years of development of sawah based rice farming and the experience of green revolution and malaria control in Asia could be applied to the progress of sawah based rice farming and the green revolution in SSA. If proper quality of sawah system platforms can be developed, it will be useful not only for sustainable food production but also for environmental conservation good for health and hygiene such as malaria control in SSA too. In order to promote sawah based rice cultivation in SSA, I tried to find out the possible method or approach of "farmer-led sawah system development and rice cultivation", i.e., Sawah technology

First is the definition. Figure 1 shows Sawah (SUIDEN) in West Sumatra, Indonesia. This photo was taken near the center of the Google earth image below. With a little getting used to, observing available Google earth images will give you an idea of what kinds of sawah platforms ("paddy" fields) are being developed in SSA. Sawah is called paddy in English, but the word paddy is very confusing in Africa, and I think that paddy paradox probably partly comes from this. I think it's better to define "paddy" fields with the Indonesian word sawah. Because the English paddy originated in Indonesian "padi", which means rice plant and or rice grain before threshing or in the kusk (see Table 1)

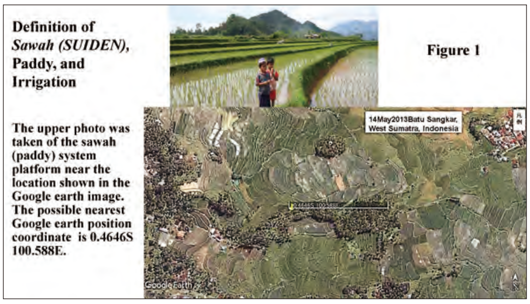


Figure 2 shows the distinction between irrigation, drainage and sawah(paddy) fields. In Asia, irrigated sawah(paddy) fields are developed in irrigated rice fields, but in SSA, sawah(paddy) fields are often not developed in irrigated rice fields. Basically, the irrigation system is a government or community-based platform. On the other hand, historically, sawah (paddy) fields are basically created, managed, and improved by the farmers themselves. In Africa, there is no clear concept and defined concept of sawah(paddy), so there are many confusions. Therefore, in order for farmers to take the initiative and promote the development of endogenous sawah based rice cultivation, I think it is desirable to take a bottom-up approach based on sawah platform development rather than emphasizing only top-down irrigation development.

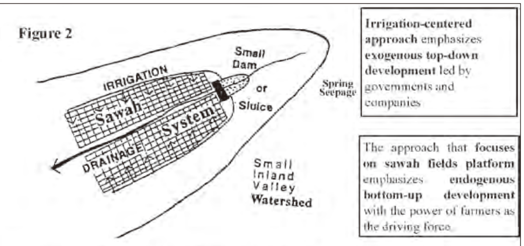


Figure 2. Sawah system with irrigation and drainage facilities for control of water in an inland valley watershed

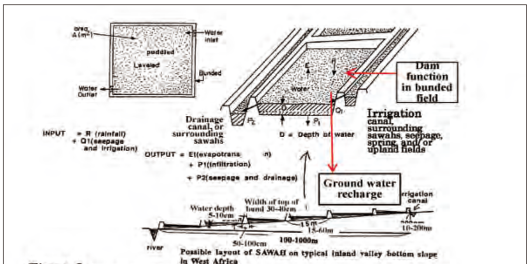


Figure 3 Sawah plot: A bunded, leveled, and puddled rice field with inlet of irrigation and outlet to drainage, thus control water and weeds as well as manage nutrients

A sawah plot is very simple. As all of you know, sawah plots surrounded by bund (AZE in Japanese), and the soil surface of the inside of a sawah plot is leveled. Basically, if the level difference of the sawah plot is within 10 cm, appropriate aged seedlings can be transplanted properly on the entire surface of the sawah plot. One plot of sawah is completely surrounded by bunds (AZE). There is water entrance (in) and exit (out). Other water ingress and egress can be evaporation, leaking from bund, underground infiltration, rainfall, seepage, sudden flooding, and surface runoff. Sawah plots are, in a sense, the same as living cell. The evolutionary level of a sawah platform can be defined by the easiness of artificially controlling the inflow and outflow of water in a sawah system platform.

Table 1. Definition and genesis of technical terms of Paddy and Sawah System Platform

	English	Malay–Indonesian	Chinese (漢字, Japanese)
Grain and Plant	Rice	Nasi	米, 飯, 稲
Biotechnology	Paddy ←·····	Padi	稲, 籾
Environment Ecotechnlogy	(Paddy)? ↙	Sawah	水田(Suiden)

Note: Asian countries like China, Japan, Malay-Indonesia and others have diverse own words to describe diverse rice culture. But there are no proper concept and technical term such as *Sawah* or *Suiden* (水田 in Japanese) in English/French and local languages in West Africa and SSA. The English term of paddy originate padi in Malay-Indonesian, which means just rice plant and or unhusked rice grain.

As for a technical term, we have no choice but to communicate in English at the moment, but since English is not based on rice culture, we are using the term "paddy" which has meanings both rice plant and the environment. Especially in Africa it is a mess. I think "paddy paradox" is partly the product of this confusion. Even if you use English erroneous term "paddy", the most of Asia countries have their own technical term equivalent to sawah in Indonesia and SUIDEN in Japanese, so there is no confusion. This is an obstacle to proper sawah platform development and sawah based rice cultivation as well as technology transformation in Africa. Since the word "paddy" originated from Malay-Indonesian is already using in English, I suggest to use the word "sawah" originated from Malay Indonesian, which means the artificially improved rice growing environment as shown in Figure 1, 2 and 3.

Table 2. Two Aspects of Technology Evolution of Rice Farming

Evolution (improvement) of rice "variety" by breeding	Evolution (improvement) of rice field "sawah platform" by sawah technolgy
(1) Domestication, >10,000 years ago, of Asian rice, Oryza Sativa (Japonica, Indica, Aus / Boro) in the vicinity of China, India, Myanmar border was confirmed by Genetic studies. (2) After that, Asian rice spread its distribution all over the world co-evolving with sawah system platform (3) Although African rice, *Oryza Glaberrima*, was domesticated in the Niger basin thousands of years ago, Sawah platform was not born. (4) An interspecific hybrid variety (NERICA) was born, but co-evolution with the growing environment (Sawah platform) has not been promoted.	(1) Archaeological studies show the Sawah system platform was invented about 5000-7000 years ago in the middle reaches of the Yangtze River and has been evolved. It technology was transferred to Japan 3000 years ago and has been evolved. It was similarly transferred to Asian countries and then to the world. (2) In SSA, its technology was transferred to Madagascar about 1000 years ago and to Sukuma land of Tanzania at least 100 years ago. In West Africa, the French government had promoted the irrigation technology through the Office du Niger program since 1920s. During 1960s-70s Taiwan team had been transferred the technology in Cote d'Ivoire, Senegal, Burkina Faso, and other SSA countries. (3) Since 2010, especially since 2017, Google Earth has released images in chronological order, the accelerated evolution of sawah platfom in all over the SSA can observe.

As explained in Table 2, rice cultivation has evolved while co-evolving "domestication and breeding technology for rice plants” and "creation and improvement technology for rice growing environment called irrigated sawah field(platform)". Breeding by biotechnology and sawah platform development by ecotechnology are the two wheels of a car. According to a recent Genetic study, the Asian rice Oryza Sativa was domesticated in the Pearl River basin in southern China about 10,000 years ago, and the African rice Oryza Glaberrima was cultivated in the Niger river basin thousands of years ago. On the other hand, recent archaeological research has revealed that the prototype of the sawah system platform, which is surrounded by bunds(Aze) and can control water, was invented in the middle reaches of the Yangtze River 5,000 to 7,000 years ago.
The transfer of both cultivated species and the improvement technology as well as the irrigated sawah system platform and the improvement technology have co-evolved and spread around the world. It is estimated that sawah based rice farming spread to Japan 3,000 years ago, to Madagascar 1,000 years ago to Africa, to Tanzania 200 years ago, and to West Africa 100 years ago. Along with the technology of cultivated species, a technology for sawah system platform was also tarnsferred sooner or later.
It is very clear that both the good variety and good environment are equally important. Since the impact of high yielding varieties in the Asian Green Revolution has been overestimated, it seems that Africa has been focused too much on breeding research. For example, there is a variety technology called NERICA, but the problem is that we didn't think much about improving technology on the cultivation environment, such as sawah technology.

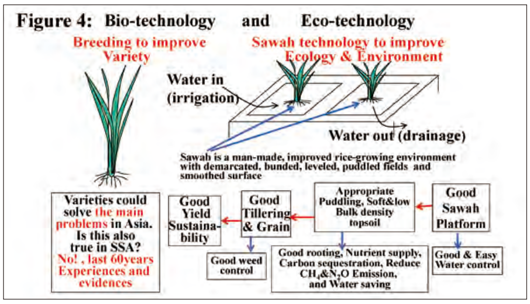
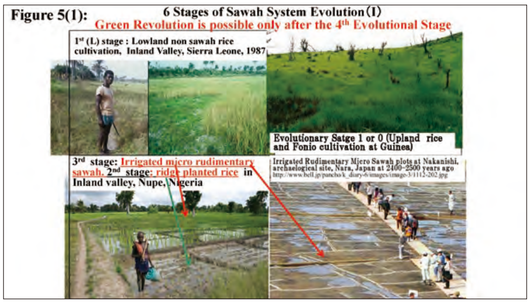
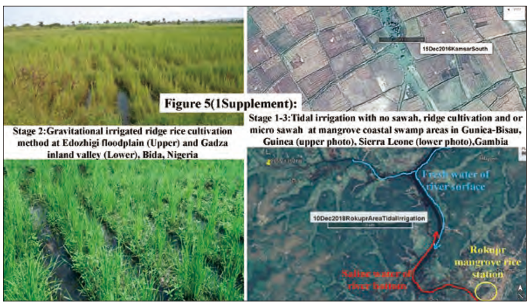


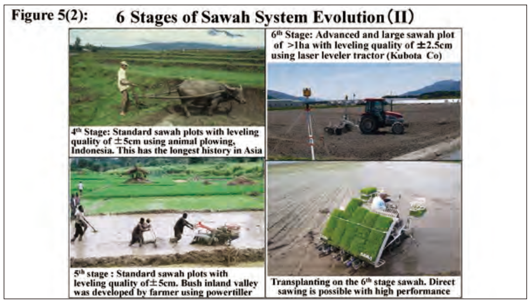
Figure 4 compares Biotechnology and Eco-technology. The improvement on the sawah platform research has virtually stopped in the last 50 years due to the focus on breeding in Japan because of the acreage reduction policy (GEN-TAN) on rice in 1970-2018.
Biotechnology (breeding) is improving variety, eco-technology is improving rice growing environment, which core target is improving the water management platform, i.e., sawah. The purpose of eco-technology is how to improve the level of sustainable water control through the control of the in and out of water. The basic device is the sawah platform. Agricultural land is the foundation of the country. We need both biotechnology and eco-technology.



The various rice-growing platforms found in Africa introduced last time on 25th of August are summarized as shown in Figures 5 (1) and (2). We have classified the evolution levels of various rice cultivation platform based from the perspective of the water management level of rice farmland. The upper right of Fig. 5 (1) is the shifting rice cultivation in the Guinea Highlands. The evolution stage/level is 0 because most rice fields are not flooded. However, depending on the undulations of the terrain, it will be flooded partly and periodically (evolution stage 1). The upper left is a small inland valley rice farm in Sierra Leone. Since it is a lowland, when there is water, it is flooded. However, since there is no artificial water control, the evolution level is 1. The lower left photo is a small (micro) quasi sawah field in Bida, central Nigeria (assumed evolutionary stage 3). There is a ridge in the plot where the child stands with a mulberry on his shoulder. Rice is cultivated in ridges in that plot (let's call it evolutionary stage 2). Both are irrigating over rice fields. As for the water sources, natural springs are common, but weirs are also created for irrigation cannals. The photo on the lower right is a small sawah plots developed about 2,500 years ago, which were found by archiological excavation in Nara, Japan. The size of both small sawah plots is about 5x5m = 25m^2, the two of which are almost the same size. Farmland management depends on what kind of agricultural tools the farmers have. With the African hoe on the shoulder of the boy in the lower left photo, only such small lot sawah fields or ridge cultivation can be done.

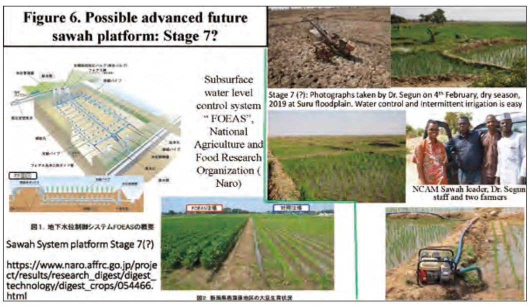


The upper and lower photographs on the left side of Fig. 5 (1 Supplement) are ridged rice cultivation in the Edozhigi irrigated scheme, Bida, Nigeria. On the right is the tidal irrigated rice fields of Guinea Bisau and Shera Leone on the Gulf of Guinea. Both look like large sawah plots, but they are not leveled, and smaller plots are created or ridged in the large plots for cultivation. Although irrigation is carried out by the ebb and flow of the tide, it is a system that practically difficult manage water on farmland. Therefore, in this state, so-called modern agricultural technology cannot be applied, and the Green Revolution cannot be achieved (a mixture of sawah platform evolution levels 1-3).



The upper left of Fig. 5 (2) is the water buffalo plowing in a sawah plot at West Sumatra, Indonesia (sawah evolution stage 4). When cows and horses become available, rice can be transplanted after puddling and leveling sawah plots surrounded by bunds. After 1950, powertillers can be available for bigger and straight shaped sawah platforms (paddy field evolution stage 5, the photo of lower left was take at the Sawah project site at Bimso No1, Ghana on 2001) and after 2000 tractor cultivation attached with laser levelers is common in Japan(evolution stage 6, the photos was taken at Shiga prefecture, Japan on 2012). In evolution stages 4 and 5, the leveling degree of a single sawah field is ± 5 cm, and seedlings with a plant height of about 15 cm can be transplanted in all area in a sawah plot. In evolution stage 6, the leveling degree reaches ± 2.5 cm with a laser leveler, and young seedlings with a plant height of less than 15 cm can be transplanted. Direct sowing is also possible. Such agricultural machinery, farmland platforms stage and farmland management systems will co-evolve. It was difficult for African peasants to reach these four stages. There are various reasons. Infectious diseases such as tsuetsue flies are also the cause, but I think that the slave trade and colonial rule are the main causes.

I think so-called "paddy paradox problem" may relate that various rice cultivation platforms are mixed up description as "paddy" and investigated in SSA. Although it is described as rice field in the photo, as you can see, this is not a standard sawah system field. It's just a wetland where rice is planted. There are many rice fields which have the similar environment as shown in the picture. Similar environment can be found even in a part of various sawah platform fields. You can also see the similar environment in the picture at the lowlands of Sierra Leone and the slash-and-burn rice fields in Guinea, which I showed you earlier. Even if it is not a rice fields, there are many micro wetlands like the photo on poor management roads and drains as well as many similar bushes in villages and towns. If we mixed up all these as "paddy" and investigate, "paddy paradox" will occur. In short, we have to define the environment scientifically to know what kind of water management system caused or control the mosquitoes.



Figures 6 and 6 (Supplement) are for the possible future sawah system platform (evolution stage 7). In Japan, the evolution of the sawah platform has stopped under the GEN-TAN (rice acreage reduction) policy in 1970-2018. Since the GEN-TAN policy was abolished in 2018, I thought about what the future sawah platform of water management system would be like. The left side of Fig. 6 is a system called FOEAS which can control both groundwater level and surface water. It was recently installed at the Takatsuki Research Farm of Kyoto University. It is a platform for freely carrying out both upland crops and wetland rice cultivation in the same field.

On the right side of Figure 6 is a floodplain sawah system platform endogenously developed by Kebbi farmers under the guidance of the Sawah team led by Dr. Segun of NCAM (Agricultural Mechanization Center) and the Kebbi State Agricultural Authority. This floodplain has groundwater shallower than 5-10m even in the dry season. As you can see in the photo of the poertiller in the upper right of the figure, there is no water on the ground surface in the dry season, but it can be easily irrigated with a portable pump (horizontal photo). Canal system is not necessary. With this system, there is always groundwater, so farmers control water by turning on or off the pump. Therefore, water management is very easy and intermittent irrigation is possible at any time in dry season. In this floodplain, vegetable cultivation such as onions and tomatoes and rice cultivation have been rotated for more than 30 years. I think the level of water management is close to the stage 7, although it is due to the blessings of nature, which are exquisite hydrological conditions. As shown in Figure 1 of the August 25 report, there are many large wetlands are distributing along the Sahel belt from Senegal to Sudan, which total area is more than 10 times bigger than Nile delta of Egypt. These wetlands have similar hydrology, soil and climate (high insolation) of the Nile Delta.

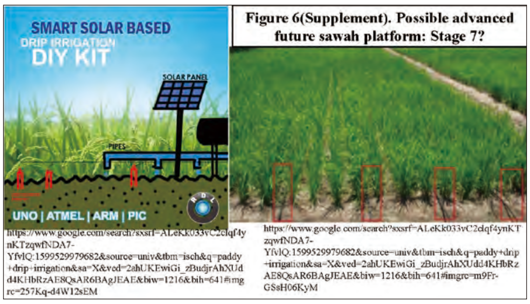


Figure 6(Supplement). Possible advanced future sawah platform: Stage 7?

Figure 6 (Supplement) shows that an Israeli company recently launched a drip irrigated rice cultivation system. This system can also use sunlight for electricity. The arid regions of Africa have high potential for solar power generation. The Kebbi system in Figure 6 also allows for a combination of solar power and fuel engin pump as well as generator. If electricity is available, farmers can use a submersible pump, so groundwater can be pumped deeper than 10-100m. However, the cost is more than three times that of a suction pump.

Drip irrigated rice cultivation has recently been attempted in Nigeria. It may become widespread if the cost is reduced significantly in future technological development.

The above is an overview of the evolution level of farmland platforms from the perspective of how easy it is to manage water. Naturally, different water management systems should have different malaria infection control measures. Therefore, I think it is necessary to properly observe the ecology and water management system of the rice farmland platform and conduct a survey based on it.

Sawah Hypothesis 1:
Sawah is the Platform for Research, Development, and Application of Scientific Technology

- British Enclosure for the platform of Agricultural Revolution, Modern Science, Industrial Revolution and Capitalism
- Sawah system platform and Enclosure land platform are equivalent

Next, I will talk about on Sawah Hypothesis 1 regarding the Green Revolution in Africa. The Sawah Hypthesis 1 and sawah platform will be compared the British enclosure theory and enclosed farmland platform. The British enclosure formed the basis of the British Agricultural Revolution in the 15th and 19th centuries. The British Agricultural Revolution is said to have laid the foundation for the scientific, industrial, and capitalist developments.

Figure 7:

Before Enclosure In UK:

Open Field system

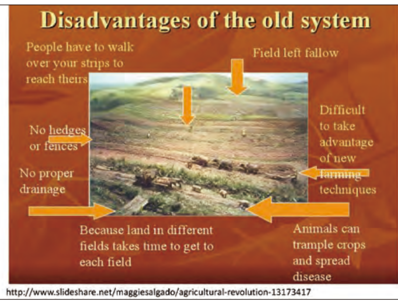


Figure 7 illustrates what happened before the enclosure farmland, which was the beginning of the British Agricultural Revolution. It seems that the farmland before the enclosure was like the farmlands of Sierra Leone, Guinea, and Nigeria, which are shown in Figures 15-17, 49, and 58 in my report on 25th of August. The divisions of farmland were not clear, and the ownership and usage rights were not clear, and various people were using the farmlands separately in various places and in various ways.

Figure 8

Figure 8 is a photo of British farmland after being enclosed. Similar to the sawah system platform, the enclosure divides, classifies, and contributes to reclaim the farmlands. Compartmentalization of farmlands has some disadvantages such as dividing and distinguishing between rich and poor, but it increases agricultural productivity and improves farmland management efficiency. Classification of farmlands based on the difference in ecological environment is the prerequisites to scientific agricultural technology development.

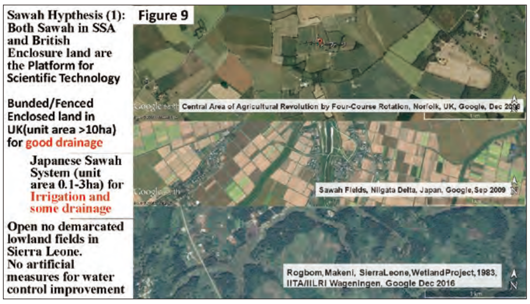


Figure 9

The top of Figure 9 shows Google images of the current farmlands of Norfolk in England, the middle is the Niigata Plain, Japan, and the bottom is a near Rogbom village area in Sierra Leone. My parents' house is a rice and dairy farm in the Niigata Plain. Rogbom Village is one of the first sites where I was dispatched to IITA (International Institute of Tropical Agriculture) as a JICA expert to start research on sawah based rice cultivation. As you can see briefly, there is a clear delineation on the ground except near Rogbom village area. If farmlands are not classified, parceled, and organized, we can't even find out what's wrong in farms. Of course, various water management technologies cannot be applied, and various science and technology cannot be used. Drainage has been a major issue on farmland in the United Kingdom. Before World War II, the Niigata Plain was somewhat similar condition as shown in Figures 45 and 46 (wetlands in Mali) in my report on August. Rice was cultivated while soaking up to the neck and riding a boat. The drainage was a major problem along with irrigation in the Niigata Plain. On the other hand, in the village of Rogbom area in Sierra Leone, there is no platform for finding problems and solving the problems found.

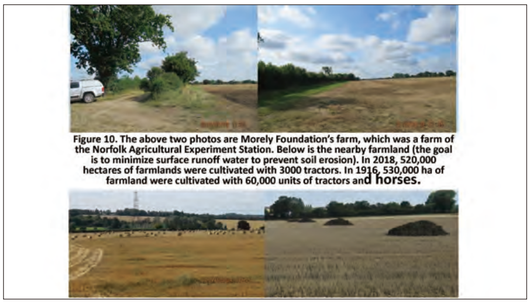


Figure 10. The above two photos are Morely Foundation's farm, which was a farm of the Norfolk Agricultural Experiment Station. Below is the nearby farmland (the goal is to minimize surface runoff water to prevent soil erosion). In 2018, 520,000 hectares of farmlands were cultivated with 3000 tractors. In 1916, 530,000 ha of farmland were cultivated with 60,000 units of tractors and horses.

Figure 10 is a photo of Norfolk, the birthplace of the British Agricultural Revolution, when I surveyed it last summer. You can see the farmland surrounded by banks and hedges, which retains the remnants of the former enclosure farmlands. The two pictures above are the fields of the former Norfolk State Agricultural Experiment Station. Currently, it is a test fields of Morley Foundation's Farm. There is about 10-20ha in one section. Norfolk is the UK's No. 1 agricultural state. The biggest problem with farmland in the UK is poor drainage, which causes water to come out to the surface and become flooded. This is because water flows on the surface of the farmland and the topsoil is washed away by soil erosion. Since it is a field crop, the roots become oxygen deficient. Thus, the main purpose of the farmland platform improvement in the UK is to eliminate these two harms.


Figure 11 ALEC DOUGH, Breaking New Ground, Agriculture in Norfolk 1914-72, Barnwell Print Ltd, Dunkir, Aylsham, UK, Reprinted 2016

As shown in Figure 11, the UK has been enthusiastically spending a great deal of time and efforts on farmlands improvement. This was not possible on the farmlands without land divisions fenced by banks, stone walls, or hedges and whose ownership was unclear. For the first enclosure movement, 400 years from 1450 to 1850. With the birth of the enclosed and fenced farmland platform, a four crops rotation system has become possible, and the land has been improved. Over the next 100 years to date, UK farmers installed underdrain drainage pipes about 1 m depth every 10 m to create a system that prevents water from coming out to the surface. Today, the number of farmlands that use groundwater irrigation is increasing.

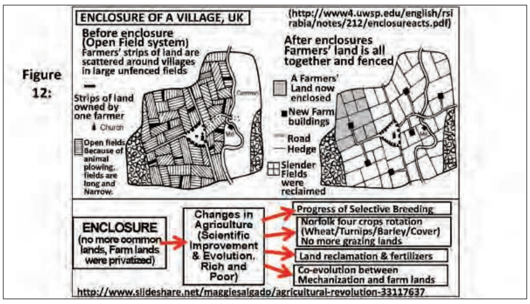


Figure 12 is showing the difference of farmland platform before and after the enclosure. In the figure on the left, which shows the situation before the enclosure, all the farmland is mixed and messed up. The reason why each farmland is drawn in elongated plots is that horse cultivation was the basis at that time. In the figure on the right, the farmland is expanded, divided, and organized in an orderly manner. Classification is the start of science and technology development. It is also possible to select and improve varieties suitable for the environment of each plot. All modern agricultural technologies, such as the development of new crop rotation methods, fertilizer technology, and agricultural machinery, are premised on a classified and organized farmland platform.

Figure 13 are the photographs of the rice platforms of before (left side) and after(right side) the sawah technology application at small inland valley of Biemso village 50km from Kumasi town in Ghana. The location of Google earth on this site is 6.8816N 1.847W. The rice farm on the left is a traditional lowland rice cultivation, which has been turned into a standard sawah system platform to allow irrigation and drainage control. This work was carried out mainly by farmers. This gave the farmer group the skills to develop, restore and manage irrigated sawah system on their own. With this platform, it has become possible for a farmers and researchers to do what is good or bad for various varieties. Scientific data cannot be obtained by investigating in a messy ecological environment as shown in the photo on the left.

The African Development Bank and the Ministry of Food and Agriculture in charge of ODA tried to create an irrigated rice field with a bulldozer using civil engineer contractors who do not have irrigated sawah development technology but failed (2010-16). This destroyed the lowland ecosystem. Now a group of farmers with Sawah Technology is repairing the sawah platform again. This process can be observed in Google earth images (2001-20) at the location information 6.8816N 1.847W.

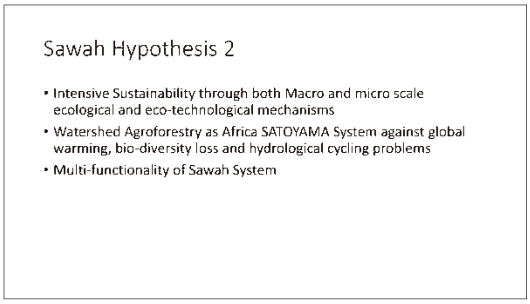
Fig 13 . Sawah hypothesis (1) for Scientific Platform: Farmers' Sawah should come the first to realize Green Revolution. Farmers fields have to be classified and demarcated ecotechnologically. Then scientific technologies can apply and evolve effectively. SSA's bushy open field systems have been long sustained till now. This might come from more than hundreds years of long history of slave/colonial rule.

Fig 14. Evolution of Sawah Ssytem through the evolution of Sawah Technology at Kebbi State during 1987 to 2015. Non sawah open rice fields at Arugunu in 1987 evolved to standard irrigated sawah system by sawah technology in 2011, which is further improving sawah system of rice growing environment in 2015.

Figure 14 shows an example of expanding the ecosystem to which the sawah technology is applied from the original target of small inland valleys, as shown in the Figure 13, to the floodplains (and inland deltas) of large rivers. The upper left is the floodplain in December 1987 near Argungu in Kebbi, Nigeria. At that time, African rice was cultivated without any water control measures. The photographed point of the left side below is almost the same place as the photo in 1987, and above is the site where Kinki University and the NCAM (Agricultural Mechanization Center) team conducted training on Sawah Technology (endogenous development of sawah platform and sawah based rice cultivation by farmers' own efforts) in 2011. The photo taken on the right in 2015 shows the improved sawah technology training using the Indonesian KHS Quick type cultivator attached of the Kubota engine. This site is almost the same site in 2011 in left.

In this floodplain, irrigated micro/small sawah based rice cultivation (evolutionary stage 3) and vegetable cultivation have been carried out for decades as shown in the upper right photo. This platform was due to the Fadama project supported by the World Bank. As a result of the adoption of Sawah Technology since 2011, it has become possible for farmers to develop standard sawah platform (evolutional stage 4 and 5) by their own efforts. Google earth location is 12.756N 4.512E. You can observe the progress of sawah platform development and improvement from 2007 to 2020 as well as the progress of rainy and dry season rice cultivation.

Sawah Hypothesis 2 states that lowland sawah based rice cultivation has sustainable productivity more than 10 times higher than that of the upland farming systems in a same watershed. The hypothesis explains that by achieving high intensive sustainability of lowland sawah based rice cultivation, it will be a possible basic strategy for forest conservation and restoration by reducing the development pressure by unsustainable upland farming systems in SSA.



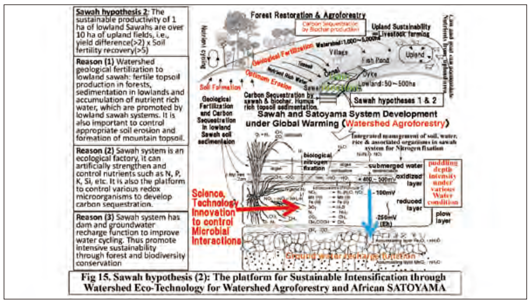


Fig 15. Sawah hypothesis (2): The platform for Sustainable Intensification through Watershed Eco-Technology for Watershed Agroforestry and African SATOYAMA

Figure 15 explains the sawah hypothesis 2 from three mechanisms. In addition, it will explain the importance of integrated management of forests, upland fields, and lowland sawah fields in the catchment area.

The first is the macro mechanism of natural geological and geographic fertilization associated with the water cycle. Fertile topsoil is formed in the forest. Fertile soil in forests and fields is eroded and accumulates in lowlands. Rainwater also becomes mineral-rich river water in this process and flows down to the lowlands. The sawah system platform developed in the lowlands will be a platform for effective use of this eroded topsoil and mineral water.

The second is that it becomes a science and technology platform which enables the management and enhancement of plant nutrient dynamics associated with redox reactions in sawah soils under water-manageable sawah fields. The natural supply of fertilizer components such as nitrogen, phosphorus and potash are much higher than in forests and upland crops fields. Regarding climate change, it is effective for carbon sequestration and control of nitrous oxide gas emission. Sawah fields are negative in terms of methane generation. Once the sawah platform has a high level of water management at the evolution stage 6 or 7, it will be possible to develop climate change countermeasure rice farming technology. It also enables research and develop the malaria mosquito control technology.

The third is that the sawah platform has a dam function and a groundwater recharge function and will be a water cycle management platform. This is especially important for SSA, which have great groundwater utilization potential.

The upper left photo of Figure 16 shows a traditional lowland non sawah rice plantation and the cocoa farms as well as forests above it in a small inland valley watershed near Kumasi in Ghana. The photo on the lower right shows an example of a sawah field developed just below the cacao garden, where trees and rice collaborate to create intensive and sustainable land use. The sawah system will be a platform for integrated management of uplands and lowlands. This is the work I did during the JICA research project conducted in 1997-2001. So far, little scientific and quantitative data has been obtained for sawah hypothesis 2. It remains at an empirical and intuitive level, as shown in Table 3 below. Future research progress is expected.

Table 3. Sawah hypothesis (2) : Sustainable Productivity of high quality lowland Sawah is more than 10 times than Upland Field

1ha sawah is equivalent to 10-15ha of upland

	Upland		Lowland(Sawah)
Area (%)	95 %		5 %
Productivity (t/ha)	1-3(1 ≦ **)		3-6 (2**)
Required area for sustainable1 ha cropping*	5 ha	:	1 ha

* Assuming 2 years cultivation and 8 years fallow in sustainable upland cultivation, while no fallow in sawah
**In Case of No fertilization

Table 3 shows the judgmental empirical data of the sawah hypothesis 2. The table assumes that the average lowland area is about 5% that can be developed the irrigated sawah platform in a watershed. The area of the African continent excluding the desert is about 2 billion ha, and if the area that can be developed as irrigated sawah is 50 million ha, it is 2.5%. It is more than 10% in the equatorial forest zone and less than 5% in the savant zone. Floodplains and inland deltas in the Sahel belt are also less than 5%.

In upland rice cultivation, the yield of paddy is less than 1t / ha without fertilization, and about 1-3t / ha even with fertilization. However, if a sawah field platform that can manage water is created, the yield can be more than 2t / ha (Fig 31 and 32) even without fertilization, and 3-6t / ha with fertilization, which is more than double the yield. Furthermore, sawah based rice farming do not need to be fallow because the three mechanisms described in Fig. 15 work. On the other hand, for upland rice, if it is cultivated for 2 years, it has to take about 8 years of fallow to restore the soil fertility. The yield difference between upland rice and lowland sawah rice is more than doubled, and the area required for fallow is about five times larger. Therefore, sustainable productivity of sawah based rice farming should be more than

10 times higher than upland rice. The above is a summary of empirical data in Japan, Asian countries, and SSA. It goes without saying that each catchment area has a different value. The scientific proof of the sawah hypothesis 2 will require the accumulation of vast amounts of research data in the future.

Below, we will explain some practices of the Sawah Technology on the premise that irrigated sawah platform will be an intensive and highly sustainable rice cultivation platform in SSA (Sawah hypotheses 1 and 2). The point of Sawah Technology is the technology that SSA's farmers develop irrigated sawah platform by their own power and do sawah based rice cultivation. The development of irrigated sawah platform so far has been carried out by foreign engineers contracted under ODA agent such as JICA. This is an extrinsic irrigated sawah system development. It was common to learn about rice cultivation on an irrigated sawah platform developed by ODA or governments. Sawah Technology is a technology that SSA's peasants do on their own. Design a sawah system on their own and develop it quickly with a machine of the appropriate scale, such as a power-tiller, without relying on heavy machinery. Train it on-the-job so that it can be transferred by farmers. Rather than relying on foreigners, we emphasize the intrinsic/endogenous development will be able to accelerate the irrigated sawah system platform development in SSA. The point is that the technology like sawah technology which can contributes to the empowerment of millions and tens of millions of SSA peasants may be the key.

Figure 17:

Figure 17 is a photo of the starting point of Sawah Technology. Find the right topography and the right season and make right bunding layout based on the right sawah platform design. Researchers and engineers from the SRI (Soil Research Institute) of the Sawah Team in Ghana are discussing with farmers group (they are the main developers) for the development while conducting on-the-job training.

Figure 18:

Figure 18 shows how a power-tiller is operating attached plow, puddler or leveler, which are effective to make bunds, dig canals, and puddling. It takes a lot of effort to make bunds, level rice fields, dig canals, and to make big bunds for flood control. Since one power-tiller of 10Hp can work equivalent to about 40 to 50 manpower, development works can accelerate. African peasants are very strong, but when the appropriate machinery powers are added, everyone gets better. In fact, Africa has many low-lying terrains, so heavy machinery is not always necessary. In addition, waterways, ditches, holes, etc. are everywhere, whether in floodplains or small inland valleys. Thus, heavy machinery cannot be used in many places at the beginning.

Figure 1: Indonesian G1000 Boxer can move soil 25m for leveling(10th Dec 2015)

Figure 1 is the mistake in Figure 19, which is showing leveling and soil movement operation using power tiller attached leveler. Proper modification and liquefaction allow for sufficient leveling without a bulldozer and canal digging without backhoe (see also Figure 18).

Figure 20: Divide Indonesian made powertillers into parts and transport 16 sets in one container to refugee camps of Tissi, the border of Chad, Sudan, and Central African Republic. Then, assembled by farmers under the guidance of NCAM (Total cost was $3000/set). Farmers do well digging up to 20m depth by hand digging or mechanical digging. Usually up to a depth of 7-8 m is enough.

Figure 20 shows an example of Sawah Technology practices in the central part of the African continent, where access is the most difficult. It was carried out as a refugee settlement project (leader: Yoko Fujimura) of the International Organization for Migration (IOM) Chad Branch. It was conducted at Tissi on the border between Sudan Darfur and Central Africa in Chad, Haraze on the border with Central Africa, and Bagasola on the border with Nigeria where Lake Chad is located. We disassembled 16 sets of Indonesian power-tillers, put them in one container with 10% spare parts, and shipped them to these refugee camps. The powertillers were assembled in the village as a training for the farmers' repair skill. It can be procured anywhere in Africa for less than $3,000 per cultivator (Indonesia local price $2,000, shipping fee $1,000). When JIRCAS (Japan International Research Center for Agricultural Scinces) conducted an action research of sawah technology application in Kumasi, Ghana in 2009-12, powertiller with similar performance became expensive at $9,000 per set through ODA-related companies. The tube-well digging training was carried out by dispatching a Nigerian sawah farmer. Even by hand digging, we can dig up to a depth of 10 m and a depth of 20 m with an Indian well digger of $2,000 per set within 2-3 days.

Figure 21: Sawah technology training and demonstration at Haraze, border town of Central Africa Republic, and Tissi, border of Sudan, during December 2015 to April 2017

Figure 21 shows various practices of canal digging, transplanting, puddling, and rice observation during the heading period at the Tissi and Haraze sites, the power of female refugees stood out.

May 2015-April 2017, 18 sawah team menbers were dispatced to Chad sites. The menbers are composing 7 lead farmers proficient in Sawah Technology in Nigeria, 9 NCAM staff, and Mr. Wakatsuki and Mr. Chikara Yamamoto ex-JOCV (Japan Overseas Cooperation Volunteers). We stayed in the field for a total of 1-8 months and conducted on-the-job training for refugees. We developed 2-3 ha of irrigated sawah system in each of the above three sites, trained to up to paddy harvest. After the training and demonstration, we expected refugees to continue and expand on their own. Nigerian sawah teams are ready to do the similar demonstration training even in Sudd Wetlands in South Sudan if IOM South Sudan requests

(personal communication from Y. Fujimura of IOM)

Activities in such a harsh environment have revealed the power of individual Sawah Technology-proficient farmers dispatched from Nigeria in their diverse disciplines. They can work without suffering from the same living environment as refugees. Power tiller assembly and repair, sawah system layout and bunds construction, canal cutting, well digging, pump management and sawah plots leveling, seedling raising, transplanting, water management, rice growth management, fertilization, weed control, pest control were all trainable by on-the-job. I recognized that each farmer is literal HYAKU-SHOU (in Japanese which means one hundred family business can practice). Each of them could cover various fields of sawah technology, such as agricultural machinery, agricultural civil engineering, irrigation and drainage, crops management, soil fertilizer, post-harvest, and rural development.

This is 3 minutes YouTube, which is produced by public relations of the Buhari administration of the Nigerian APC party. This party got the administration for the first time in 16 years in 2015. Our Sawah Technology training and dissemination activities in Kebbi were mainly conducted around 2011-14 during the Jonathan administration of PDP party. In April 2015, the Governor of Kebbi was also replaced. The Anchor Borrowers' Program, which was started by the Buhari administration in the video to promote rice cultivation, which is a low-interest loan system for farmers.

<Video playback>

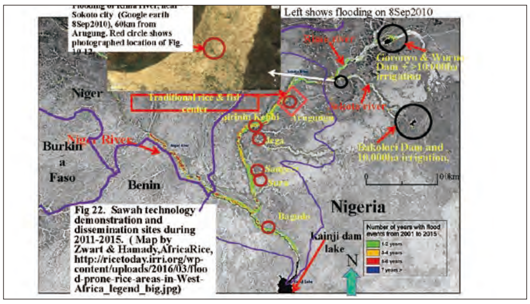


Figure 22 shows the floodplains of the main rivers of Kebbi state, i.e., the Rima (Sokoto), the Zamfara, and the Niger river. Activities to implement Sawah Technology were conducted mainly in 2010-12 at the six major rice-growing areas from Argungu to Bagudo in Kebbi state, which are indicated by red circles. These activities were conducted based on the MOU with the World Bank and NCAM/Kinki university's KAKENHI (JSPS's specially promoted project in 2007-11). The dissemination targets were the officers of Fadama III, lowland development program in Kebbi, and rice farmer's association. 18 demonstration plots of sawah platform were developed through the on-the-job training on the first year as shown in the Table 3.

The total area of the flood plains where rice can cultivate is about 500,000 ha in the whole Kebbi state. The areas painted in red in the floodplains are shown that these areas were 5-6 floods during the rainy season from July to October during the past 15 years from 2001 to 2015. Therefore, there is a risk of flood damage during the rainy season at those red colored area. However, flood damage can be avoided in the dry season crops (November-June), which have expanded rapidly since 2013. Moreover, it is possible to make a second crop in dry season.

In addition to the Kebbi state, similar Sawah technology training and demonstrations operated intensively in 2010-12 under the MOU with the World Bank were conducted in Lagos, Benue, Ebony, Delta, and Capital Special State (FCT), too. It was also conducted in Niger state. However, except for small numbers of villages in the Bida area of Niger state, no significant endogenous developments like Kebbi have been seen so far.

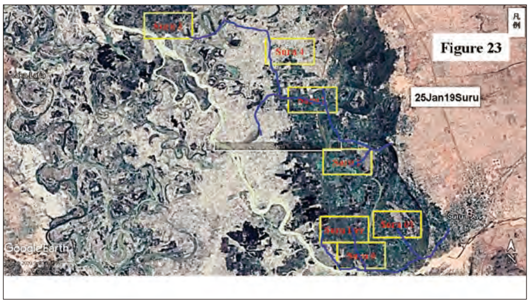


Figure 23

Figure 23 shows the floodplain near Suru town where the 3 minutes YouTube reports rice farming. The brown areas are uplands, and the white, gray, and black-green areas are floodplains. There is 6,000ha flood plain in the range of this photo. The black and green areas indicate that rice is being planted on the irrigated sawah fields in the dry season. Google photos were taken at the end of January, so the dry season crop area will further expand from February to March. The yellow squares are the areas where the NCAM team conducted a field survey in February-March 2020. The survey was also conducted during the rainy season in September 2019, but the survey was abandoned due to the flood water that spreads throughout the floodplain, as shown in Figure 13 of the report on August 25.

Figure 24: Suru 2 site has various sawah development history by farmers self-support efforts in 2010-2019

Figure 24 is an enlarged view of Suru2, one of the yellow squares in Fig. 23. If you enter the location information (11.949N, 4.150E) of the center of this Fig. 23 into Google earth, you can observe that the sawah system development by the farmers' self-help efforts has been expanded rapidly from 2010 to 2020. The Su2a-Su2k farmlands within the range of about 70ha in the Fig. 23 shows individual farmland with an area of 1-5ha. Sawah field development has expanded rapidly due to the self-help efforts of farmers. These were developed by individual farmers from 2010-19. You can also check the comparison with the surrounding area and the changes in land use over the past 10 years. You can see also how sawah based rice cultivation developed, including the rainy season and dry season cultivations.

Figure 25A shows the 2010 floodplain of Suru2. There were few paddy fields. Figure 25B is a Google image of the same location in February 2016. In February 2016, dry season, about 40% of sawah plots were planted with rice. Some sawah plots have not been planted yet. These are all farmer's self-developed sawah fields. It spreads almost all over the flood plain around here.

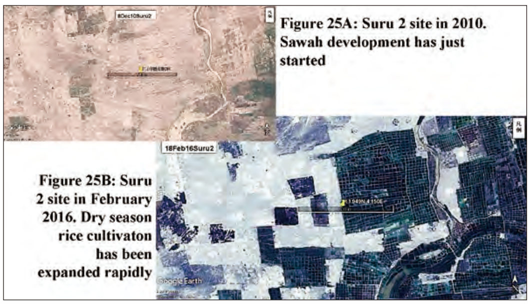


Figure 25A: Suru 2 site in 2010. Sawah development has just started

Figure 25B: Suru 2 site in February 2016. Dry season rice cultivaton has been expanded rapidly

Figure 26:

Figure 26 photos show the portable pump irrigated micro/small sawah plot platform (the evolutionary stage of 3) that the World Bank and the Fadama III project have promoted over the past 30 years before the introduction of Sawah Technology. The location is the floodplain of the Zamfara River near the town of Jega shown in Figure 22

Figure 27 shows a model paddy field (evolution stage 5) developed for Sawah Technology On-the-job training. The evolution of paddy fields in the Zamfara river floodplain can also be observed in the 2003-19 time-series images near Google earth's location information 12.199N 4.373E.

Figure 29 photos were taken during a joint survey by the Fadama III (Lowland Development Project phase 3) authorities in Kebbi and the NCAM Sawah Team in May 2011 to confirm the results of the Sawah Technology demonstration and training. The location is a government irrigation project site in the floodplain just north of the state capital, Birnin Kebbi (location information is 12.478N 4.202E). Before the introduction of Sawah Technology, it was a rudimentary small sawah platform in evolution stage 3.

May is the end of the dry season and the amount of solar radiation is high. The varieties are mixed, but the yield is very high. The result of this implementation of Sawah Technology is described as "The yield so far increased from 1.5-2.5t / ha to 6.5-7.2t / ha by Sawah (Eco-) Technology." on page 10 of the following World Bank report. Document of the World bank, page 10
(http://documents1.worldbank.org/curated/en/956751479735474649/text/FADAMA-III-ICR-P096572-Nov-2-2016-11162016.txt)
This is the location where the data for Birnin Kebbi in 1 of the Table 3 below was taken.
Table 3 summarizes the implementation of Sawah Technology in Kebbi state in 2010-14. In 2011, Kinki University's KAKENHI (JSPS research fund) provided two Chinese power-tillers and made 18ha demonstration plots while conducting on-the-job training. Within one year, 9 ha was developed/reclaimed (evolutional level 5 sawah platform) with one unit per tiller, and an average paddy yield of 7.1 t / ha was obtained. This is the result of 1. In 2012-14, the lead farmers bought 22 power tillers at his own expense as shown in the Table 3-2. By 2013, 131ha of sawah based rice was cultivated. The dry season crop in 2014 expanded to 199ha. The average yield was 6.3t / ha. This is the result of 2 of the Table 3. After that, the state government bought 1,000 cultivators and sold them to farmers at a low price (about $3,000) in 2014-15. After that, the government changed. The situation after that was unknown, but Google Earth became observable in 2017-18, sawah platform spread endogenously on a scale of 100,000 ha throughout the flood plains of Kebbi state, and 1.8 million tons of paddy production per year in 2016-17, which was reported by USDA, IFPRI, University of Michigan, and FMARD(Federal

Ministry of Agriculture and Rural Development, Nigeria) as shown in the next Figure 29 was issued. Quantitative measurement of the area expansion of sawah platform developed in 2010-20 is being carried out using the JSPS' s Kaken-Hi, "Academic Survey on Rice Revolution in Kebbi state through the farmers 'endogenous sawah platform development, 2018-21".

Table 3. Training, Demonstration and Extension of Sawah Technology in 6 Rice Centers, Kebbi State during March 2011 to May 2014

1. Kinki University/NCAM/Fadama III Demonstration and Training, March 2011-April 2012

Local Government	Farmers	Powertillers No. supplied	Total Sawah developed(ha)	No. of 100kg Paddy bag	Paddy yield (ton/ha)
Argungu*	Shared	2 shared	6.5	487.5	7.5
Birnin Kebbi*	Shared	2 shared	3.5	227.5	6.5
Jega*	Shared	2 shared	8	560	7
Total		shared	18	1275	7.1**

* The six sites are shown in Figure 3. Although we monitored the extension progress, no yield data were obtained
**Mean

2. Endogenous Extension, April 2012-October 2013 / 3. Dry season, Nov. 2013-May 2014

	Farmers	2. No. of powertiller bought	2. Sawah area developed (ha)	2. No. of 100kg paddy bag	2. Paddy yield (ton/ha)	3. No. of powertiller bought	3. Sawah area developed (ha)	3. No. of 100kg Paddy bags	3. Paddy yield (ton/ha)
Argungu*	MGD farm*	2	15	975	6.5	2	20	1400	7
	JUM farm	1	10	650	6.5	1	10	650	6.5
	ABK farm	1	4	260	6.5	1	8	480	6
	AK farm	1	3	180	6	1	6	360	6
	AMB farm	1	4	240	6	1	5	300	6
	Dr YA farm	1	4	240	6	1	5	300	6
	ANL farm	1	3	180	6	1	5	325	6.5
	AMI farm	1	6	390	6	1	10	650	6.5
	ASD farm	1	5	300	6	1	5	300	6
Birnin Kebbi*	ABA farm*	1	4	260	6.5	1	4	—	—
	BB farm	1	3	180	6	1	6	360	6
	AS farm	1	3	180	6	1	6	360	6
Bagudo*	ABB farm*	5	35	2450	7	5	50	3500	7
Jega*	HMJ farm*	1	7	455	6.5	1	14	910	6.5
	AUA farm	1	20	1200	6	1	40	2400	6
Suru*	Dr.UD farm	1	5	300	6	1	5	300	6
Total		22	131	8440	6.4**	22	199	12595	6.3**

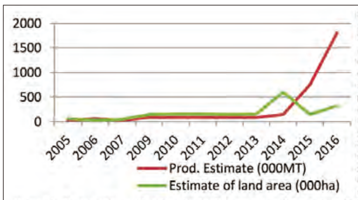


Figure 1. Trend of Rice(Paddy) Production and Land Area in Kebbi State. Data Source: Kebbi State Agricultural Development Project (2017)
(By Bello Shehu and Abubakar Lolo, 2017, Promoting Rice Productivity in Kebbi State: Linking Data and Policy , USAID, Michigan State Univ, IFPRI, and FMARD)

Figure 29 The green line shows the annual rice production area, and the red line shows the annual paddy production. According to the official statistics of Nigeria (NAERLS etc.), Kebbi Province was the 10th largest paddy producing state in Nigeria with annual paddy production of 100,000 tons in 2011-12 and average paddy yield of 2t/ha. However, with the expansion of high-yield dry season cropping that began in 2013, in 2017 it rapidly increased to 1.8 million tons and became the No. 1 rice-growing state (reports on the left of FMARD, USAID, IFPRI, etc.). Are there scientific data or facts that support this? To this end, it is premised that the annual planted area is 400,000 ha (irrigated paddy rice cultivation with an average yield of 4.5 t/ha with two crops of 200,000 ha in the rainy season and the dry season has expanded independently in all states, Do such facts exist?

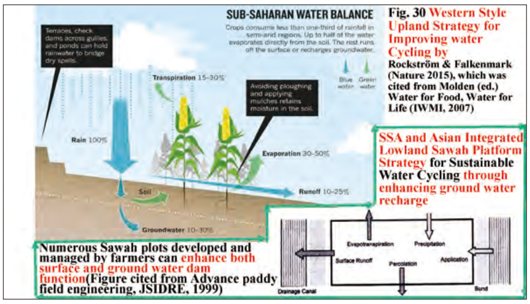


Fig. 30 Western Style Upland Strategy for Improving water Cycling by Rockström & Falkenmark (Nature 2015), which was cited from Molden (ed.) Water for Food, Water for Life (IWMI, 2007)

Figure 29 (1 in Figure 1 is a mistake of 29) was investigated jointly by USAID (US Department of Agriculture), University of Michigan, IFPRI (International Food Policy Research Institute), and FMARD (Federal Ministry of Agriculture and Rural Development). I am not sure about the credibility of the data. The green line is the estimated rice cultivation area at the 50,000ha level and the red line is the annual paddy production of 100,000 tons and the average yield of 2 t / ha level until 2012. In 2014, however, the planted area was 250,000 to 500,000 ha, and in 2016, 1.8 million tons of paddy was produced, which is unbelievable rapid increase. In northern states in Nigeria, dry season cropping began in earnest in 2013. It was launched in earnest with the policy support of Dr. Akinwumi Adesina (currently the President of the African Development Bank), former agricultural economist at Africa Rice and then Minister of FMARD (until 2015).

Figure 30 summarizes the characteristics of the water cycle in Africa by Rockstrom. In SSA, 15-30% of rain is used for biological production and 30-50% evaporates directly. These blue waters are circulating directly or indirectly in biological production. These green waters are not subject to water resource development. The outflow from rivers is as low as 10-25%, and the proportion of groundwater is as high as 10-30%. These blue waters are target of development to control to improve water circulation. In Asia, river runoff is greater than groundwater inflow, so river water irrigation is used more often. The use of groundwater in Asia poses a high risk of salt damage. In Japan, about 60% of the surface is washed away, and floods are more of a problem. In the case of Africa, there is a lot of unused water that goes underground. It turns out that how to use groundwater is important. I did not know the importance of the ground water use until we did the implementation of sawah technology in Kebbi and Chad. How to use the underground water is unexpectedly paradoxical, and until recently I did not know what to do with it either. Perhaps Africa Rice is not aware of this either. The potential is very high.

Based on the characteristics of the water cycle in SSA, the Western-style strategy, typically of Rockstrom has a central strategy of surface runoff management and soil erosion prevention. They are trying to promote no-till farming, terraces, and check dam development in Upland.

I think this upland strategy only is not enough in SSA. SSA and Asian integrated lowland sawah platform strategy should promote more in future for intensive sustainability of lowland rice cultivation (Sawah hypothesis 2).

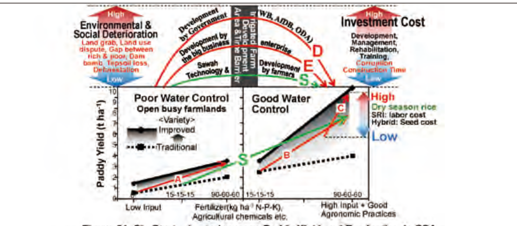


Figure 31. Six Strategies to Increase Paddy Yield and Production in SSA
A type strategy: Upland **NERICA** technology
B type strategy: **Asian Green Revolution technology**
C type strategy: **Hybrid seed and System Rice Intensification**
D type strategy: **Contractor based ODA** irrigation/drainage development
E type strategy: Irrigation by **private big business enterprises**
S type strategy: Sawah technology with sustainable mechanization

Figure 31 is a comparative summary of the various strategic technological developments currently underway to realize the Green Revolution of rice cultivation in SSA. Strategy A is a biotechnology-oriented strategy that assumes undeveloped farmland such as upland rice NERICA. Strategy B is an attempt to direct application of the three Asian Green Revolution technologies of irrigation, high-yielding varieties, and fertilizers/agrochemicals to SSA. However, the background to Asia's success was the history of endogenous sawah platform development which was carried out by farmers for more than centuries. Isn't these modern science and technology effective in SSA (Sawah hypothesis 1)? Strategy C is an ultra-high yield cultivation technology that uses SRI (System Rice Intensification) farming methods and hybrid seeds, assuming a more sophisticated sawah system field platform. Strategy D is the development of irrigated sawah platform implemented by the governments of African countries through ODA. Irrigated sawah platform development, maintenance, maintenance, and restoration costs at SSA are high, and environmental and lowland destruction occurs frequently. Does ODA dependence destroy independence and hinder self-help efforts? The E strategy is the development of irrigated sawah platform by private companies. Wouldn't countless farmers be eliminated (Land Grab)? The S strategy is emphasizing the innovation by endogenous sawah platform development and appropriate mechanized cultivation by Sawah (Eco-) Technology. Isn't it desirable to have technology that empowers the numerous farmers in order to break through the time and area barriers of sawah platform development, which is the premise of the rice revolution? Then, isn't it easy to scale up by transferring agricultural technology, and isn't it possible to develop endogenously?

The development of endogenous sawah platform was rarely seen in West Africa. However, in the state of Kebbi, within 10 years since 2010, more than 100,000 ha of sawah platform has been developed, and more than 1 million tons of paddy has been produced annually. This exceeds the paddy production of Office du Niger in Mali, which has realized sawah platform development for 100,000 ha over 100 years at a cost of more than 100 billion yen. In the case of Kebbi, I think it was realized with an investment number of billions of yen.

Table4. Paddy production, paddy yield (t/ha), home produced milled rice consumption kg/year/ person and Malaria death ratio(person/100,000person/year) of Asian top 20 countries during 1961-2018. FAOSTAT 2020; UNDESA 2019; USDA 2020; Global Burden of Disease(GBD), IHME2017, **Nominal GDP in 2018 and Inflation Adjusted GDP(world bank)** (Compiled by Wakatsuki & Iwashima on 3rd September 2020)

Rank	Countries	Mean paddy production (million ton) (**Paddy yield (t/ha)**, Milled rice consumption per capita (kg/person)) | Death rate from malaria (deaths per 100 000 population)												SawahPlatformEvolutionalLevel	GDP(2018Nominal)$	GDPInflationAdjust2019
		1961-1970		1981-1990		1991-2000		2001-2010		2011-2015		2016-2018				
1	**China**	85(2.9, 71)		171(5.2, 98)		189(6.1, 95)	0.0	182 (6.3, 85)	0.0	205 (6.8, 92)	0.0	212(6.9, 93)	0.0	4,5,6	9580	15309
2	India	55(1.5, 68)		93(2.3, 73)		122(2.6, 78)	7.2	135 (3.1, 73)	5.0	158 (3.6, 77)	4.2	168(3.8, 79)	4.0	2,3,4, 5	2039	6427
3	Indonesia	14(1.9, 87)		39(4.0, 146)		49(4.3, 155)	5.8	57 (4.7, 155)	4.3	70 (5.1, 175)	3.4	81(5.2, 192)	3.1	1,2,3,4,5,6	3871	11189
4	Bangladesh	16(1.7, 175)		23(2.2, 157)		29(2.8, 156)	9.3	42 (3.8, 186)	4.1	51 (4.5, 210)	2.7	54(4.7, 210)	2.3	3,4,5,6	1749	3524
5	Viet Nam	9.2(1.9, 151)		16(2.8, 161)		26(3.7, 215)	1.8	36 (4.8, 269)	1.7	44 (5.7, 303)	1.6	43(5.6, 286)	1.6	4, 5, 6	2551	6172
6	Thailand	12(1.8, 233)		19(2.0, 227)		22(2.3, 230)	1.1	31 (3.0, 295)	0.2	35 (3.1, 318)	0.0	30(3.0, 271)	0.0	1,2,3,4,5,6	7448	16278
7	Myanmar	7.7(1.6, 197)		14(3.0, 230)		17(3.0, 241)	13.8	28 (3.7, 350)	13.6	27 (3.8, 323)	8.1	26(3.8, 299)	7.4	1,2,3,4,5	1300	5592
8	Philippines	4.4(1.4, 87)		8.6(2.6, 98)		10(2.9, 93)	0.9	15 (3.5, 107)	0.3	18 (3.9, 114)	0.1	19(3.9, 111)	0.1	1,2,3,4,5	3104	7599
9	Japan	17(5.3, 108)		13(6.1, 69)		12(6.2, 61)	0.0	11 (6.5, 53)	0.0	10 (6.7, 51)	0.0	9.9(6.7, 48)	0.0	5 & 6	39304	43236
10	Pakistan	2.3(1.6, 28)		4.9(2.5, 33)		6.2(2.7, 30)	3.5	8.0 (3.2, 31)	3.4	9.7 (3.7, 32)	2.7	11(3.8, 32)	2.6	3,4, 5	1565	5035
11	**Cambodia**	2.7(1.2, 257)		2.0(1.3, 160)		3.1(1.7, 178)	14.3	5.9 (2.4, 272)	12.4	9.2 (3.2, 384)	9.5	10(3.5, 403)	8.4	1,2,3,4,5	1504	3645
12	South Korea	5.0(4.2, 107)		7.7(6.3, 118)		7.0(6.4, 96)	0.0	6.4 (6.6, 83)	0.0	5.6 (6.8, 70)	0.0	5.4(7.1, 66)	0.0	5 & 6	33320	43029
13	Nepal	2.2(1.9, 122)		2.8(2.0, 103)		3.5(2.4, 100)	4.7	4.2 (2.7, 102)	3.6	4.8 (3.2, 111)	2.7	4.9(3.3, 110)	2.6	1,2,3,4,5	1034	2443
14	Sri Lanka	1.1(2.1, 62)		2.4(3.0, 91)		2.6(3.2, 87)	2.3	3.3 (3.7, 104)	0.4	3.9 (3.7, 118)	0.0	3.5(3.6, 106)	0.0	2,3,4, 5	4099	11669
15	Lao PDR	0.7(1.0, 184)		1.3(2.0, 210)		1.8(2.6, 204)	0.4	2.7 (3.5, 287)	0.3	3.6 (3.9, 345)	0.3	3.9(4.2, 353)	0.2	1,2,3,4 5	2566	6397
16	**DPR Korea**	2.1(4.3, 100)		2.2(3.4, 73)		2.8(4.8, 81)	0.0	2.3 (4.1, 61)	0.0	2.8 (5.2, 69)	0.0	2.3(5.0, 57)	0.0	4, 5	1298	1667
17	Malaysia	1.3(2.2, 83)		1.8(2.6, 70)		2.1(3.0, 63)	0.1	2.3 (3.4, 55)	0.1	2.5 (3.7, 52)	0.0	2.8(4.1, 56)	0.0	3, 4, 5	11072	26808
18	Iran	0.9(2.7, 23)		1.7(3.4, 21)		2.4(4.1, 24)	0.0	2.5 (4.3, 22)	0.0	2.3 (4.2, 19)	0.0	2.3(4.0, 18)	0.0	3, 4, 5	5417	19082
19	Taiwan	2.9(3.7, 138)		2.7(4.8, 87)		2.0(5.5, 60)	0.0	1.5 (5.6, 43)	0.0	1.7 (6.3, 44)	0.0	1.8(6.5, 47)	0.0	5, 6	25008	57095
20	Turkey	0.2(4.0, 5)		0.3(4.8, 4)		0.3(5.2, 3)	0.0	0.6 (7.0, 5)	0.0	0.9 (8.0, 7)	0.0	0.9(8.0, 7)	0.0			

Annual Malaria Death per 100,000	1900	1930	1950	1970	1990	1997
Middle East,South Asia&WesternPacific	453	376	66	4	5	3
China and North East Asia	77	108	49	20	0	0
Sub Saharan Africa	223	216	184	107	148	164

(Charter R&Mendis KN. 2002, Clinical Microbiology Reviews, Oct. p564-594)

In Table 4, we were finally able to dock the malaria infection death and rice cultivation data. According to Charter and Mendis, which data are shown in the Table 4 below, in Asia, the malaria deaths were eradicated in most countries between 1970-90, the core period of the Green Revolution, On the other hand, SSA has a very high malaria infection mortality rate even in 1997. Only Myanmar, Cambodia, Bangladesh, Indonesia and India have had some malaria deaths even in 2016. However, the death rates are gradually decreasing since 2000.

The first column of the table 4 shows annual national paddy production in million tons, the first data in parentheses is paddy yield (t / ha), and then the annual consumption of home-produced rice per capita. The red-colored figures show the number of malaria deaths per 100,000 people. The numbers from 1 to 6 in the rightmost three columns indicate the estimated sawah platform evolution level for each country, of which red-colored number shows the estimated evolutional stage of national average of sawah platform. The national evolutionary stage of sawah platform seems to be proportional to the paddy yield by country. The relatively low malaria death rate despite the low yield in Thailand may be due to the policy that given high priority to exports and the higher quality of rice over yield. Overall, I think malaria deaths are roughly proportional to rice productivity and the status of national sawah platform level, which is the core of the national land management.

Table 5. Paddy production, paddy yield (t/ha), home produced milled rice consumption kg/year/ person and Malaria death ratio(person/100,000person/year) of SSA 30 countries during 1961-2018. FAOSTAT 2020; UNDESA 2019; USDA 2020; Global Burden of Disease(GBD), IHME2017; **WHO2018&2019, Nominal GDP in 2018 and Inflation Adjusted GDP(world bank)** (Compiled by Wakatsuki & Iwashima on 10th of September 2020)

Rank	Countries	Mean paddy production [10,000 ton] (Paddy yield [t/ha], Milled rice consumption per capita [kg/person]) | Death rate from malaria [deaths per 100 000 population]													Sawah platform evolution level	GDP(2018 Nominal)	GDP(Inflation Adjusted 2019)
		1961-1970	1981-1990	1991-2000		2001-2010			2011-2015			2016-2018					
	Egypt	209(5.2, 42)	245(6.0, 31)	476(8.2, 47)	0	607(9.7, 50)	0	0	552(9.5, 39)	0	0	506(9.1, 33)	0	0	4, 5, 6	2573	12251
1	Nigeria	26(1.3, 3.2)	176(2.1, 13)	311(1.7, 18)	129	351(1.5, 15)	126	131	543(1.9, 20)	94	107	699(2.0, 23)	70	61	1,2,3,4,5,6	2033	5348
2	Madagascar	167(1.8, 178)	218(1.9, 133)	247(2.1, 113)	31	348(2.8, 115)	47	16	403(3.9, 110)	26	27	382(4.5, 93)	27	17	4, 5, 6	459	1714
3	Tanzania	12(1.1, 6.4)	49(1.6, 14)	66(1.6, 14)	61	131(1.9, 21)	58	34	237(2.4, 30)	29	44	297(2.5, 34)	29	40	2,3,4,5,6	1040	2711
4	Mali	16(1.0, 18)	22(1.2, 17)	56(1.9, 36)	129	109(2.5, 52)	138	138	206(3.1, 78)	134	88	291(3.4, 98)	98	121	1,2,3,4,5,6	927	2424
5	Guinea	26(1.7, 42)	61(1.7, 68)	95(1.7, 80)	87	131(1.7, 88)	170	144	196(1.2, 112)	114	105	222(1.2, 115)	96	74	1,2,3	910	2670
6	Côte d'Ivoire	27(1.0, 39)	54(1.2, 33)	65(1.3, 28)	144	72(2.0, 24)	158	116	172(2.4, 48)	104	71	209(2.7, 54)	75	30	1,2,3,4,5	1691	5455
7	Sierra Leone	40(1.3, 97)	49(1.3, 80)	38(1.3, 55)	176	67(1.3, 72)	219	177	112(1.7, 102)	147	109	90(1.1, 75)	136	95	1,2,3	539	1790
8	DR Congo	10(0.8, 3.6)	31(0.8, 6.4)	37(0.7, 5.7)	156	32(0.8, 3.6)	161	119	76(0.8, 6.6)	108	105	95(0.8, 7.5)	98	78	1,2,3	496	1143
9	Senegal	11(1.3, 18)	14(2.0, 13)	19(2.4, 13)	88	30(2.8, 16)	58	44	56(3.9, 25)	27	58	70(4.2, 28)	19	26	4,5,6	1441	3536
10	Ghana	4.3(1.1, 3.4)	7.2(1.1, 3.4)	19(1.9, 6.7)	115	29(2.2, 8.2)	151	52	55(2.6, 13)	110	67	73(2.8, 16)	77	46	1,2,3,4,5	2217	5637
11	Burkina Faso	3.5(0.9, 4.2)	4.1(1.7, 3.3)	7.7(2.1, 4.6)	161	13(2.0, 5.9)	195	191	31(2.2, 11)	167	103	29(1.7, 10)	132	114	1,2,3,4,5	716	2280
12	Liberia	14(0.8, 70)	28(1.2, 84)	12(1.1, 33)	100	19(1.2, 35)	133	86	27(1.2, 41)	85	69	28(1.1, 37)	75	41	1,2,3	728	1487
13	Chad	3.2(1.1, 6.0)	3.9(1.2, 4.5)	9.8(1.5, 8.5)	61	13(1.2, 8.0)	75	172	26(1.5, 12)	63	137	26(1.4, 11)	52	58	1,2,3	885	1645
14	Benin	0.2(0.7, 0.4)	0.8(1.2, 1.2)	2.3(1.7, 2.3)	63	8.4(2.7, 6.3)	110	104	25(3.4, 15)	90	80	34(3.4, 19)	87	55	1,2,3,4,5	1242	3424
15	Uganda	0.5(1.1, 0.4)	2.6(1.3, 1.1)	8.1(1.4, 2.4)	164	16(1.6, 3.4)	138	52	23(2.4, 4.0)	51	55	26(2.7, 3.9)	58	29	1,2,3,4,5	724	2272
16	Mauritania	0.1(1.5, 0.4)	3.5(4.5, 12)	6.7(3.7, 18)	11	8.0(4.5, 16)	14	22	21(5.1, 35)	9	50	24(5.3, 34)	9	34	4,5,6	1319	5412
17	Cameroon	1.3(1.0, 1.4)	7.1(4.2, 4.4)	4.4(3.3, 2.0)	104	7.5(1.5, 2.6)	142	?	20(1.3, 5.5)	105	?	35(1.3, 8.9)	90	?	1,2,3,4,5	1556	3804
18	Guinea-Bissau	4.4(1.0, 42)	10(1.5, 72)	11(1.7, 65)	89	12(1.6, 55)	46	108	18(1.7, 67)	25	96	18(1.4, 62)	15	33	1,2,3,4	822	2072
19	Mozambique	9.0(1.3, 6.9)	8.8(0.9, 4.3)	12(0.8, 4.8)	105	13(0.6, 3.8)	129	125	17(0.6, 4.3)	96	71	12(0.6, 2.7)	73	50	1,2,3,4,5	475	1334
20	Togo	2.0(0.8, 7.0)	2.0(1.0, 3.7)	5.9(1.7, 6.4)	104	8.0(2.3, 8.7)	124	63	16(2.1, 15)	114	83	14(1.7, 11)	110	53	1,2,3,4	670	1662
21	Kenya	1.7(4.2, 1.1)	4.5(3.5, 1.4)	4.7(4.0, 1.1)	58	5.0(3.1, 0.8)	41	?	12(4.1, 1.7)	12	28	10(3.8, 1.3)	13	26	4,5,6	1831	4309
22	Malawi	1.0(0.9, 1.4)	3.6(1.6, 2.9)	6.2(1.7, 3.8)	161	9.3(1.7, 4.5)	77	51	12(1.9, 4.7)	51	63	11(1.7, 3.7)	46	39	2,3,4	350	1104
23	Ethiopia	–(–, –)	–(–, –)	1.2(1.6, 0.1)	33	3.5(2.0, 0.3)	20	4	11(2.9, 0.7)	2	16	14(2.9, 0.8)	3	10	1,2,3,4,5	854	2312
24	Rwanda	0.0(2.1, 0.1)	0.7(2.5, 0.7)	1.0(3.7, 0.9)	113	5.3(4.2, 3.6)	44	?	8.6(4.6, 4.9)	24	33	11(3.4, 5.9)	30	34	2,3,4,5	787	2318
25	Niger	2.2(1.6, 3.4)	5.7(2.6, 5.0)	6.3(2.6, 4.1)	119	7.0(3.4, 3.2)	144	100	8.5(4.0, 2.9)	167	111	11(4.2, 3.1)	136	86	1,2,3,4,5	414	1270
26	Burundi	0.3(2.2, 0.6)	2.3(3.0, 2.9)	4.4(3.0, 4.6)	212	6.9(3.2, 5.7)	142	?	6.1(2.1, 4.0)	79	32	6.6(1.6, 5.0)	84	48	1,2,3,4,5	307	787
27	Gambia	3.4(1.3, 51)	2.7(1.6, 22)	2.1(1.5, 11)	63	3.8(1.5, 15)	36	83	5.5(0.9, 17)	17	84	5.4(0.8, 15)	9	29	1,2,3	713	2298
28	Zambia	0.0(0.4, 0.1)	0.9(1.0, 0.8)	1.2(1.0, 0.8)	59	2.2(1.4, 1.1)	46	87	4.3(1.5, 1.6)	31	78	3.6(1.3, 1.3)	30	42	1,2,3	1503	3624
32	South Sudan	0.2(1.0, 0.1)	0.3(1.0, 0.1)	0.3(0.9, 0.1)	52	2.2(3.3, 0.3)	53	–	–(–, –)	34	56	–(–, –)	37	49	1,2,3	353	1570
	Sudan	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4,5	817	4123

Table 5 shows SSA's similar data of the Table 4 for Asian countries. Data are shown since the independence of the top 30 rice-growing countries of SSA. You can see some characteristics and correlated trends between rice cultivation and malaria death rates for 30 years from 1990. Although it has not been statistically analyzed yet, the general trends can be summarized as follows.

1. There are differences depending on the ecological environment.

(1) (a) East African countries such as Madagascar, Tanzania, Kenya, Ethiopia, Rwanda and Zambia with highland cool climate, (b) Senegal, Mauritania, Chad, Sudan and other countries with cool and dryness, and, (C) In Guinea-Bissau and Gambia, where the mangrove zone is prioritized, all of (a)-(c) countries the deaths from Malaria infection are relatively small.

(2) The malaria infection death rate is relatively high in countries with large water masses. Mali, Ghana, Malawi, Uganda, Burundi, Chad, and South Sudan are the examples.

2. Is there any sign that SSA has entered the process of eradicating malaria death due to the progress of sawah based rice cultivation as seen in Asia? This seems possible by comparing the trends countries in 2000-18 that have begun to increase the productivity (yields) through the progress of sawah based rice cultivations and those that have not.

(1) The major rice-growing countries (15 kg or more consumption / year / person) with low productivity (2 t / ha or less) are Guinea, Sierra Leone, Liberia, Guinea-Bissau, Gambia, etc. These countries have no improvement in malaria infection death.

(2) The major rice-growing countries (15 kg or more / year / person) whose productivity is originally high or have improved in recent years are Nigeria, Madagascar, Tanzania, Mali, Ivory

Coast, Senegal, Ghana, Benin, Mauritania, etc. These countries have tended to improve in recent years.
(3) Non-major rice-growing countries (15 kg / year / person) with low productivity (2 t / ha or less) are DR Congo, Burkina Fasso, Chad, Cameroon, Mozambique, Togo, Malawi, Burundi and Zambia. The improvement trend of malaria infection death is unclear
(4) Non-major rice-growing countries (15 kg or less / year / person) whose productivity was originally high or improved in recent years are Uganda, Kenya, Uganda, Ethiopia, Niger, and Sudan. The improvement trend of malaria infection death is unclear
Figure 31 compares agricultural productivity between the United Kingdom and Japan as well as major rice countries of Asia and Africa. The data was provided to reinforce the hypothesis that agricultural productivity would be parallel to the land development rate, and therefore would correspond to the decrease of malaria deaths. Basically, productivity in Asia is increasing by catching up with Japan and China, and SSA countries such as Madagascar and Ghana are catching up with Asian countries, which means that they are developing in a so-called flying flock of geese style.

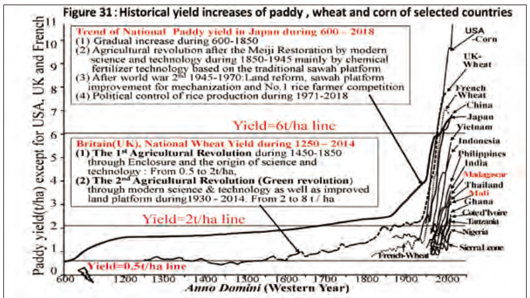


Figure 31 : Historical yield increases of paddy , wheat and corn of selected countries

Figure 32 is a magnified view of the trend resolution of Figure 31. Britain has a very interesting trend. Britain had the lowest wheat productivity less than 0.5t/ha in the 1450 plague period. It took 400 years until to mark the yield 2t/ha in 1800. This is the so-called British Agricultural Revolution. After that, from prewar to the present, 2t has risen to about 10t/ha now. During this time, UK farmers proceeded with farmland improvement for drainage improvement and from harrow cultivation to tractor cultivation. It goes without saying that breeding and crop production technology have improved in parallel. Japan stopped developing sawah platform improvement in the 1970s. Until now, there was a 50-year blank, during which time Japan's paddy yield was overtaken by British wheat yield. Historically, for the past 1,000 years as shown in the Figure 31, Japanese paddy yield was twice that of British wheat yield (Sawah hypothesis 2).

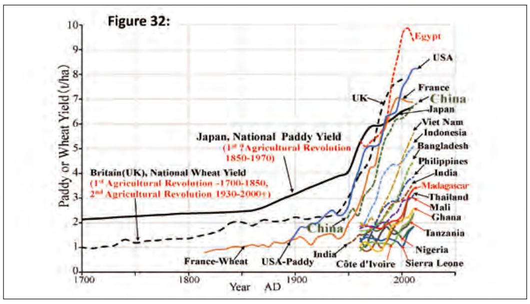


Figure 32:

Possible pathways to Reducing Malaria Transmission Through the Promotion of Rice Cultivation by Endogenous Sustainable Sawah System Platform Development

Possible Central Dogma (Hypothesis):
Endogenous Water Controllable Land Platform Development>Agricultural Revolution>Scientific Revolution> Economic Development>Medical Platform Development

(1) **Malaria death ratio in Asia and SSA in 1900-2000:** During the colonial era, death rates were high in both Asia and Africa. However, Asia, which fought the revolutionary war and became independent by 1950, almost eradicated malaria through the green revolution after the 1960s and the subsequent economic development. Minor malaria death still remain in some areas such as Cambodia, Myanmar, India and Indonesia, which countries still remains undeveloped bush-shaped lands. On the other hand, although SSA became independent 10 years later in 1960, the agricultural revolution has not been realized and the malaria mortality rate remains high as of 2000
(2) **Country Characteristics of Malaria mortality of SSA in 1990-2018:Countries along the Central Dogma where malaria mortality is declining or have not improved at all =Cote d'Ivore, Senegal, Ghana, Nigeria, Tanzania, Guinea, DR Congo Sierra Leone**
(3) **Poor Statistical reliability of WHO and FAO data: Mali, Guinea, DR Congo, Niger, Burundi, Madagascar, Nigeria**
(4) **Rice cultivation is still minor for majority of eastern African Countries, which have domestic rice consumption 10 kg/person or less**
(5) **Possible effects of environment: Large water body (Mali, Ghana, Malawi, Uganda, Burundi, Chad, South Sudan), Highland countries in Eastern Africa, Dryland countries, mangrove area countries**

Finally, the central hypothesis for eradicating malaria infection was summarized as Central Doguma. Agricultural revolution will be possible if water controllable farmland platform has developed appropriately cover the nation which can be managed by farmers, which will lead to the science and technology as well as economic development, and the platform development for eradicating malaria. It seems that the current SSA cannot eradicate malaria

mainly due to the lack of proper agricultural land platform, national land water management infrastructure and thus human management platform.
The starting point is the quality farmland platform. But at the same time, we also need reliable data. There are quite a few suspicious data even from international organizations such as WHO and FAO. For example, in FAOSTAT data of Mali (Figure 35, reported August 25), rice production and yield have been very high in recent years. However, a closer look reveals that per capita grain production in Mali has been over 400 kg in recent years. Total grain equivalent amount of 200 kg / year / person indicates sufficient food production. Mali has achieved 400 kg / year / person in 2017 is at a level which grain can export to foreign countries. Or is this data a manifestation of Land-grab seizure by foreign companies?

Takagi : Dr. Wakatsuki, thank you very much. May I ask Dr. Kobayashi to speak now?

Sawah hypothesis 2: The sustainable productivity of 1 ha of lowland Sawahs are over 10 ha of upland fields, i.e., yield difference(>2) x Soil fertility recovery(>5)

Reason (1) Watershed geological fertilization to lowland sawah: fertile topsoil production in forests, sedimentation in lowlands and accumulation of nutrient rich water, which are promoted by lowland sawah systems. It is also important to control appropriate soil erosion and formation of mountain topsoil.

Reason (2) Sawah system is an ecological factory, it can artificially strengthen and control nutrients such as N, P, K, Si, etc. It is also the platform to control various redox microorganisms to develop carbon sequestration.

Reason (3) Sawah system has dam and groundwater recharge function to improve water cycling. Thus promote intensive sustainability through forest and biodiversity conservation

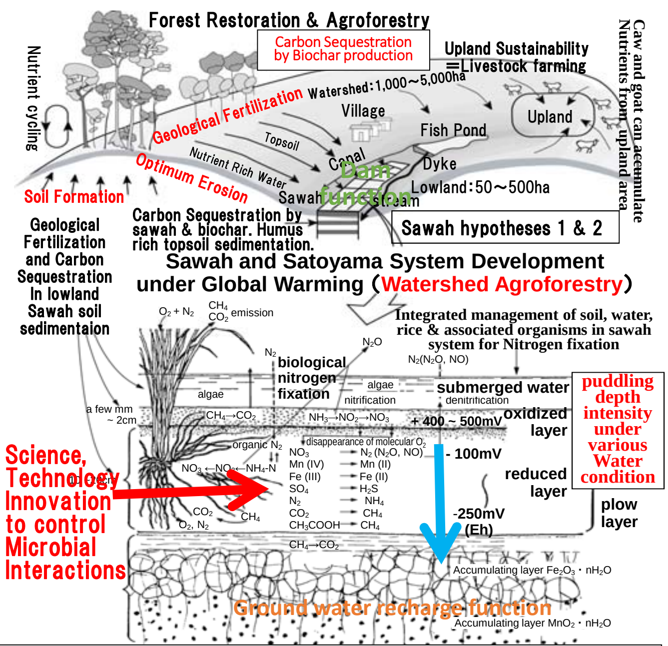


Fig 15. Sawah hypothesis (2): The platform for Sustainable Intensification through Watershed Eco-Technology for Watershed Agroforestry and African SATOYAMA

Table 3. Training, Demonstration and Extension of Sawah Technology in 6 Rice Centers, Kebbi State during March 2011 to May 2014

1. Kinki University/NCAM/Fadama III Demonstration and Training, March 2011-April 2012

Local Government	Farmers	Powertillers No. supplied	Total Sawah developed (ha)	No. of 100kg Paddy bag	Paddy yield (ton/ha)
Arugungu*	Shared	2 shared	6.5	487.5	7.5
Birinin Kebbi*	Shared	2 shared	3.5	227.5	6.5
Jega*	Shared	2 shared	8	560	7
Total		shared	18	1275	7.1**

*The six sites are shown in Figure 3. Although we monitored the extension progress, no yield data were obtained

**Mean

2. Endogenous Extension, April 2012-October 2013 / 3. Dry season, Nov. 2013-May 2014

	Farmers	2. No. of powertiller bought	2. Sawah area developed (ha)	2. No. of 100kg paddy bag	2. Paddy yield (ton/ha)	3. No. of powertiller bought	3. sawah area developed (ha)	3. No. of 100kg Paddy bags	3. Paddy yield (ton/ha)
Arugungu *	MGD farm*	2	15	975	6.5	2	20	1400	7
	JUM farm	1	10	650	6.5	1	10	650	6.5
	ABK farm	1	4	260	6.5	1	8	480	6
	AK farm	1	3	180	6	1	6	360	6
	AMB farm	1	4	240	6	1	5	300	6
	Dr YA farm	1	4	240	6	1	5	300	6
	ANL farm	1	3	180	6	1	5	325	6.5
	AMI farm	1	6	390	6	1	10	650	6.5
	ASD farm	1	5	300	6	1	5	300	6
Birnin Kebbi*	ABA farm*	1	4	260	6.5	1	4	—	—
	BB farm	1	3	180	6	1	6	360	6
	AS farm	1	3	180	6	1	6	360	6
Bagudo*	ABB farm*	5	35	2450	7	5	50	3500	7
Jega*	HHJ farm*	1	7	455	6.5	1	14	910	6.5
	AUA farm	1	20	1200	6	1	40	2400	6
Suru*	Dr.UD farm	1	5	300	6	1	5	300	6
Total		22	131	8440	6.4**	22	199	12595	6.3**

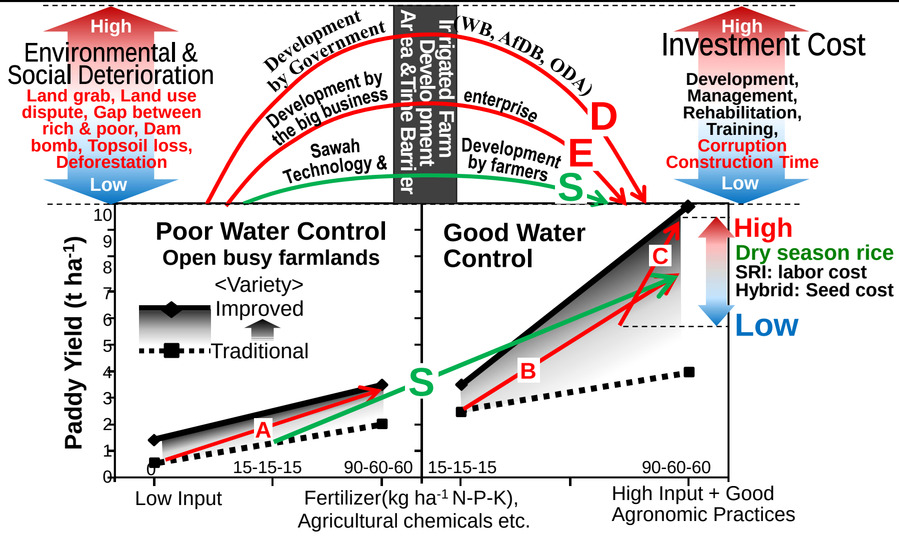


Figure 31. Six Strategies to Increase Paddy Yield and Production in SSA

A type strategy: Upland **NERICA** technology
B type strategy: **Asian Green Revolution technology**
C type strategy: **Hybrid seed and System Rice Intensification**
D type strategy: **Contractor based ODA** irrigation/drainage development
E type strategy: Irrigation by **private big business enterprises**
S type strategy: Sawah technology with sustainable mechanization

Table4. Paddy production, paddy yield (t/ha), home produced milled rice consumption kg/year/ person and Malaria death ratio(person/100,000person/year) of Asian top 20 countries during 1961-2018. FAOSTAT 2020; UNDESA 2019; USDA 2020; Global Burden of Disease(GBD), IHME2017, **Nominal GDP in 2018 and Inflation Adjusted GDP(world bank)** (Compiled by Wakatsuki & Iwashima on 3rd September 2020)

Rank	Countries	Mean paddy production [million ton] (**Paddy yield [t/ha],** Milled rice consumption per capita [kg/person]) | Death rate from malaria [deaths per 100 000 population]										SawahPlatformEvolutionalLevel	GDP(2018Nominal)$	GDPInflationAdjust2019
		1961-1970	1981-1990	1991-2000		2001-2010		2011-2015		2016-2018				
1	**China**	85(2.9, 71)	171(5.2, 98)	189(6.1, 95)	0.0	182 (6.3, 85)	0.0	205 (6.8, 92)	0.0	212(6.9, 93)	0.0	4,5,6	9580	15309
2	India	55(1.5, 68)	93(2.3, 73)	122(2.8, 78)	7.2	135 (3.1, 73)	5.9	158 (3.6, 77)	4.2	168(3.8, 79)	4.0	2,3,4, 5	2039	6427
3	Indonesia	14(1.9, 87)	39(4.0, 146)	49(4.3, 155)	5.8	57 (4.7, 155)	4.3	70 (5.1, 175)	3.4	81(5.2, 192)	3.1	1,2,3,4,5,6	3871	11189
4	Bangladesh	16(1.7, 175)	23(2.2, 157)	29(2.8, 156)	9.3	42 (3.8, 186)	4.1	51 (4.5, 210)	2.7	54(4.7, 210)	2.3	3,4,5,6	1749	3524
5	Viet Nam	9.2(1.9, 151)	16(2.8, 161)	26(3.7, 215)	1.6	36 (4.9, 269)	1.7	44 (5.7, 303)	1.6	43(5.6, 286)	1.6	4, 5, 6	2551	6172
6	Thailand	12(1.8, 233)	19(2.0, 227)	22(2.3, 230)	1.1	31 (3.0, 295)	0.2	35 (3.1, 318)	0.0	30(3.0, 271)	0.0	1,2,3,4,5,6	7448	16278
7	Myanmar	7.7(1.6, 197)	14(3.0, 230)	17(3.0, 241)	13.8	28 (3.7, 350)	13.5	27 (3.8, 323)	9.1	26(3.8, 299)	7.4	1,2,3,4,5	1300	5592
8	Philippines	4.4(1.4, 87)	8.6(2.6, 98)	10(2.9, 93)	0.9	15 (3.5, 107)	0.2	18 (3.9, 114)	0.1	19(3.9, 111)	0.1	1,2,3,4,5	3104	7599
9	Japan	17(5.3, 108)	13(6.1, 69)	12(6.2, 61)	0.0	11 (6.5, 53)	0.0	10 (6.7, 51)	0.0	9.9(6.7, 48)	0.0	5 & 6	39304	43236
10	Pakistan	2.3(1.6, 28)	4.9(2.5, 33)	6.2(2.7, 30)	3.5	8.0 (3.2, 31)	3.4	9.7 (3.7, 32)	2.7	11(3.8, 32)	2.6	3,4, 5	1565	5035
11	**Cambodia**	2.7(1.2, 257)	2.0(1.3, 160)	3.1(1.7, 178)	14.3	5.9 (2.4, 272)	12.4	9.2 (3.2, 384)	9.5	10(3.5, 403)	8.4	1,2,3,4,5	1504	3645
12	South Korea	5.0(4.2, 107)	7.7(6.3, 118)	7.0(6.4, 96)	0.0	6.4 (6.6, 83)	0.0	5.6 (6.8, 70)	0.0	5.4(7.1, 66)	0.0	5 & 6	33320	43029
13	Nepal	2.2(1.9, 122)	2.8(2.0, 103)	3.5(2.4, 100)	4.7	4.2 (2.7, 102)	3.6	4.8 (3.2, 111)	2.7	4.9(3.3, 110)	2.6	1,2,3,4,5	1034	2443
14	Sri Lanka	1.1(2.1, 62)	2.4(3.0, 91)	2.6(3.2, 87)	2.3	3.3 (3.7, 104)	0.4	3.9 (3.7, 118)	0.0	3.6(3.6, 106)	0.0	2,3,4, 5	4099	11669
15	Lao PDR	0.7(1.0, 184)	1.3(2.0, 210)	1.6(2.6, 204)	0.4	2.7 (3.5, 287)	0.3	3.6 (3.9, 345)	0.3	3.9(4.2, 353)	0.2	1,2,3,4 5	2566	6397
16	**DPR Korea**	2.1(4.3, 100)	2.2(3.4, 73)	2.8(4.8, 81)	0.0	2.3 (4.1, 61)	0.0	2.8 (5.2, 69)	0.0	2.3(5.0, 57)	0.0	4, 5	1298	1667
17	Malaysia	1.3(2.2, 83)	1.8(2.6, 70)	2.1(3.0, 63)	0.1	2.3 (3.4, 55)	0.1	2.5 (3.7, 52)	0.0	2.8(4.1, 56)	0.0	3, 4, 5	11072	26808
18	Iran	0.9(2.7, 23)	1.7(3.4, 21)	2.4(4.1, 24)	0.0	2.5 (4.3, 22)	0.0	2.3 (4.2, 19)	0.0	2.3(4.0, 18)	0.0	3, 4, 5	5417	19082
19	Taiwan	2.9(3.7, 138)	2.7(4.8, 87)	2.0(5.5, 60)	0.0	1.5 (5.8, 43)	0.0	1.7 (6.3, 44)	0.0	1.8(6.5, 47)	0.0	5, 6	25008	57095
20	Turkey	0.2(4.0, 5)	0.3(4.8, 4)	0.3(5.2, 3)	0.0	0.6 (7.0, 5)	0.0	0.9 (8.0, 7)	0.0	0.9(8.0, 7)	0.0	5, 6	9405	25129

Annual Malaria Death per 100,000	1900	1930	1950	1970	1990	1997
Middle East,South Asia&WesternPacific	453	376	66	4	5	3
China and North East Asia	77	108	49	20	0	0
Sub Saharan Africa	223	216	184	107	148	164

(Charter R&Mendis KN, 2002, Clinical Microbiology Reviews, Oct, p564-594)

Table 5. Paddy production, paddy yield (t/ha), home produced milled rice consumption kg/year/ person and Malaria death ratio(person/100,000person/year) of SSA 30 countries during 1961-2018. FAOSTAT 2020; UNDESA 2019; USDA 2020; Global Burden of Disease(GBD), IHME2017; **WHO2018&2019, Nominal GDP in 2018 and Inflation Adjusted GDP(world bank)** (Compiled by Wakatsuki & Iwashima on 10th of September 2020)

Rank	Countries	Mean paddy production [10,000 ton] (**Paddy yield [t/ha],** Milled rice consumption per capita [kg/person]) | Death rate from malaria [deaths per 100 000 population]													SawahPlatformEvolutionalLevel	GDP(2018Nominal)$	GDPInflationAdjust2019
		1961-1970	1981-1990	1991-2000		2001-2010			2011-2015			2016-2018					
	Egypt	209 (5.2, 42)	245 (6.0, 31)	476 (8.2, 47)	0	607 (9.7, 50)	0	**0**	552 (9.5, 39)	0	**0**	506 (9.1, 33)	0	**0**	4, 5, 6	2573	12251
1	Nigeria	26 (1.3, 3.2)	176 (2.1, 13)	311 (1.7, 18)	129	351 (1.5, 15)	126	**131**	543 (1.9, 20)	94	**107**	699 (2.0, 23)	70	**61**	1,2,3,4,5,6	2033	5348
2	Madagascar	167 (1.8, 178)	218 (1.9, 133)	247 (2.1, 113)	31	348 (2.8, 115)	47	**16**	403 (3.9, 110)	29	**27**	382 (4.5, 93)	27	**17**	4, 5, 6	459	1714
3	Tanzania	12 (1.1, 6.4)	49 (1.6, 14)	66 (1.6, 14)	81	131 (1.9, 21)	56	**34**	237 (2.4, 30)	29	**44**	297 (2.5, 34)	29	**40**	2,3,4,5,6	1040	2711
4	Mali	16 (1.0, 18)	22 (1.2, 17)	56 (1.9, 36)	129	109 (2.5, 52)	138	**138**	206 (3.1, 78)	134	**88**	291 (3.4, 98)	98	**121**	1,2,3,4,5,6	927	2424
5	Guinea	26 (1.7, 42)	61 (1.7, 68)	95 (1.7, 80)	87	131 (1.7, 88)	132	**144**	196 (1.2, 112)	114	**105**	222 (1.2, 115)	96	**74**	1,2,3	910	2670
6	Côte d'Ivoire	27 (1.0, 39)	54 (1.2, 33)	65 (1.3, 28)	144	72 (2.0, 24)	166	**116**	172 (2.4, 48)	104	**71**	209 (2.7, 54)	76	**30**	1,2,3,4,5	1681	5455
7	Sierra Leone	40 (1.3, 97)	49 (1.3, 80)	38 (1.3, 55)	176	67 (1.3, 72)	219	**177**	112 (1.7, 102)	147	**109**	90 (1.1, 75)	135	**95**	1,2,3	539	1790
8	DR Congo	10 (0.8, 3.6)	31 (0.8, 6.4)	37 (0.7, 5.7)	156	32 (0.8, 3.6)	161	**119**	76 (0.8, 6.6)	108	**105**	98 (0.8, 7.5)	98	**78**	1,2,3	496	1143
9	Senegal	11 (1.3, 18)	14 (2.0, 13)	19 (2.4, 13)	88	30 (2.8, 16)	60	**44**	56 (3.9, 25)	27	**58**	70 (4.2, 28)	19	**26**	4,5,6	1441	3536
10	Ghana	4.3 (1.1, 3.4)	7.2 (1.1, 3.4)	19 (1.9, 6.7)	115	29 (2.2, 8.2)	151	**52**	55 (2.6, 13)	110	**67**	73 (2.8, 16)	77	**46**	1,2,3,4,5	2217	5637
11	Burkina Faso	3.5 (0.9, 4.2)	4.1 (1.7, 3.3)	7.7 (2.1, 4.6)	161	13 (2.0, 5.9)	195	**191**	31 (2.2, 11)	167	**103**	29 (1.7, 10)	132	**114**	1,2,3,4,5	716	2280
12	Liberia	14 (0.8, 70)	28 (1.2, 84)	12 (1.1, 33)	100	19 (1.2, 35)	133	**86**	27 (1.2, 41)	85	**69**	28 (1.1, 37)	75	**41**	1,2,3	728	1487
13	Chad	3.2 (1.1, 6.0)	3.9 (1.2, 4.5)	9.8 (1.5, 8.5)	61	13 (1.2, 8.0)	75	**172**	26 (1.5, 12)	63	**137**	26 (1.4, 11)	52	**58**	1,2,3	885	1645
14	Benin	0.2 (0.7, 0.4)	0.8 (1.2, 1.2)	2.3 (1.7, 2.3)	83	8.4 (2.7, 6.3)	110	**104**	25 (3.4, 15)	90	**80**	34 (3.4, 19)	87	**55**	1,2,3,4,5	1242	3424
15	Uganda	0.5 (1.1, 0.4)	2.6 (1.3, 1.1)	8.1 (1.4, 2.4)	184	16 (1.6, 3.4)	138	**52**	23 (2.4, 4.0)	54	**55**	26 (2.7, 3.9)	56	**29**	1,2,3,4,5	724	2272
16	Mauritania	0.1 (1.5, 0.4)	3.5 (4.5, 12)	6.7 (3.7, 18)	11	8.0 (4.5, 16)	14	**22**	21 (5.1, 35)	9	**50**	24 (5.3, 34)	9	**34**	4,5,6	1319	5412
17	Cameroon	1.3 (1.0, 1.4)	7.1 (4.2, 4.4)	4.4 (3.3, 2.0)	104	7.5 (1.5, 2.6)	142	**?**	20 (1.3, 5.5)	105	**?**	35 (1.3, 8.9)	92	**?**	1,2,3,4,5	1556	3804
18	Guinea-Bissau	4.4 (1.0, 42)	10 (1.5, 72)	11 (1.7, 65)	89	12 (1.6, 55)	46	**108**	18 (1.7, 67)	25	**96**	18 (1.4, 62)	18	**33**	1,2,3,4	822	2072
19	Mozambique	9.0 (1.3, 6.9)	8.8 (0.9, 4.3)	12 (0.8, 4.8)	165	13 (0.6, 3.8)	129	**125**	17 (0.6, 4.3)	96	**71**	12 (0.6, 2.7)	73	**50**	1,2,3,4,5	475	1334
20	Togo	2.0 (0.8, 7.0)	2.0 (1.0, 3.7)	5.9 (1.7, 8.4)	104	8.0 (2.3, 8.7)	124	**63**	16 (2.1, 15)	114	**83**	14 (1.7, 11)	110	**53**	1,2,3,4	670	1662
21	Kenya	1.7 (4.2, 1.1)	4.5 (3.5, 1.4)	4.7 (4.0, 1.1)	58	5.0 (3.1, 0.8)	41	**?**	12 (4.1, 1.7)	12	**28**	10 (3.8, 1.3)	13	**26**	4,5,6	1831	4509
22	Malawi	1.0 (0.9, 1.4)	3.6 (1.6, 2.9)	6.2 (1.7, 3.8)	161	9.3 (1.7, 4.5)	93	**51**	12 (1.9, 4.7)	51	**63**	11 (1.7, 3.7)	48	**39**	2,3,4	350	1104
23	Ethiopia	- (- , -)	- (- , -)	1.2 (1.8, 0.1)	33	3.5 (2.0, 0.3)	20	**4**	11 (2.9, 0.7)	2	**16**	14 (2.9, 0.8)	3	**10**	1,2,3,4,5	854	2312
24	Rwanda	0.0 (2.1, 0.1)	0.7 (2.5, 0.7)	1.0 (2.7, 0.9)	113	5.3 (4.2, 3.6)	44	**?**	8.6 (4.6, 4.9)	24	**33**	11 (3.4, 5.9)	30	**34**	2,3,4,5	787	2318
25	Niger	2.2 (1.8, 3.4)	5.7 (2.6, 5.0)	6.3 (2.8, 4.1)	119	7.0 (3.4, 3.2)	144	**100**	8.5 (4.0, 2.9)	167	**111**	11 (4.2, 3.1)	136	**86**	1,2,3,4,5	414	1270
26	Burundi	0.3 (2.2, 0.6)	2.3 (3.0, 2.9)	4.4 (3.0, 4.6)	212	6.9 (3.2, 5.7)	142	**?**	6.1 (2.1, 4.0)	79	**32**	8.6 (1.6, 5.0)	84	**48**	1,2,3,4,5	307	787
27	Gambia	3.4 (1.3, 51)	2.7 (1.6, 22)	2.1 (1.5, 11)	63	3.8 (1.5, 15)	36	**83**	5.5 (0.9, 17)	17	**84**	5.4 (0.8, 15)	9	**29**	1,2,3	713	2298
28	Zambia	0.0 (0.4, 0.1)	0.9 (1.0, 0.8)	1.2 (1.0, 0.8)	59	2.2 (1.4, 1.1)	46	**67**	4.3 (1.5, 1.8)	31	**78**	3.6 (1.3, 1.3)	30	**42**	1,2,3	1503	3624
32	South Sudan	0.2 (1.0, 0.1)	0.3 (1.0, 0.1)	0.3 (0.9, 0.1)	52	2.2 (3.3, 0.3)	53	**-**	- (- , -)	34	**55**	- (- , -)	37	**49**	1,2,3	353	1570
	Sudan				13		10	**-**	2.4 (2.9, 0.4)	6	**-**	3.0 (3.6, 0.5)	6	**-**	4,5	817	4123