Zero Malaria 2030

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.

First Session :
Rice Production and Malaria in Asia and Africa

<Event Outline>

In Asia, paddy rice cultivation is widely diffused and rice is essential as a staple food in dietary life, rice cultivation is widespread and rooted in daily life. On the other hand, in Africa, where rice cultivation was introduced as an economic policy, rice is a commodity product, and it is hard to say that it is rooted in a daily life. While comparing the meaning of “rice” in agriculture in Asia and Africa, we discussed from a broader perspective how paddy rice cultivation in both region affect local people, local environment and economy.

Especially, in the discussion emphasizes the inclusion of the perspective of the local residents, not just the comparison of regional agriculture. In particular, we explored changes in the residents' awareness of rice and changes in local communities in Africa through introducing wetland rice cultivation.

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
by Dr. Masahiro Takagi, Malaria No More Japan

5 : 15 pm Theme “Is Rice Production Culture? Economy? Can We Apply the Asian Empirical Knowledge into Africa? ”, moderated by Prof. Koji Tanaka, Kyoto University

5 : 25 pm Keynote speech

- Dr. Toshiyuki Wakatsuki, Shimane University
  “Overview on the progress of rice production and Sawah (SUIDEN 水田 , Paddy) based rice farming in Sub Saharan Africa (SSA) in 1961-2018”
  Dr. Wakatsuki introduced various rice production and paddy rice cultivation in some Sub-Sahara African countries.
- Mr. Kiyoshi Shiratori, Specially Appointed Professor of The Center for African Area Studies, Kyoto University “Rice development and waterborne diseases”
  Mr. Shiratori had a presentation about his project in Tanzania in 80s, introducing its participatory rural approach to rice production and its close connection with waterborne diseases including malaria. And he raised issues such as the comprehensive approach to the development of paddy rice production and the control measures of waterborne diseases, and the efficient and effective countermeasures to these issues.

6 : 10 pm Discussion and Q&A
We use chat system for checking the questions and comments from the floor.
Speakers and commentators use both Japanese and English.

6 : 50 pm Closing remarks

7 : 00 pm Close

Event Discussion (first session)

Opening remarks

Takahiro Shinyo (Chairman, Malaria No More Japan; Chairman, Executive Committee of ZERO Malaria 2030 Campaign)

Shinyo : Dear all, thank you for your participation. I am Shinyo, Chairman of Malaria No More Japan.

We, Malaria No More Japan has its headquarters in the US, and our organization was established as a sister organization in 2012. Through 8 years, Malaria No More Japan has contributed to the global health and combat against malaria, which suffers 3.2 billion people in the world.

We have implemented ZERO Malaria 2030 Campaign to achieve “zero malaria” world by 2030, and various committee members such as Hon. Keizo Takemi, the Member of House of Councilors, and Dr. Shigeru Omi, the President of the Japan Community Health Care Organization, and other stakeholders.

This is the fourth meeting. At the first meeting, we had an expert meeting on the malaria countermeasures in Africa. The second one is related to the possibility of malaria countermeasure investment by the private sector. The third time was climate change and mosquito-mediated infectious disease. This is the fourth time. Our theme for today is rice production and malaria. Also, next month, we will again have a session on the same theme of rice production and malaria. Today, we will be basically focusing on Asia and Africa, and we would like to have a discussion among experts. With that background, what will be the knowledge we can utilize with the background of malaria? This is what we would like to discuss today.

There is a very long history of paddy rice production and malaria. In Africa and also in other Asian countries, we saw the outbreak of malaria as they started the rice production, and among some of the farmers, there is a mutation and there is a sickle cell and also thalassemia. There are some anti-malaria genes which are being acquired in some cases. Also, in food supply, we have been trying to increase food production. To that end, we need to have different types of methods. For example, paddy rice production is one of the methods to do that. In order to increase that, we need to have irrigation facilities. The more water we have, we will have more habitants of malaria and schistosomiasis, so we need to think about the trade-off with the countermeasures against malaria. This is really a headache for us.

With regard to malaria, this is an old infectious disease. Before humans became the host, bovine were the host. As the population increased, we worked on deforestation in order to develop land. From that perspective, they are now infectious to humans. However, food issues and infectious disease – they are intertwined with the development by humans.

The aggression by humans to animal inhabitants are occurring, so wildlife, viruses,

and germs – how are we going to isolate from there will be an area we need to consider. The coronavirus is no exception.
Be it global warming or infectious disease – they are manmade phenomena. As people say, we are now entering into “Anthropocene” type of era. Food issues and infectious disease issues are at any rate closely linked with the increase of our population. We will have 9.3 billion, which is expected to be our population number. This is going to be a great issue for us, but this is not today’s theme.
Today, we have experts and we would like them to discuss over paddy rice production and also rice cultivation. Also, from Malaria No More Japan, we have Dr. Masahiro Takagi, Professor Emeritus of Nagasaki University, as the moderator. We would like to have the insights from many of the experts. For this round table and the next round table, we are receiving a grant from RBM Partnership to End Malaria, so we would like to express our gratitude to that organization.
So much for my talk, and as long as time allows, we would like to exchange opinions. Thank you very much for your attendance.

Takagi : Thank you very much, Dr. Shinyo. As was introduced by Dr. Shinyo, I am one of the board members of Malaria No More Japan, Takagi. Today, I will be in the backstage and I will be moderating behind the stage. It is great to see you all.
As the chariman explained earlier, this is the fourth round table. We will be paying particular attention to Africa and we will explore the issues and relations with rice production and malaria. Similar to the COVID-19 problem, the relationship between rice production and mosquitoes, if we are to produce more food, we might struggle with the increase of mosquitoes, and therefore the conflicting interests of both sides. In the discussions today, in pursuing the higher production of food, and regardless of what is the reason, there are some facts that exist in the world that mosquitoes have actually decreased with the increased food production and the malaria problem has alleviated in some parts of the world, so inclusive of all these kinds of examples.
We welcome two prominent experts to talk about today’s topic. We thank both of the experts for accepting our offer. The first one is Dr. Wakatsuki, who has committed to introduce paddy rice cultivation in Africa. And the second is Mr. Shiratori, who has implemented rural development projects in Africa, and saw the process to take root in the community. I expect to hear about actual and weighty stories from these two speakers.
Prof. Tanaka will summarize and moderate this

session, and the contents will once again be raised in the second session scheduled for September. We believe that the issues and challenges summarized at the end of today's session will be once again picked up in the second round table in September.

At my hand, we have the attending experts from a diverse range of disciplines. From London, Dr. Jo Lines; and Kallista Chan; and also Dr. Saito are also attending today's session as well. From a different point of view, inclusive of the issue of mosquitoes, we will expect to hear some useful comments. Dr. Kobayashi has been joining this meeting. Thank you very much for joining despite your busy schedule. He is an expert in malaria, so the type of topic which we will pick up today, how that will become useful in the discussions with regard to malaria, we would like to hear from him later as well. Following Mr. Shiratori's discussion, I think there is a great extent of relevance from agricultural development and farming promotion that was made by Mr. Amameishi of Japan International Cooperation Agency (JICA). Mr. Amameishi is also joining these discussions as well. After the lectures from the two prominent speakers invited for today, we would like to invite other experts to give some inputs to these discussions so that we can enrich the content of today's round table. We will look forward to the discussions today as long as time permits.

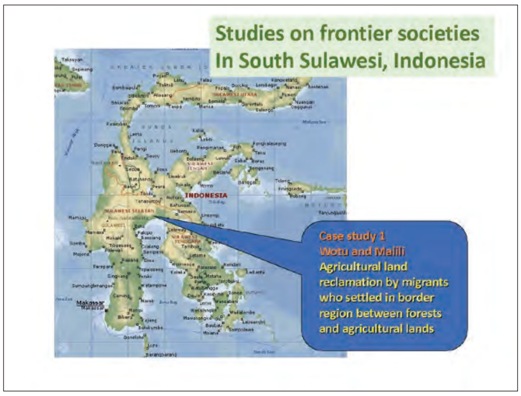
Now, Prof. Tanaka, I will pass the microphone to you, so if you could serve as an anchor and moderator. Thank you.

Brief Presentation by Koji Tanaka

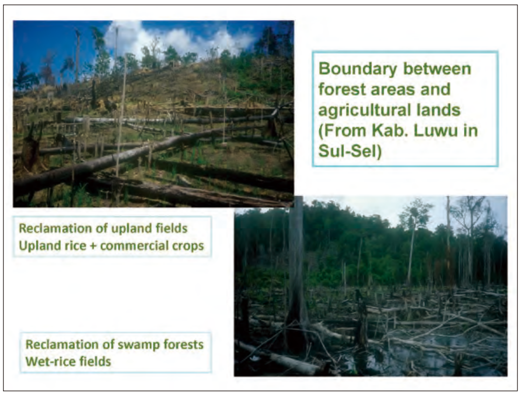
(Professor Emeritus, Center for Southeast Asian Studies, Kyoto University)

Tanaka : Just as Dr. Takagi mentioned, rice production and malaria are the themes for today's round table. If I look back at the history of rice production, be it Asia or Africa, both of them have very long histories, but in Africa, Asian-rice introduction and its expansion took place rather recently in comparison to Asia, mostly shorter than a half century or a few decades ago. Asian farmers, whichever they are East, Southeast, or South Asians, have developed a variety of rice production systems adapting to their given, diversed conditions such as climate, topography and hydrology. Despite this difference between Asia and Africa, we need to draw our attention to the so-called "Green Revolution" starting in the late 1960s in Asia and prevailing both in Asia and Africa through 1970s on-ward. Through this Green Revolution, cultivated area and production of rice increased rapidly in Asia. With the development of economies in Asia, new, intensive rice-growing techniques were introduced and wet-rice fields were newly reclaimed in various regions. Later, the same situation took place in Africa, too. In today's round table, keeping such background in mind, we are going to discuss on how the development of rice production has been related to malaria.

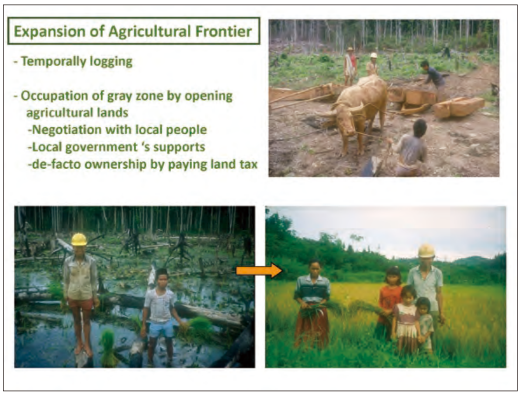
I carried out a number of researches related to rice cultivation in various countries in Asia from the late 1970s to the 1990s, not just for increasing rice production but for understanding sociocultural and ecological aspects of African rice cultures. In relation to these concerns of mine, I had an experience of conducting research in Indonesia in the 1980s on pioneering settlers who reclaimed wet-rice fields in forest areas. In the course of conducting research, I met malaria patients more frequently and could see more serious spread in frontier villages. Although the following slides do not show anything about malaria, I would like to show them so that you can imagine what the condition of pioneering villages was. I hope you can see how the reclamation of wet-rice fields proceeded, and how the environment of frontier villages changed from these slides.



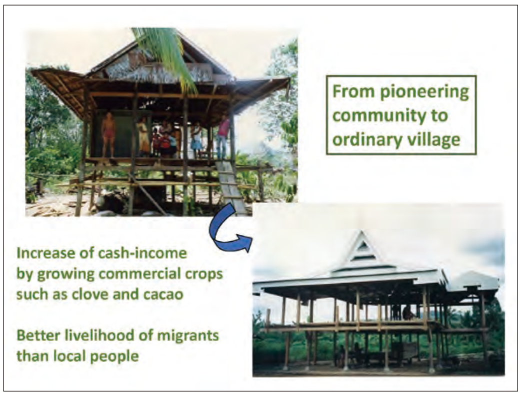
This slide indicates the location where I conducted researches; central part of Sulawesi island in Indonesia. From the late 1970s to 1980s many migrants were sent to new settlement sites provided by the central government's transmigration project. They were transferred from overpopulated Java and Bali islands. Besides these officially-arranged migrants, there were spontaneous migrants, who moved with their initiatives and, in some cases, illegally penetrated in the forest regions to reclaim new rice fields. The following slides show how new settlements were opened by the latter.



This slide indicates what the condition of newly-reclaimed land. Given the circumstances, the migrants penetrated into forest areas, be it wetland or upland, and reclaimed rice fields.



Temporarily, illegal logging was conducted. In parallel with this operation, wet-rice fields were also reclaimed and rice began to be planted immediately after reclamation. The left picture indicates a new rice field in the second year after reclamation. As you can see from the right picture, natural forests was totally converted to manmade environment, and the newly-reclaimed wet-rice field shown in the left hand had drastically changed to ordinary wet-rice fields in appearance after five to six years.



This slide shows changes in living conditions in frontiers. At the very beginning, they lived in a simple cottage, but as the development went on, they built a big house, even modern one equipped with toilet inside the house. As this shows, the expansion of wet-rice fields means the expansion of living space of the migrants, and this expansion automatically corresponds with the increase of the number of toilets, ponds and tanks; they are all stagnant pools as well. So, I think, you can easily imagine that malaria became more spread in frontier regions of human migration.
As you can see from these slides, with the development of wet-rice fields, the original ecosystem is significantly transformed into a human-controlled ecosystem, and of course

the hydrological conditions are also changed. Pioneer settlers extend the frontiers of wet-rice-field reclamation, unstable living space with poor water management is also expanding. I suppose this is the reason why the frontier regions appear to be more susceptible to malaria and infectious diseases.
However, as rice cultivation is stabilized and living space is improved, the original frontier situation also disappears. Pioneer settlements transforms themselves into an ordinary village, in which various countermeasures against malaria are taken into action through administrative services. In Asia where the drastic economic development took place and the expansion of rice fields is no more significant, malaria has declined drastically, too. I assume that similar situation took place and is taking place in Africa. For instance, I heard that malaria infections expanded widely and seriously in areas where large scale irrigation scheme was implemented in Africa.
But, on the other hand, I am not sure what is and will be taking place in Africa; does it follow the same procedures as experienced in Asia or take a different way? Despite its shorter history of Asian rice growing, many types of rice-growing systems have been introduced to and established under a variety of individual geographical conditions in Africa. In this round table, we are going to focus on the links between rice growing and malaria, but I would like to start the round table with learning the history and current situation of rice growing and its development in Africa from two speakers, who have been long engaged in technical and academic cooperation for the development of rice cultivation in Africa.
According to Dr. Takagi, I am expected to play a role as the moderator for this round table, but I think it would be my role now to start the session, and to find the way for bridging today's achievement to the next meeting.

Takagi : Thank you very much, Prof. Tanaka. The time is running out, therefore we would like to invite Dr. Wakatsuki without further ado. We would like to listen to the lecture by Dr. Wakatsuki. Dr. Wakatsuki, please.

Overview on the progress of rice production and Sawah (SUIDEN水田, Paddy) based rice farming in Sub Saharan Africa (SSA) in 1961-2018

T. Wakatsuki (Shimane University), 25th of August 2020

(25th of August 2020)

1. Rice ecology and potential of Sawah based rice farming in SSA
2. Rice and related statistics
3. Various rice cultivation platforms of non- Sawah and Sawah system in SSA

(10th of September 2020)

4. Definition of Sawah (Suiden), Paddy, Irrigation, Eco-technology
5. Sawah Hypothesis (1) for Scientific and (2) for Sustainable platform of rice cultivation
6. Practices on Sawah Technology（アフリカ水田農法）for endogenous development of irrigated sawah system platform
7. Nigeria Kebbi rice revolution, IOM Chad, Ghana sawah project, AfricaRice-Smart valley (SMART-IV)

“Overview on the progress of rice production and Sawah (SUIDEN 水田 , Paddy) based rice farming in Sub Saharan Africa (SSA) in 1961-2018” by Toshiyuki Wakatsuki (Shimane University)

Wakatsuki : Thank you very much for the introduction. There are two rounds of opportunity for me to talk. Today, my focus is on rice cultivation in sub-Saharan Africa rather than to discuss malaria.

Please proceed with the Power Points.

I will talk about the rice production progress in Africa as a whole. The first occasion for today, I will talk about the various rice farming platform and practices as well as statistical trends to know what the progress of rice production was in Africa during 1961-2018. In relation with Malaria I would like to talk about in September. Just intuitively, I am thinking that “SUIDEN”（水田）Based Rice Farming, (i.e., rice paddies in English), will be usable for eradicating malaria ultimately. That is my desired conclusion in making my arguments. The English term of “paddy, paddies” are not appropriate to use in SSA, therefore I will use the Indonesian term of “Sawah”. The term of “SUIDEN”, and “Sawah” are the same concept and meaning, but “Paddy” is sometime the same meaning of “SUIDEN” and “Sawah” but often different meaning in SSA. This problem will be discussed in next time on 10th of September. Today I will use the term of “Sawah” to describe “SUIDEN”, but I will only use the term of “Paddy” to describe “unhusked rice grain”, such as “paddy production” and “paddy yield” .

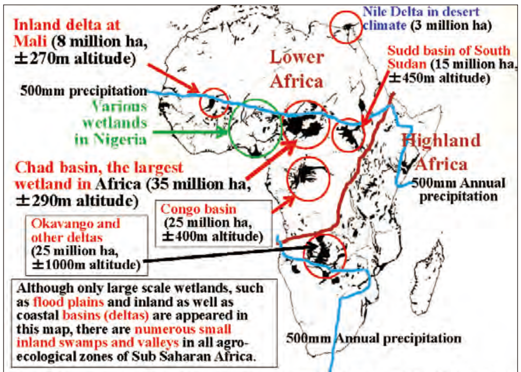


Fig. 1. Distribution of flat wetland soils in Africa (Van Dam and Van Diepen 1982)

Figure 1 shows the distribution of lowlands throughout Africa. Very interesting is the 500mm rainfall line along the southern edge of the Sahara Desert, which is the so-called Sahel belt. South of that area, there are lots of wetlands, i.e., from the Senegal River, the inland delta of Mali, various wetlands of northern Nigeria, Lake Chad, and Sud basin, which eventually leads to the Nile river and Nile delta. Interestingly, these wetlands distribute in the inland area of African continent at various heights and even low rainfall areas. This is different from Asia, which has major wetlands along the coastal area with ample rainfall. Although the precipitation is low groundwater levels are shallow to moderate depth (< 10-20m). These inland wetlands have somewhat similar situation of the Nile Delta in desert climate, where the rivers flow from the southern forest area, Guinea and Sudan savanna even northern Sahel zones. Thus, although there is low precipitation, there is high availability of water.
Another characteristic of the African continent is that West Africa is lowland Africa and East Africa is highland Africa, with a plateau of about 1,000 m or more. This makes difference in the ecology of suitable rice cultivation, about 80% of the potential of suitable rice cultivation is in West Africa and 20% is in East Africa.
SSA's traditional rice-growing areas are distributed along the Guinea Gulf coast, which have widespread distribution of a Japanese “satoyama” like wetlands. Initially, I started with sawah based rice cultivation in such small inland valleys. This area also has great potential for endogenous sawah system platform development. In addition to this, I have noticed the huge potential of the large wetlands in the northern Sahel belt for the past 5 or 10 years. Since the total area is very large, if we carefully select, 10-20% of the total wetland area, and carry out sustainable development, I think that it will be okay as a countermeasure against the food crisis of SSA expected in the near future..

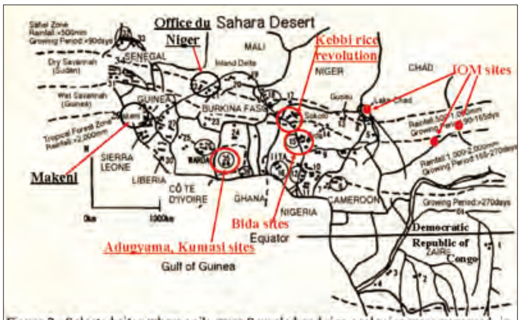


Figure 2. Selected sites where soils were Sampled and rice ecologies were surveyed in Western and parts of Central Africa during 1986-1998. Red circles shows Kebbi State of Rice Revolution in 2010-2019 based on the sawah technology development at Bida and Adugyama area in 1986-2017. Three red marks shows IOM-Chad/NCAM sawah project sites, i.e., Baga sola (Nigeria border), Tissi (Darfur border) and Haraze(Central Africa border) in 2015-17. Office du Niger (1932), Makeni (Taiwan 1961, IITA1986)

As shown in Fig. 2, when I was assigned to IITA, International Institute of Tropical Agriculture, Ibadan, Nigeria, as a JICA expert in 1986, I made many extensive rice soils and rice ecology survey trips using four-wheel drive vehicles. Since I specialized in soil science, my first job was to take the soils and compare the sawah rice soils in Asia.
There is a red circle described as Bida site in the middle of Fig. 2. Here we rented a rice farm of a farmer and developed an Asian style sawah platform for 1ha mainly by manual labor. We used IRRI made turtle powertiller (about $1,000 per unit at that time) developed by IRRI for some leveling and puddling for transplanting. This sawah platform gave us paddy yields 5-6t/ha using many high yielding varieties, while farmers’ traditional rice fields platform never gave the paddy yields higher than 3 t/ha using the same standards fertilization amount.
As a result, I thought it would be easy to realize the Green Revolution if Suiden, sawah platform is available, but it was not understood by the top research management at the CGIAR Center, an international organization such as IITA and Africa rice. Jobs that involve the sawah platform development were evaluated as not

research activities. Western research top managers could not understand the scientific essence of sawah based rice cultivation, thus they did not understand the importance of the sawah platform for rice cultivation at all. Another thing is that the farmers at the Bida sites never did develop sawah platform and manage the sawah based rice farming by themselves. After that, I had been doing basic rice soil research for the first three years. But how about an African farmer to develop sawah platform endogenously? I've been wondering what to do. Aside from the empirical research level, the dissemination level that has an actual impact was almost unsuccessful until we confirmed Kebbi Rice Revolution in 2017-19. I would like to talk about that next time on 10th of September.

Table 1. Comparison of top soil (0-30cm) fertility prperties of Inland Valleys (IVS) and Flood plains (FLP) in West Africa, Tropical Asia(T.Asia) and Japan

Location	No.of sites	T-C (%)	T-N (%)	BrayP1 ppm*	BrayP2 ppm**	pH H₂O	Exchangeble Cations(Cmol/kg) Ca	K	Mg	Na	eCEC	Sand (%)	Silt (%)	Clay (%)	eCEC /Clay
IVS	185	1.28	0.11	3.9	8.7	5.3	1.89	0.25	0.88	0.19	4.2	69	19	12	29.2
CV(%)***		95	82	85	85	4	98	85	119	115	81	27	68	97	72
Sahel	5	0.62	0.066	2.7	6	6	4.82	0.63	1.87	0.46	8.24	56	24	20	41.2
Sudan	3	0.55	0.068	2.6	5.8	5.9	4.62	0.52	1.85	0.48	7.66	55	25	20	38.3
Guinea	98	0.73	0.07	2.9	6.5	5.3	1.33	0.2	0.51	0.11	2.66	67	20	13	20.5
Forest	79	2.04	0.166	5.3	11.8	5.3	2.28	0.27	1.24	0.26	5.72	65	15	20	28.6
FLP	62	1.1	0.1	3.2	7.7	5.4	5.61	0.49	2.69	0.77	10.4	40	14	46	24.2
CV(%)***		78	69	72	50	15	81	96	79	176	64	61	61	47	65
Sahel	12	0.62	0.071	2.9	7.3	5.7	5.86	0.56	3.81	1.56	12.12	50	13	37	33
Sudan	24	0.83	0.088	2.3	7.3	5.4	7.26	0.57	3.08	0.55	12.34	34	12	54	23
Guinea	19	1.63	1.33	4.1	8	5.5	3.92	0.47	1.93	0.75	7.8	40	26	35	23
Forest	7	1.44	0.086	4.2	9.8	5.2	4.11	0.14	1.47	0.35	7.03	34	26	39	18
T.Asia	410	1.41	0.13	nd	16.9	6	10.4	0.4	5.5	1.5	17.8	33.9	27.7	38.4	46.4
CV(%)***		1.28	0.11		47.1	18	95	75	96	200	65	77	50	56	nd
Thailand	80	1.05	0.09	nd	6.2	5.2	7.2	0.3	4.3	1.4	13.2	38.2	25.2	36.7	36
CV(%)***		63	67		229	12	104	133	128	379	73	77	44	64	nd
Japan	84	3.33	0.29	nd	57.3	5.4	9.3	0.4	2.8	0.4	12.9	49.2	29.6	21.2	60.8
CV(%)***		2.02	0.15		52	9.3	57	75	64	100	34	37	36	48	nd

*Available-P determined by Bary No.1, **Available-P determined by Bary No.2 ***Coefficent of variation%
Sampling years are 1986-1998 for IVS and FLP, 1963-1974 for T. Asia and Japan (Kawaguchi and Kyuma 1977)
nd: not determind
Data sources are Buri(1999) and Buri et al(1999, 2000) for flood plains. Issaka et al(1996 and 1997) and Issaka(1997)

This is too much details soil fertility data. In the table, the "T.Asia" shows the average fertility in tropical Asia, and there is Thailand below it. IVS means the soils of inland valley swamp, which are somewhat like Japanese "satoyama", distributed mainly in equatorial forest and Guinea savanna zones. Then there are floodplains and inland deltas where the Sahel and Sudan savanna zones which have less rainy but more fertile. If generalized, the West African soil fertility is close to that of Thailand. As I said earlier, Africa is different from Asia in that Asia has large lowlands, Deltas, along the coast. However, in Africa, as shown in the topographical classification map on the left side of Fig. 3, at which the A is the inland delta of Mali, B is Chad basin, D is Sudd basin of South Sudan, and C is the Congo basin. These huge lowlands are distributed inland at various altitudes of 200-1,000m. As shown in the figures on the right of Fig. 1 and Fig. 3, there is no sea in the Sahel belt, but it is a lowland plain compared to the Sahara Desert in the north and the Guinea Savannah belt in the south, and where river waters are flowing and create many huge fertile lowlands. If it rains, it will flood. However, there is a wide range of places where there is no destructive flooding like in Asia. The rainfall in the Sahel zone on the right of Fig. 3 is as small as 500 mm, but the groundwater in the area that looks blue is shallow. Moreover, since this groundwater is flooded every year at rainy season, the problem of salt damage may be avoided considerably.

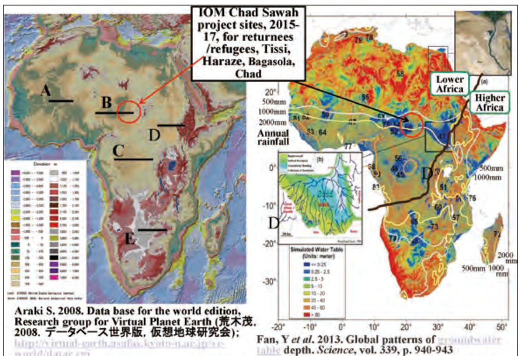


Fig. 3. Distribution of inland basins in various altitudes with shallow groundwater for possible future application of sawah technology in Sub Saharan Africa

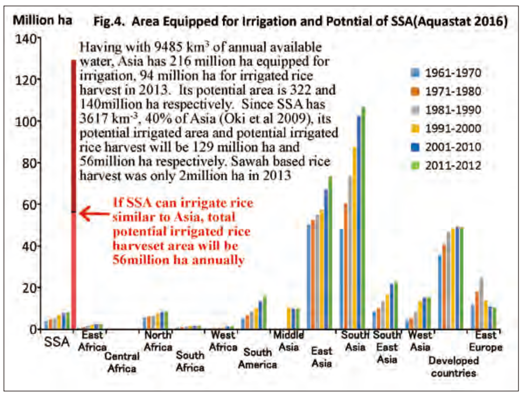


Figure 4 shows the changes in the irrigated area of each region in the world over the past 50 years. We can see that irrigation development has hardly progressed in the eastern, central, western and southern parts of SSA. As we saw earlier, the total area of lowland area is about 240 million ha (Table 2), but rain and so-called available water are only about 40% of Asia (Oki et al 2009). Roughly speaking, since Asia now has an annual irrigated sawah based rice cultivation area of about 128 million ha, SSA should have a potential of about 51 million ha, i.e., 0.4x128 million. The light red colored part of the bar graph below of the SSA in the Figure 4 shows the potential area for irrigated sawah field, and the dark red bar graph shows the estimated potential for upland irrigation. Briefly, the irrigation potential is almost comparable to the total of South Asia (India, Pakistan, and Bangladesh). However total area of SSA's irrigated sawah platform is currently 2million ha only.

Table 2. Distribution of wetlands and potential irrigated sawah area in Sub Saharan Africa(SSA). (Andriesse 1986, Windmeijer & Andriesse 1993, Potential Sawah area estimate by Wakatsuki 2002 & 2013, Wakatsuki et al. 2012)

Classification	Area (million ha)	Area for potential irrigated sawah development
Coastal swamps	17	4-9 million ha (25-50%)
Inland basins(deltas)	108	5-20 million ha (5-20%)
Flood plains	30	8-23 million ha (25-75%)
Inland valleys	85	9-21 million ha (10-25%)

Note 1. Although initial priority was small inland valleys because of easier water control, flood plains and inland basins (delta) in Sudan and Guinea Savanna zones should be given priority, such as Kebbi, Jigawa, and Borno in Nigeria and Chad, where wide distribution of shallow ground water (Gleeson et al. 2012, Fan et al. 2013) makes small pump irrigated sawah efficient and soil fertility is high.

Note 2. Estimated potential sawah area and paddy production are 0.5-1 million ha and 2-4 million tons of paddy in Ghana, 3-5 million ha and 12-20 million tons in Nigeria, and 26-73 million ha and 104-292 million tons in SSA. Estimations in Table 3 can be supported by following data, i.e. Asia has 140million ha of potential (94 million ha of sawah rice harvest in 2013) with 9485 km^3 of available water, whereas SSA has 3617 km^3 of water availability (40% of Asia) gives 56 million ha potential harvest area (only 2 million ha sawah rice harvest in 2013) (Oki et al. 2009, AQUASTAT 2016, FAOSTAT 2016)

Table 2 shows the area of each lowland type in SSA, with 17 million ha of Coastal swamps, 100 million ha of Inland basins (deltas) in the Sahel belt. There are 30 million ha of floodplains and 108 million ha of Inland valleys. For the potential of irrigated sawah platform for each type, the range of numerical values were estimated from the past various action research and development trials and the developed area of each region. It has an overall estimated potential of 26 to 73 million ha, which mean is 50million ha, for irrigated sawah platform field development. However, as I said earlier, the wetlands of Africa are 240 million ha, thus 50million ha for future development is about 20% of total wetlands. About 80% of the natural wetlands remain. Currently it is 2 million ha, so it is less than 1%. This pristine wetland is poorly managed by humans. I think it is a future task to determine to what extent it will be the target of human development.

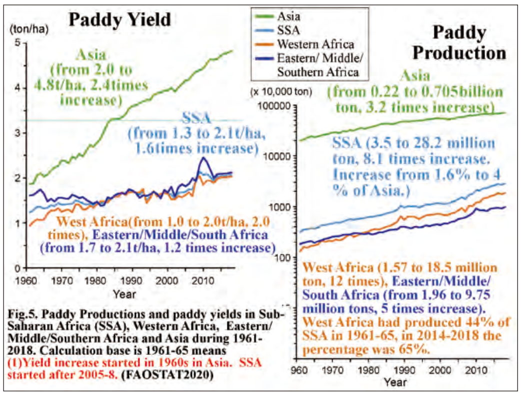


Fig.5. Paddy Productions and paddy yields in Sub-Saharan Africa (SSA), Western Africa, Eastern/ Middle/Southern Africa and Asia during 1961-2018. Calculation base is 1961-65 means
(1)Yield increase started in 1960s in Asia. SSA started after 2005-8. (FAOSTAT2020)

The left side of Fig. 5 compares the changes in paddy yield over the past 50 years in Asia, SSA, West Africa, and East Africa. In Asia, yields have increased from just under 2 tons 60 years ago to about 5 tons now. In SSA, the yield has been increasing in the last 10 years, from about 1 ton to about 2 tons now. SSA are now in the same state as when the Green Revolution began in Asia.

The right side of Fig. 5 shows the trend of paddy production. Sixty years ago, SSA had a production volume of 3.5 million tons, 1.6% of that in Asia, but the production volume has increased rapidly, and as of 2018, the production volume is 4% of Asia, which is 28.2 million tons. In 1960s, West Africa used to contribute about 40% of the total paddy production in SSA, 1.57 million tons, but now in 2018 it has increased rapidly to 65%, 18.5 million tons, and it is predicted that it will reach about 80% in near future.

Table 3 shows how much paddy production has increased over the past 60 years by country. Nigeria was fifth in SSA 60 years ago, but in 2018 it is by far the number one. Madagascar and UR Tanzania are the main rice-growing countries in Eastern Africa. In Madagascar, Asian style rice cultivation has been practiced for a long time, but surprisingly, the production volume has not increased enough to match the population increase in the last 50 years. Tanzania is growing rapidly. 24 times in the last 50 years. Nigeria is 32 times. Others up to about 15th place are all West African countries. Almost every country has increased production more than 10 times. However, Sierra Leone and Liberia, which are dyed red had domestic crises such as civil war. However, most African countries are rapidly increasing their paddy production.

Table 3. Top 32 SSA countries based on the average paddy production (x 1000 tons) in 2014-18. The ranking numbers in 1961-65 and paddy yield data(t/ha) in 2014-18 are also shown. The countries which production rate between (2014-18)/(1961-65) was more than 10 time are shown in green, 5-10times in white, and less than 5 in red (FAOSTAT 2020)

Rank by 2014-18 data	Countries	Mean paddy Production in 1961-65 (x1000tons)	Mean paddy Production in 2014-18 (x1000tons)	Average growth rate for 2014-18 and 1961-65	Paddy yield in t/ha	Rank by 1961-65 data	Rank by 2014-18 data	Countries	Mean paddy Production in 1961-65 (x1000tons)	Mean paddy Production in 2014-18 (x1000tons)	Average growth rate for 2014-18 and 1961-65	Paddy yield in t/ha	Rank by 1961-65 data
1	Nigeria	207	6648	32	2.00	5	17	Mauritania	0.6	244	414	5.22	29
2	Madagascar	1563	3829	2.5	4.32	1	18	Guinea-Bissau	48	169	3.5	1.47	12
3	UR Tanzania	120	2901	24	2.55	8	19	Togo	21	142	6.9	1.70	18
4	Mali	172	2645	15	3.29	6	20	Ethiopia	-	137	>100	2.92	31
5	Guinea	230	2138	9.3	1.22	3	21	Mozambique	94	130	1.4	0.52	10
6	Côte d'Ivoire	220	2098	9.5	2.62	4	22	Malawi	5.8	112	19	1.77	23
7	DR Congo	62	996	16	0.76	11	23	Kenya	14	108	7.7	3.86	19
8	Sierra Leone	336	954	2.8	1.30	2	24	Niger	11	103	9.5	4.19	20
9	Senegal	100	715	7.2	4.10	9	25	Rwanda	0.01	102	16986	3.31	30
10	Ghana	34	685	20	2.78	13	26	Burundi	2.7	73	27	1.77	26
11	Burkina Faso	32	309	9.7	1.97	15	27	Angola	27	54	2.0	1.08	17
12	Cameroon	10	297	29	1.24	22	28	Gambia	33	52	1.6	0.79	14
13	Benin	1.0	292	300	3.32	28	29	Zambia	-	37	>50	1.37	32
14	Liberia	125	273	2.2	1.11	7	30	Comoros	10	31	3.0	1.27	21
15	Chad	29	266	9.3	1.43	16	31	Sudan (former)	1.2	28	23	3.23	27
16	Uganda	3.2	249	78	2.60	25	32	CentralAfricanR.	4.6	11	2.5	1.54	24

Table 4. Increases of annual paddy production over the past 10 years in the top 32 SSA countries. Overall difference was 11.9, i.e., 27.5-15.5, million tons between 2007/8 and 2017-18 averages. The relative % contribution of the top 32 SSA are shown, too. FAOSTAT 2020. *Note 780 of Nigeria and 40 in DR Congo by USDA2020

Rank by 2014-18 mean paddy production	Countries	Mean annual paddy Production in 2007-08 (x10,000tons)	Mean annual paddy Production in 2017-18 (x10,000tons)	Differences between (2017-18)-(2007-08)	Percentage to the total increment in SSA	Rank by 2014-18 mean paddy production	Countries	Mean annual paddy Production in 2007-08 (x10,000tons)	Mean annual paddy Production in 2017-18 (x10,000tons)	Differences between (2017-18)-(2007-08)	Percentage to the total increment in SSA
1	Nigeria	368	671(780*)	303(412*)	25(33)	17	Mauritania	8	24	16	1.3
2	Madagascar	375	382	6	0.51	18	Guinea-Bissau	14	18	4	0.3
3	UR Tanzania	138	294	156	13.1	19	Togo	8	14	6	0.5
4	Mali	135	297	162	13.6	20	Ethiopia	4	14	10	0.8
5	Guinea	147	227	80	6.7	21	Mozambiq	10	12	3	0.2
6	Côte d'Ivoire	64	211	147	12.3	22	Malawi	11	12	0	0.02
7	DR Congo	32	99(40*)	68(12*)	5.7(1*)	23	Kenya	3	11	7	0.6
8	Sierra Leone	63	91	27	2.3	24	Niger	6	11	5	0.4
9	Senegal	30	74	44	3.7	25	Rwanda	7	11	4	0.4
10	Ghana	24	75	50	4.2	26	Burundi	7	6	-2	decrease
11	Burkina Fas	13	24	11	0.9	27	Angola	1	6	5	0.4
12	Cameroon	7	35	28	2.3	28	Gambia	2	5	3	0.2
13	Benin	9	37	28	2.3	29	Zambia	2	4	2	0.2
14	Liberia	26	25	-1	decrease	30	Comoros	2	3	1	0.1
15	Chad	14	26	12	1.0	31	Sudan (form)	3	3	0	0.04
16	Uganda	17	26	9	0.8	32	CentralAfican	4	1	-3	decrease

Table 4 shows the increase in paddy production by country over the last 10 years. JICA's CARD (Coalition for African Rice Development) started 10 years ago, and production has increased in most countries over the past 10 years, especially in Nigeria. However, you need to be careful about the reliability of the data. The data in the table uses FAOSTAT (Statistics Database of the Food and Agriculture Organization of the United Nations), but there are some differences from the data in USDA (United States Department of Agriculture). In Nigeria, FAOSTAT in 2019 showed that paddy production in 2017 exceeded 10 million tons, but in Table 4, it has been revised to the 6 million tons level. On the other hand, USDA shows 8 million tons. It is necessary to pay attention to the reliability of data. Nevertheless, on the possible errors, I think that majority of SSA countries have been expanding paddy production including no tradition of paddy production such as Ethiopia.

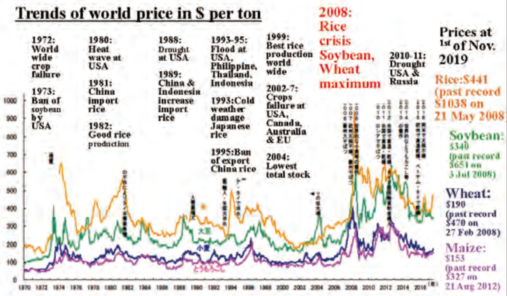


Fig.6. Trends of world trading prices of Rice at Thai (milled 2nd class FOB), Soybean, Wheat and Maize at Chicago commodity exchange during 1961-2019 (Ministry of Agriculture, Forestry and Fishery, MAFF, Japan, 2019 http://www.maff.go.jp/j/zyukyu/jki/j_zyukyu_kakaku/attach/pdf/index-146.pdf).
Note : Prices of wheat, Maize, and Soybean are prices at both the first and the last Friday of each month. Rice price is at both the first and the last Wednesday of each month. Note FOB, Free On Board at Bangkok port.

As shown in Fig. 6, one of the factors behind the rapid increase in paddy production can be seen from the trends in the international market prices per ton of rice, beans and corn, and wheat over the past 50 years. On average, rice prices have been about three times as much as wheat and corn. If farmers make 1 ton of rice, farmers will get 3 times more income. However, the necessary running cost is not much different. In addition to this, once the sawah platform fields have been developed, the amount of fertilizer can be rather small than maize and wheat production. In addition, sustainable yield is much higher (Sawah Hypothesis 2). There are many benefits of rice. Rice has special values in terms of cooking, nutritional value, preservation, transportation, and cashability, etc., which is true not only in Asia but also worldwide. It's a little higher than the price of soybeans. However, soybeans do not yield as much as rice, so in that sense, rice is a special valuable crop. As I will explain on 10th of September, sawah platform-based paddy cultivation has special additional values to realize SDGs goals in the areas of sustainable environmental protection including malaria infection.

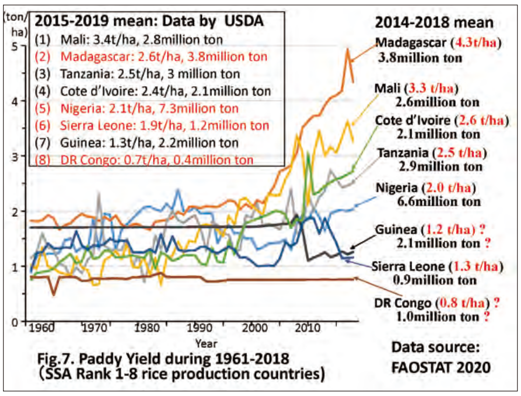


Fig.7. Paddy Yield during 1961-2018 (SSA Rank 1-8 rice production countries)
Data source: FAOSTAT 2020

Figure 7 shows productivity growth, i.e., yield change, in the top eight SSA countries over the last 50 years. It has been growing rapidly in all countries except for DR Congo, Guinea, and Sierra Leone, since around 2005. As you can see from the data of DR Congo and Guinea, this FAO data is not the actual measurement data. You can see that the data is unreliable and is written on the office desk. Be careful with such data. The data inserted at the top of Figure 7 is the USDA average for 2015-19, which is quite different from the FAO average for 2014-18. Especially in Madagascar, FAO data shows 4.3t / ha, but USDA shows 2.6t / ha. There is not much difference in production, but Nigeria has 7.3 million tons, FAO has 6.6 million tons, and FAO data released in 2019 shows that it was more than 10 million tons. Another important point is to compare with the trends of paddy yield in Egypt shown in Fig. 7 (Supplement). As shown in Figure 1 earlier, the Sahel region of SSA has an Egyptian-style ecology (high solar radiation, fertile soil, inflow river water). Egypt is now the world's highest yield, as shown in Figure 7 (Appendix). Most SSAs have such a high potential. Some countries, such as South Sudan, have no experience in rice cultivation, rice production is not high, and productivity is very low. However, it is worth about 10 Nile Deltas.

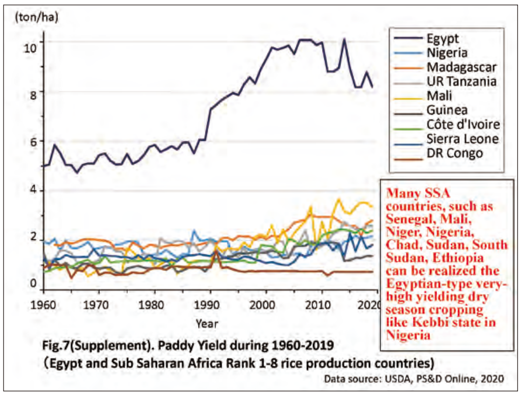


Fig.7(Supplement). Paddy Yield during 1960-2019
(Egypt and Sub Saharan Africa Rank 1-8 rice production countries)
Data source: USDA, PS&D Online, 2020

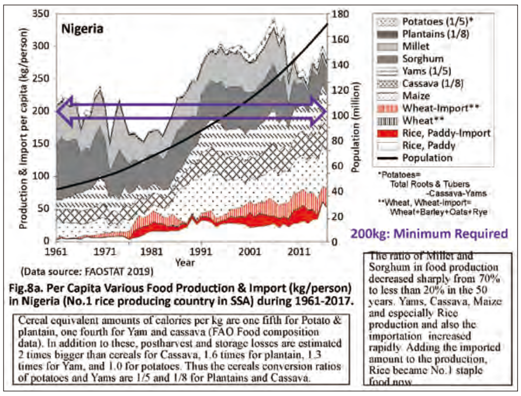


Fig.8a. Per Capita Various Food Production & Import (kg/person) in Nigeria (No.1 rice producing country in SSA) during 1961-2017.

Figure 8a shows the changes in annual grain production and consumption per capita in Nigeria, a typical SSA country, which is "the Black is beautiful" country, over the past 60 years. SSA countries eat a wide variety of grains and foods. The black line shows the trends of the population of the whole country, the white is the rice production based on paddy, the red is the import volume of rice (also displayed on a paddy basis, the conversion rate of milled rice and paddy is 0.625 x paddy = milled rice). All data are calculated in per capita. This will tell you if the country is dealing with population growth. Wheat on top of rice, then corn, cassava, yam, sorghum and millet on top. With Nigeria as the representative of SSA, basically traditional sorghum and millet have been decreased, and rice production and consumption have increased rapidly. In 2018, rice will be the number one food in Nigeria, including imports. Although corn is increasing, rice consumption is the No. 1 food in terms of paddy base. It is likely to increase more and more in the future. The grain equivalent of the line indicated by the purple horizontal arrow in Figure 8a is 200 kg / person. This figure shows the total amount of grains including the grain equivalent amount various foods such as cassava, yam, potatoes and plantains (which have high water content) on the same basis. The per capita grain production and imports of each SSA country and the breakdown are shown by the same standard. For Japanese people, one KOKU（1石）of milled rice, 150 kg (which is 240 kg of paddy equivalent, the conversion rate of paddy and milled rice is calculated as 0.625) is enough for one person's food. Thus, if you produce about 200 kg of total grain, you will not starve. Taking into account the water content and post-harvest losses and etc, one-fifth of the FAO data for potatoes and yams, and one-eighth for plantains and cassava are plotted as conversion factors for the amount of grains such as paddy, corn, and wheat. This makes it possible to make a unified comparison of the importance of various foods in different SSA countries.

Figure 8b is a calorie-based calculation using FAO published data to check the validity of the grain equivalent factors of 1/5 and 1/8 in Figure 8a. The 1,200 kcal / person / day line in this figure corresponds to the grain equivalent 200 kg / person / year line in Fig. 8a. The amount of food production (basal metabolic rate) required for per capita survival. Although exact amount may differ by each country depending on the population composition. Since the trends of Fig. 8a and Fig. 8b are almost equivalent, the grain equivalent factors of 1/5 and 1/8 are scientifically acceptable. We can improve the more practical grain equivalent factors of On the contrary, it can be seen that the calorie consumption of each food can be used to calculate the scientifically more reasonable amount of grains such as potatoes, yams, plantains and cassavas

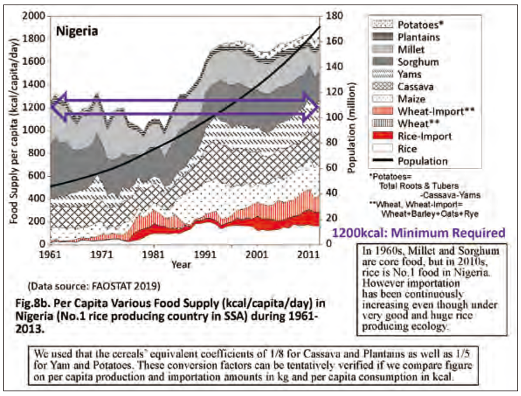


Fig.8b. Per Capita Various Food Supply (kcal/capita/day) in Nigeria (No.1 rice producing country in SSA) during 1961-2013.

We used that the cereals' equivalent coefficients of 1/8 for Cassava and Plantains as well as 1/5 for Yam and Potatoes. These conversion factors can be tentatively verified if we compare figure on per capita production and importation amounts in kg and per capita consumption in kcal.

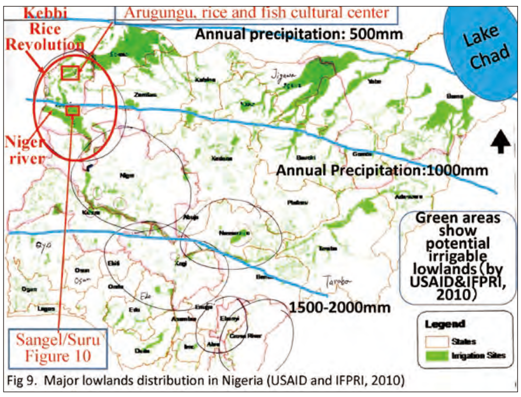


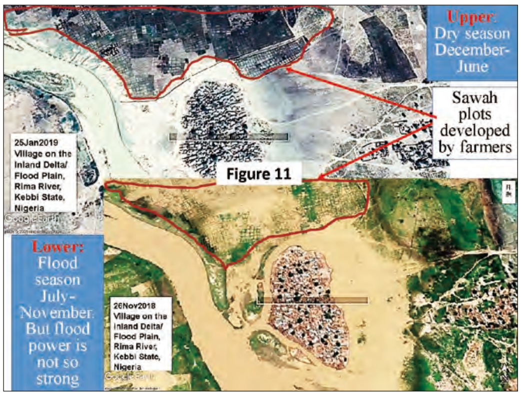
Fig 9. Major lowlands distribution in Nigeria (USAID and IFPRI, 2010)

In Figure 9, the green areas show the distribution of irrigable lowlands of Nigeria. The iso-precipitation line of 500mm, which is showing the Sahel belt, is extending near the border with Niger. Further north of the Sahel zone is Sahara Desert. There are many vast wetlands between 1,000 mm and 500 mm of annual rainfall, including Lake Chad basin. Up to now, we have been promoting the sawah (eco-) technology, and it is only in Kebbi state, northwestern Nigeria shown in Fig. 9, that the endogenous sawah platform development by the innumerable farmers has reached the scale of about 100,000 ha. This scale exceeds SSA's largest irrigation scheme, Office du Niger in Mali. It shows the magnitude of the intrinsic (endogenous) power of countless farmers. This is briefly explained in Figure 10-14 below. I will explain about the extension procedures of the Kebbi Rice Revolution in 10th of September.

Figure 10.Flood plain/Inland Delta of Rima River and Zamfara river between **Sangel and Suru, Kebbi State**. Total area of the map above is about 6000ha, of which about 30% are mobile pump irrigated sawah developed by farmers' own efforts endogenously during 2011-2019. Total area of Flood plains in Kebbi state is estimated about half million ha.

Figure 10 shows a floodplain near Sangel and Suru in Kebbi. The width of the floodplain around here is about 9km. The area of the floodplain in this Google image is about 6,000ha. The total area of floodplains and inland deltas throughout the Kebbi state is 500,000 ha. The part seen in black is the part where sawah based rice cultivation in the dry season is in progress. Sawah fields have been developed endogenously by local farmers in the last 10 years. 20-30% of the floodplain area has been developed as sawah platform and is still underway.

Figure 11 is an enlarged view of the floodplain area marked as “Village” with a red circle in the center of Figure 10. A 300m marker line in the center crosses the center of the village. The upper half of the photo shows the dry season (taken on January 25, 2019), and the lower half is the rainy season. However, even if it floods, the rice fields will not be washed away by the torrent of the flood, and the village remains protected. Immediately north of the village, you can see the countless footpaths in rice fields that divide the sawah platforms into numerous squares developed in 2016-19.



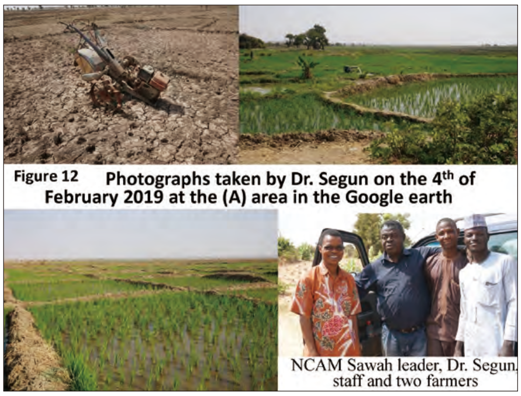


Figure 12 Photographs taken by Dr. Segun on the 4th of February 2019 at the (A) area in the Google earth

Figure 12 shows the sawah field developed by farmers, a power tiller, and small mobile pump irrigation taken in February 2019 near the A area in Figure 10. In the middle of the four persons are Dr. Segun, the deputy director of the National Center for Agricultural Mechanization (NCAM) in Nigeria and the leader in promoting Sawah Technology in Nigeria. NCAM is an organization under the Ministry of Agriculture and Rural Development of Nigeria. The upper left photo shows one power tiller and dry season flood plain. In the dry season, there is basically no water on the surface of the floodplain if no irrigation.

You can see the small pump in the center of the upper right photo. Groundwater is shallower than 5m, so 2 units can irrigate 1ha. Irrigation will be intermittent about twice a week. If you have two small portable pumps for $500, you can irrigate 3ha. The additional irrigation cost for pumps and gasoline is

$150-200 per ha. The yield of dry season crops is extremely high. This pump irrigation cost can be covered by increasing the paddy production by 1 ton. Although it has not reached the Egyptian paddy yield level yet, the traditional yield of 2t / ha so far will be 6-7t / ha, which is about three times higher.


Figure 13 Ground truth survey on September 2019, (A) position, Suru Flood plain by NCAM team. After 2013, farmers are expanding dry season rice, because of difficulty of rainy season rice cultivation, such as flooding, weed and water management, lower yield

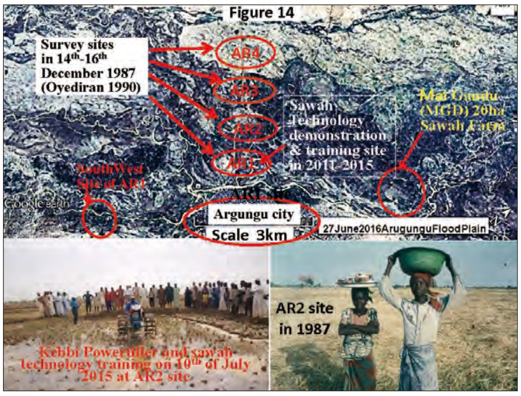


Figure 14

Figure 13 is almost the same site as Figure 12. It is a floodplain during the rainy season in September 2019. Rice is cultivating. Although pump irrigation costs are lower, but drainage is difficult, water and weed management are difficult, thus yields are lower than in the rainy season. Therefore, farmers have recently shifted more to the dry season cultivation. In the floodplain, the fluctuation of water is large between the rainy season and the dry season. In the mainstream floodplains of the Niger River, such endogenous sawah platform development is difficult where the destructive power of flooding water during the rainy season is large.

Figure 14 shows the floodplain near Argungu. The floodplain in this area is almost entirely covered with sawah platform. Argungu is a rice and fishing center in Kebbi state. The upper one shows the Google image of the floodplain of the just north of the Argung town. The lower right is the photo taken near AR2 site on 33 years ago. Details site description remains in the 1990 doctoral dissertation by Dr. Oyediran (currently a professor at LAUTECH University). African rice had been cultivated widely on the AR2 site in non-sawah fields. The lower left is almost the same AR2 site when the NCAM sawah team (the blue shirt on the left in the rice field is Dr. Segun, the white shirt in the center is Wakatsuki) conducted training and demonstration of Sawah Technology using a new Indonesian made with Kubota Co. Ltd.'s engine. Farmers have been developing sawah fields by themselves since 2011, so you can see the bindings of the sawah fields. We demonstrated that new sawah fields could develop efficiently without using heavy machinery.

Figure 15

Figure 15 shows the paddy field of Edozhigi irrigation scheme on the Kaduna river flood plain near Bida, central Nigeria. In the photo above, rice is cultivated on the ridges like upland crops. In most government irrigation schemes in Nigeria, only irrigation canals and roads are created, and farmland is maintained by farmers without any major reclamation. Therefore, often rice is cultivated in this way, sometimes just like upland rice without any bindings and leveling, or micro rudimentary sawah plots as shown in the photo below. This small plot sawah fields can be developed and managed if available agricultural tool is African hoe only (a boy is carrying it on the photo below). When farmers cannot use plowing by cows, they can only cultivate rice fields like this under irrigation. This is almost the same as the small sawah plot fields in the Yayoi period in Japan.

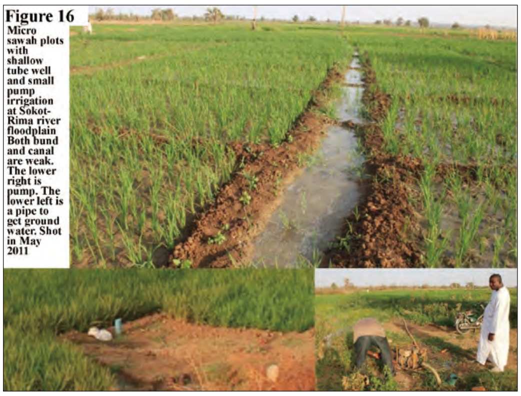


Figure 16 Micro sawah plots with shallow tube well and small pump irrigation at Sokot-Rima river floodplain Both bund and canal are weak. The lower right is pump. The lower left is a pipe to get ground water. Shot in May 2011

Figure 16 shows a portable pump irrigated micro quasi-sawah field. This kind of platforms have been common before 2010 in Kebbi and Sokoto state. The photo shows just before starting sawah technology demonstration and training by NCAM sawah team in 2011. The African Development Bank and Fadama III and ADP (Agricultural Development Project) have been promoting such irrigated rice cultivation in this area for the past 30 years. The photo on the right below shows a portable pump and its hose. In the photo on the left below, you can see the PVC pipe for pumping groundwater. Insert a suction hose into this pipe and pump it up with a portable pump to irrigate rice, onion, and other vegetables.

Figure 17 shows the largest (15,000 ha) irrigation system in Kano State that is currently in operation in Nigeria. There are dams, irrigation drainage channels and roads, but the irrigated farmlands are all small micro sawah plots prepared by farmers. It is a small bunded plots that is about 3 to 5 meters on a side.

Figure 17

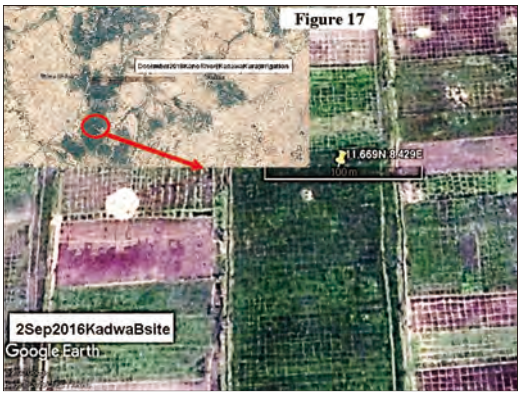
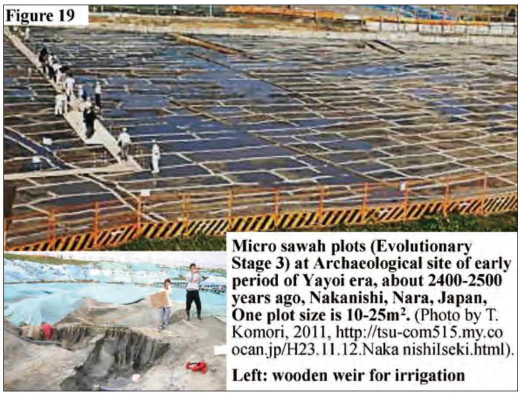


Figure 18

Sawah Technology Training to improve farmers irrigated lands by NCAM(National Center for Agricultural Mechanization) at Bakalori Irrigation Site under the transforming irrigation management in Nigeria project (TRIMING), May 2019.Traditional Micro-Sawah plots, which can be seen on the upper half of the photo, are expanding and leveling with reinforced bunds

The photo in Fig. 18 shows a power tiller with a length of about 3 m and many small sawah plots with a side of 3-5 m. It is our partner NCAM Sawah team that uses power tiller to do the standard sawah plot preparation.

Figure 19



Micro sawah plots (Evolutionary Stage 3) at Archaeological site of early period of Yayoi era, about 2400-2500 years ago, Nakanishi, Nara, Japan, One plot size is 10-25m². (Photo by T. Komori, 2011, http://tsu-com515.my.co ocan.jp/H23.11.12.Naka nishiIseki.html). Left: wooden weir for irrigation

Figure 19 shows the archaeological excavation of a small sawah plot field 2,500 years ago in Nara, Japan. It shows the early stages of sawah system evolution, much like the micro/small sawah plot system at the current Nigerian irrigation project site shown in Figure 15-17.

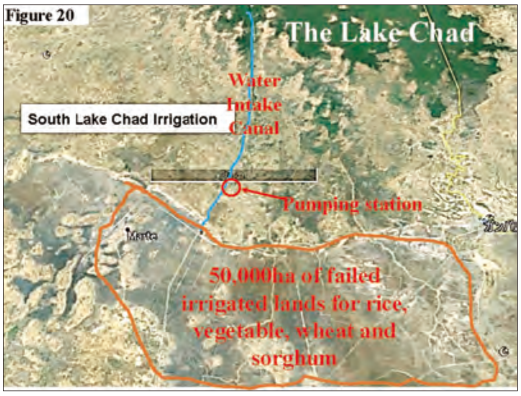
Figure 20


Figure 20 shows a large-scale (50,000 ha) irrigation project site in the south of lake Chad, irrigation with a headrace of 30 km or more, which is shown in blue color, and large pumps. It was developed under the technical guidance of Pakistan engineers at a cost of about 100 billion yen in the 1970s when there was oil money in Nigeria. The irrigation system did not work from the beginning and is now a disaster area by Boko Haram.


Figure 21
Faga pumping station, South Lake Chad Irrigation , August 1986


Figure 22
Dikwa, Nigeria, May 2011

Figure 21 shows a large pumping station that pumps water from a headrace to target areas. It is a photograph taken at the position marked "Pumping station" in the center of Fig. 20. The water level of Lake Chad does not rise, and water does not come, so it cannot be pumped. Fig. 22 is two photographs of rice cultivation and onion cultivation area near the irrigation target area in Fig. 20. This is a picture of when I and Dr. Segun (NCAM) went to this area in May 2011, just before Boko Haram became serious. The entire area can be irrigable with a small portable pump. It floods 1 to 2 m during the rainy season. Even in the dry season, the groundwater is shallower than 5m. It is part of wetlands leading to Lake Chad.

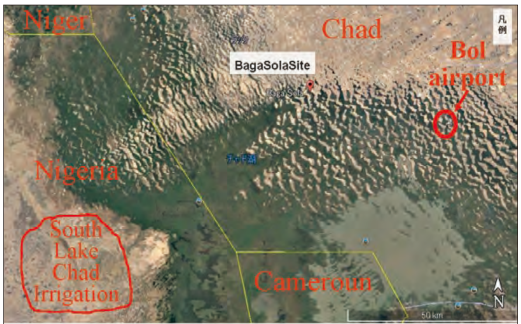


Figure 23 IOM project for the Reintegration Support for the Chadian Returnees (Refugees) from Nigerian Boko Haram

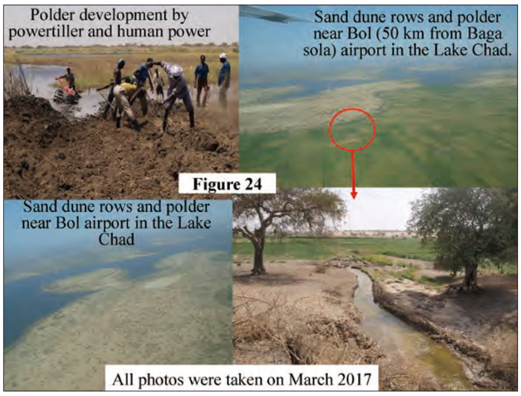


Figure 24
All photos were taken on March 2017

The upper left of Figure 23 is Niger, the upper right is Chad, the south is Cameroon, and the west is Nigeria. The irrigated land in the Boko Haram area shown in Figure 20-22 is shown. If the Boko Haram problem is resolved, the area will be capable of small portable pump irrigated rice cultivation and vegetable cultivation like the Kebbi state on a scale of 1 million hectares. On the right side of Chad, you can see that many rows of sand dunes are connected from Lake Chad. Some are connected from the Nigerian

side. These many dune lines are said to represent the process of shrinking the Great Lake Chad, which has continued for the past tens of thousands to millions of years.
Figure 24 shows the reclaimed land between the dunes of Lake Chad (upper right and lower left) and the dunes (lower right) taken from an IOM (International Organization for Migration) arranged Cessna plane. In 2015-17, we teamed up with the NCAM Sawah team including Bida and Kebbi farmers to bring in 16 sets of Indonesian power tillers in one container from Java, Indonesia. We conducted training on sawah technology for refugee settlement projects of the IOM. This is an on-the-job training for refugees to develop their own irrigated sawah system platform fields. Ten Nigerian sawah farmers trained by NCAM played an active role as the core unit of the training.

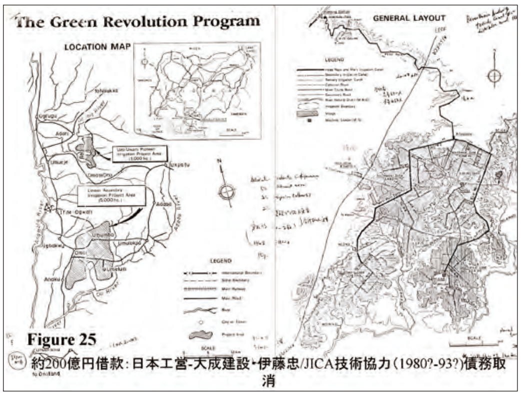


Figure 25

Figure 25 is a plan of the Lower Anambra Irrigation Project site in Nigeria. This is an ODA loan project of about 20 billion yen carried out by Nippon Koei, Taisei Corporation, and Itochu Co. Ltd. A project in 1980s when Nigeria had oil money. The project had developed 4,000ha of irrigated sawah platform for mechanized rice cultivation fields. JICA's technical cooperation was also implemented in the early 1990s.
The Anambra River is flowing at the top of Figure 26, and the white square is the pumping station. At where, huge amount of irrigation water with a head difference of 30m is pumped up to main irrigation canal by a huge pump. Large power is needed continuously. Maintenance costs are remarkably high. The Nigerian government has no control. The pump function stopped in about 10 years. The debt of this ODA loan has been cancelled.

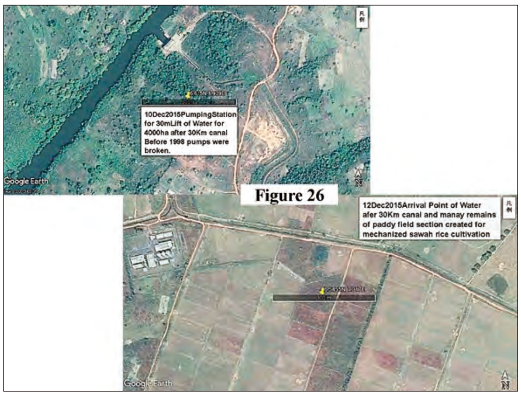


Figure 26

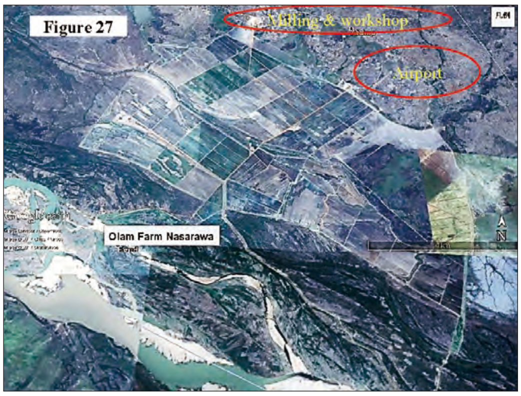


Figure 27

Figure 27 shows a private Olam Co. Ltd.'s irrigation project on the Benue River floodplain in operation as of 2020. The high quality sawah platform has been developed in total 5,000-6,000ha. There is also farm airport. There is a huge rice mill. This is an irrigation project carried out by a large-capitalized private company.
Figure 28 shows a large rice mill and many heavy machineries.
Figure 29 shows a huge sawah plots with a size of 10-20ha. Direct seeding is done by plane. Pesticide spraying is also done by an airplane. However, in direct sowing cultivation, weed management is exceedingly difficult, so we hire many farmers to weed by hand.

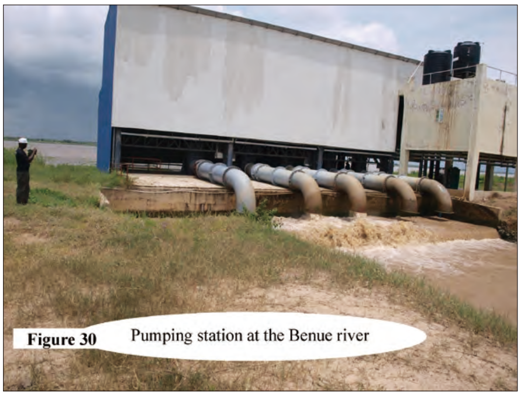
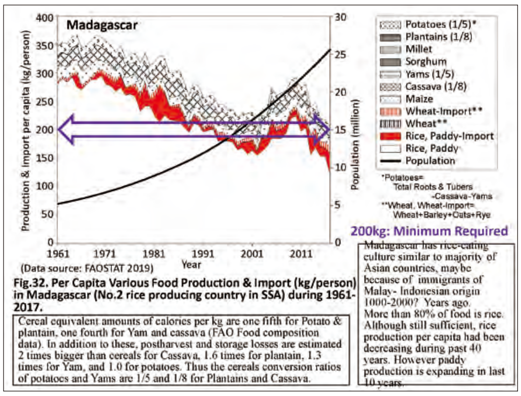


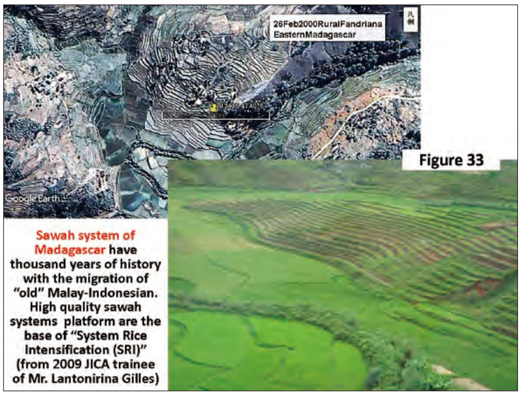
Figure 30 shows the pumping station. Water is taken from the Benue River. The Benue River originates from the Cameroonian forest area. Figure 31 shows the waterways and sawah plots fields under construction. Since this area is located downstream of the Benue River, the destructive power of flooding is great. Therefore, Olam has difficulty developing and maintaining the system. Olam has also a rice miller, and the company also train rice farmers to secure paddy for milling. In Nigeria, it seems that such private companies are forming a value chain for rice cultivation, with Thai-style rice millers at the top, by entrusting them to rice farmers.

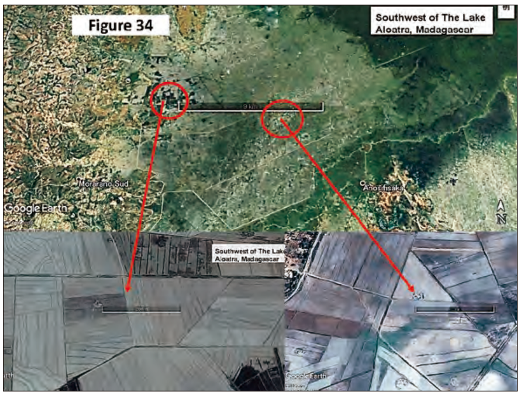


As mentioned above, almost all types of rice cultivation can be found in Nigeria. The following is an overview of SSA's representative rice-growing countries. First, Figure 32 shows the changes in food production over the past 60 years in Madagascar, the second largest rice-growing country in SSA, Rice cultivation in Madagascar is rice eater and similar to Asia. However, per capita production is not increasing. In recent years crops production has been below the 200kg / person line, and it seems that there is no measures to increase per capita food conditions.

As shown in Figure 33, the level of the sawah platform in Madagascar is almost the same as in Indonesia. The top is Google Earth and the bottom is a photo. This photo was given by a JICA trainee in 2009.

Figure 34 shows various shapes of sawah plots in the wetlands around the capital of Antananarivo. In addition to elongated rectangular sawah plots suitable for cattle cultivation, the contour bunding sawah plots can be seen. Some interesting shape of sawah plots are geometric French type, which I think, such sawah plots shape probably by the influence of France engineer, ignoring the agricultural work efficiency.





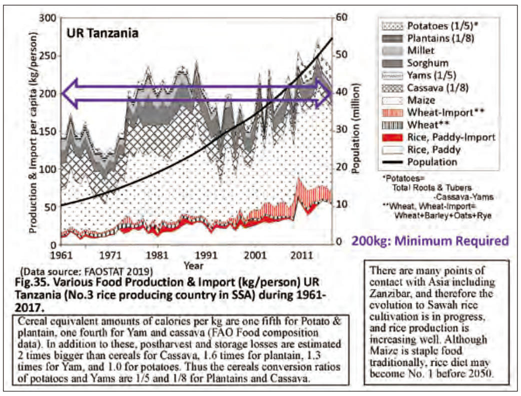
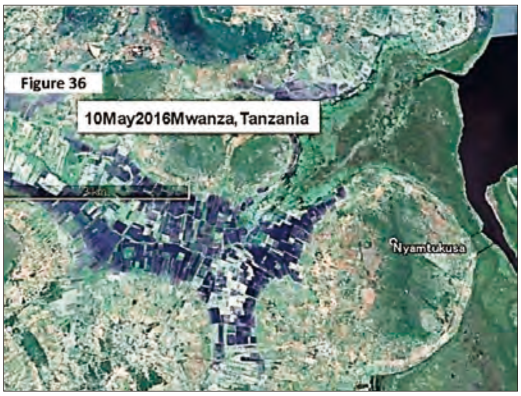


Figure 35 shows the trends of crops production and imported crops per capita over the past 60 years in Tanzania, which is the No. 3 rice producer in SSA now. Tanzania's number one staple food is maize, but rice production is growing rapidly. The rate of increase over the last 60 years far exceeds that of maize. In recent years, total food production has finally exceeded the line of 200 kg / person / year. This means that the food situation has improved.



As shown in Figures 36 and 37, Tanzania has widespread endogenous sawah platform development due to the influence of Madagascar, Zanzibar, or other Asians. Figure 36 shows sawah platform developed in alluvial lowlands and inland lowlands along Lake Victoria. The Sukuma people, who are herders who have mastered sawah based rice cultivation, are developing sawah system fields endogenously. I think it far exceeds the area of sawah system developed by ODA and government. The Sukuma people can cultivate cattle and use tractors, so they are playing a central role in developing sawah based rice farming in Tanzania.

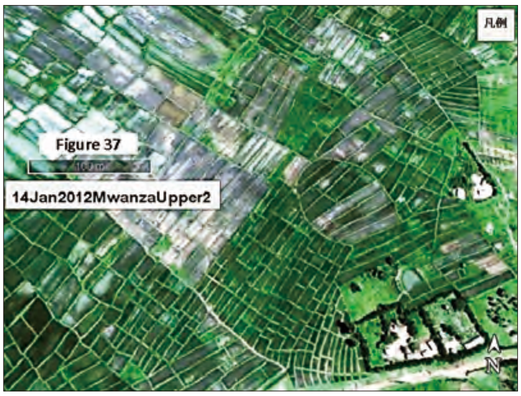


Figure 37 is the upper reaches of the lowlands along a relatively large river flood plains that appears purple in Figure 36. It is an elongated rectangular sawah plots field developed on the lower slopes of mountains and plateaus. These sawah plots even on relatively sloping areas can be cultivated by pulling plows with cows.

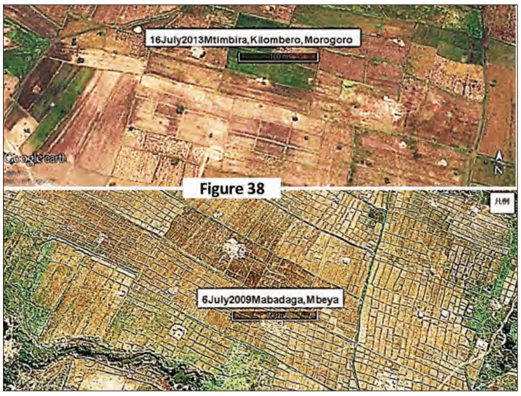


Figure 38

Figures 36 and 37 are around Lake Victoria in northern Tanzania, and Figure 38 shows rice fields in the Morogoro area in southern Tanzania. The upper part of Figure 38 has no sawah platform, but upland rice cultivation, but the lower part can clearly see how bunded and maybe levelled rice fields, i.e., sawah platform, are being developed. These appear to be endogenous developments by the Sukuma people.

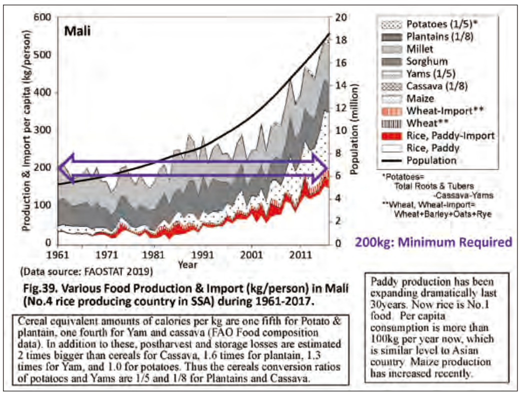


Fig.39. Various Food Production & Import (kg/person) in Mali (No.4 rice producing country in SSA) during 1961-2017.

Figure 39 shows the trends of grain production per capita in Mali. According to FAO data in Figure 39, rice production is growing rapidly in Mali. Since 2011, it has been 550 kg / person / year, far exceeding the 200 kg / person / year line. Thus, this is probably Fake data. When food production per capita exceeds twice the required amount (200 kg / person / year), it becomes a food exporter. However, it is unbelievable statistical data considering the serious social unrest in Mali in recent years.

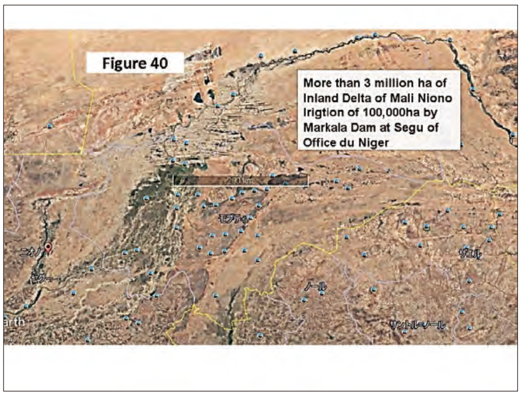


Figure 40

The core area of the Mali’s inland delta, about 8 million hectares, is shown slightly to the left of the center of Fig. 40. The small, elongated part on the left side of the figure is the Niono irrigation project site, which has about 100,000 ha. Development began in the French colonial era of the 1930s. It is the largest irrigation scheme in SSA.

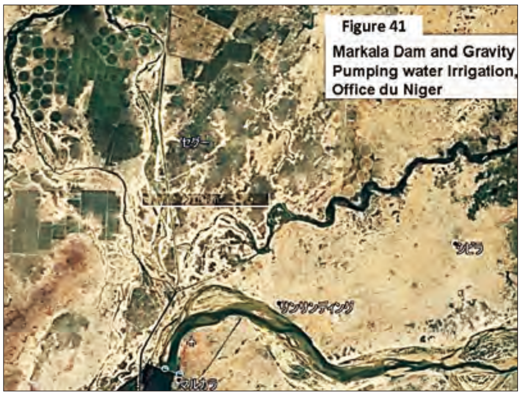


Figure 41
Markala Dam and Gravity Pumping water Irrigation, Office du Niger

Figure 42 Office du Niger, Large scale 50,000 ha irrigation project. (Google Earth 2009/2010)

A weir (dam) is built on the Niger River near Markala at the lower left of Fig. 41. This raises the water level of the Niger River by 3-10 fewmeters (weir water level unconfirmed) draws water from the left side of the weir and extends the irrigation canal to the north. Water intake is about 10% of the available water of the Niger River. About 100,000 hectares of rice and sugar cane are currently growing. Figure 42 shows the center of the Niono project site. You can see the orderly sawah platform field. These are bindings system of sawah plots fields, irrigation drainage channels and roads.

Office du Niger, 50,000ha irrigated sawah project, after long stagnation period, 1960-1990, finally Green Revolution has come true, 1990-2011+ (In addition to animal traction, farmers are making stop leaking for bund management of Sawah, then irrigation, fertilizer, and HYV become useful.)

The two pictures below Figure 43 were taken in January 1989. At that time, the rice fields and waterways were poorly managed, and the paddy yield was about 2t / ha. The two pictures above Figure 43 were taken in August 1998. The sawah plots have been improved. The two farmers in the photo are cutting the weeds on the bunds to manage the leaks. Farmers seemed to be quite proficient in sawah based rice cultivation.

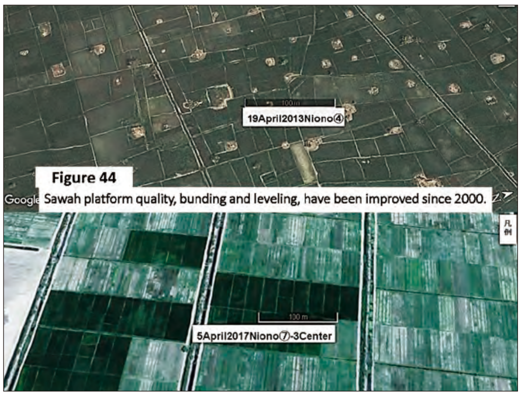
Table 5. Office du Niger, 50,000ha irrigated sawah project, after long stagnation during 1960-1990, finally Green Revolution has come true since 1990-

Year	Cultivated Area (ha)	Paddy production (t)	Yield (t/ha)	Number of Farmers	Rehabilitated Area (ha)	Number of Female Farmers	Cultivated Area per Farmer (ha)	Amount fertilizer use(t) Urea	Amount fertilizer use(t) Ammo.Phos
73/74	40,139	83,128	2.1	3,672			10.93		
74/75	40,774	86,000	2.1	4,153			9.82		
75/76	39,916	90,000	2.3	4,367			9.14		
76/77	39,567	94,400	2.4	4,542			8.71		
77/78	37,946	101,000	2.7	4,751			7.99		
78/79	36,557	95,000	2.6	4,863			7.52		
79/80	35,104	62,314	1.8	4,985			7.04		
80/81	35,589	69,290	1.9	5,107			6.97		
81/82	36,896	65,992	1.8	5,236			7.05		
82/83	35,181	56,524	1.6	5,484	450		6.42		
83/84	36,920	64,663	1.8	5,741	1,773	13	6.43		
84/85	38,154	64,086	1.7	6,665	3,778	15	5.72		
85/86	39,433	82,957	2.1	8,490	5,886	17	4.64		
86/87	39,910	88,011	2.2	9,282	7,898	16	4.3		
87/88	42,125	98,194	2.3	9,972	9,617	20	4.22		
88/89	43,352	97,796	2.3	9,459	9,880	23	4.58		
89/90	44,251	106,593	2.4	9,621	10,872	31	4.6		
90/91	43,872	143,988	3.3	9,973	12,452	41	4.4		
91/92	44,435	180,909	4.1	10,465	14,637	53	4.25		
92/93	44,843	208,541	4.7	10,864	16,870	56	4.13	5533	5533
93/94	45,442	222,634	4.9	11,159	18,455	84	4.07	5492	3440
94/95	44,950	290,978	4.6	11,842	19,190	106	3.8	5940	4055
95/96	46,407	232,206	5.0	13,235	20,790	168	3.51	7071	3931
96/97	47,984	246,112	5.3	13,767	22,170	209	3.49	8508	4379
97/98	49,314	267,186	5.5	15,441	29,106	236	3.19	7591	4034

Long stagnation period

devaluation of CFA (Office du Niger, 1998)

Table 5 shows the improvement of rice cultivation skills from 1973 to 1998. Yields increased from 2t / ha to 5t / ha mainly in 1990-95. The project started in 1932, so it took a very long time to reach this point. In such a large-scale project, it can be said that the time required for a farmer and a government engineer related to master irrigated sawah based rice cultivation is very long.



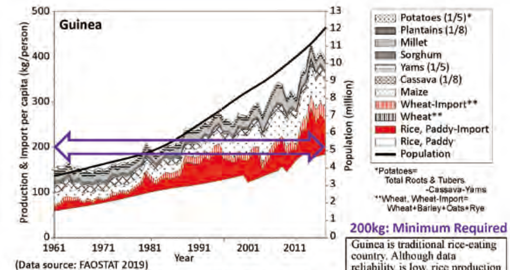
Sawah plots also appear to be well maintained, as shown in Figure 44. Therefore, the yield has reached to 5.5t/ha in1997-98 season as shown in Table5.

Mopti付近の1996年10月の稲作風景 (武田真一撮影、「写真で見るオリザの環」、pp.62-63、河北新報社)
Figure 45

African rice and fish near Mopti, January 1989.
The irrigated rice platforms occupied about 200,000ha among about 8million ha of wetlands in Mali in 2020

As shown in Figures 45 and 46, most of Mali's wetlands are such natural wetlands without human water control. Only a few percent of the 8 million hectares are maintained as irrigated sawah fields that can manage water, about 100,000 ha.

Figure 45 was taken by Mr. S. Takeda (Reporter of Kahoku Shinpou, Sendai) in 1996, and Figure 46 is a photograph of African rice cultivation areas and fish such as catfish in the wetlands along the Niger River in 1989



(Data source: FAOSTAT 2019)

Fig.47. Various Food Production & Import (kg/person) in Guinea (No.5 rice producing country in SSA) during 1961-2017.

Cereal equivalent amounts of calories per kg are one fifth for Potato & plantain, one fourth for Yam and cassava (FAO Food composition data). In addition to these, postharvest and storage losses are estimated 2 times bigger than cereals for Cassava, 1.6 times for plantain, 1.3 times for Yam, and 1.0 for potatoes. Thus the cereals conversion ratios of potatoes and Yams are 1/5 and 1/8 for Plantains and Cassava.

Guinea is traditional rice-eating country. Although data reliability is low, rice production and import have been increasing during 1960-2013. Low credibility of rice data can be confirmed straight line of paddy production and the ratio of rice paddy production amount to production area (i.e. yield) does not change at fixed 1.7t/ha in the past 50years.

Figure 47 shows Guinea's food production statistics. Guineans are rice eating people similar to Asians. However, the rice farming system is very different. The production data at the bottom of the red colored imports has straight. In addition, although a large amount of rice has been imported, the total grain production per capita has exceeded 400 kg / ha / year in recent years, which is comparable to that of food exporting countries. It is FAO data, but I think it is unreliable.

Photo No. 3. August 2002, Guinea Highland between Labe and Dalaba, Sawah Evolutionary Stage 1 or 0) Upland shifting rice and Fonio (*Digitaria exilis*) cultivation at Guinea, 2002)

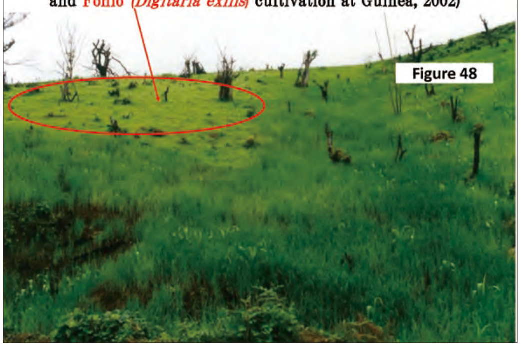


Figure 48 shows upland rice cultivation in shifting cultivation on the Guinea Plateau, which has been destroying forests. A grain called fonio, which is often cultivated in degraded soil, was also cultivated.

Figure 49 shows a typical Inland Valley in West Africa which is somewhat like Japanese “satoyama” lowland, near Kissidougou in central Guinea. Kissidougou is near the trilateral border between Sierra Leone and Liberia, it was the center of Ebola infection in 2015. In Guinea, it is common to grow rice without making sawah type platform even in floodplains and inland lowland valleys of upper end streams of the Niger River. Guinea has also tidal irrigation areas in the mangrove zone near Conakry, but there are few rice fields where artificial water management is possible.

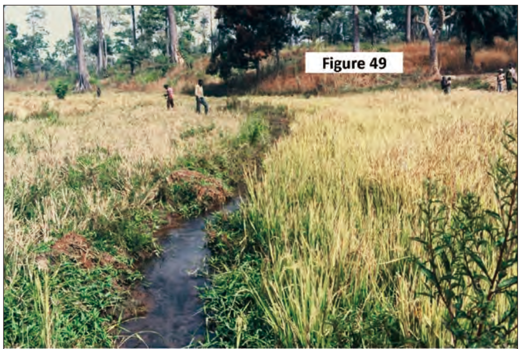
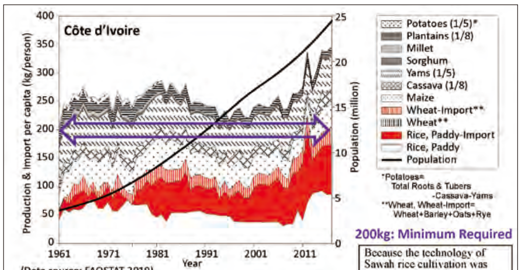


Photo No. 6, January 1989, Kissidougou, Guinea. Non sawah rice cultivation, Inland Valley, Evolutionary stage 1



(Data source: FAOSTAT 2019)

Fig.50. Various Food Production & Import (kg/person) in Côte d’Ivoire (No.6 rice producing country in SSA) during 1961-2017.

Cereal equivalent amounts of calories per kg are one fifth for Potato & plantain, one fourth for Yam and cassava (FAO Food composition data). In addition to these, postharvest and storage losses are estimated 2 times bigger than cereals for Cassava, 1.6 times for plantain, 1.3 times for Yam, and 1.0 for potatoes. Thus the cereals conversion ratios of potatoes and Yams are 1/5 and 1/8 for Plantains and Cassava.

Because the technology of Sawah rice cultivation was transferred by Taiwan, Rice production was high until 1975. But after that it decreased. Rice import sharply increased from 2002 because of civil war. Furthermore, the import amount increased sharply after civil war which was ended in 2011. But, the data lacked credibility.

Figure 50 shows food production statistics for Côte d'Ivoire. The amount of self-sufficient rice produced exceeds 50 kg per person, but in recent years the self-sufficiency rate has been less than 50%. As the population has quadrupled in the last 60 years, production has more than quadrupled, but consumption has skyrocketed. As shown in red for the amount of the imported rice, domestic production does not meet the demand.

As shown in Figure 51, Taiwan team has made a significant contribution to the promotion of

Asian style irrigated sawah platform-based rice cultivation in Côte d'Ivoire in 1962-73. About 180 engineers were dispatched to more than 20 areas nationwide. They stayed at the development site for 2-3 years in a team of about 10 people, developed more than 100 small dams and irrigated sawah platform fields on a total scale of 10,000 ha, trained more than 3,000 farmers by on-the-job style (Table 6). Taiwan team made significant contribution to establish the ability to develop endogenous irrigated sawah platform development of Côte d'Ivoire. Due to this Taiwanese heritage, there are now well-maintained rice fields nationwide in many inland valleys as shown in Figure 52 below. The sawah fields in Figure 52 are the Inland Valley that connects to the Mbe Valley, where the experimental fields of the African Rice Cultivation Center are located.

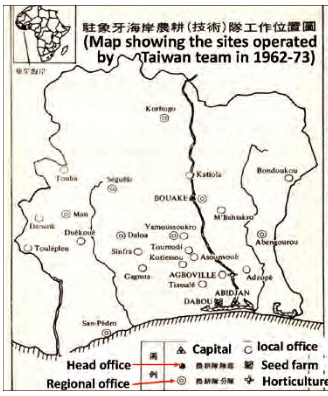


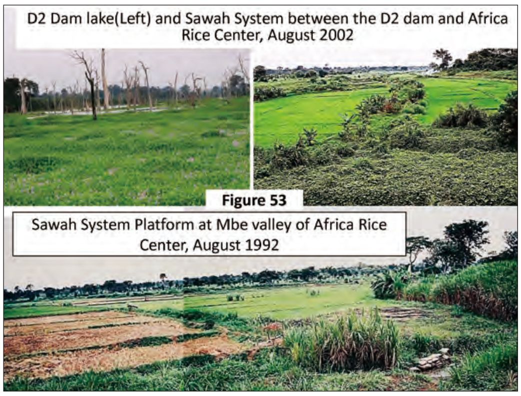
Figure 51

During 1962-73, Taiwan had operated nation-wide irrigated sawah rice platform development at 24 sites: (1) Experts dispatched: 180 person, (2) No. of farmers trained : 3384, (3) Irrigated sawah developed: 5475ha, (4) No. of Dam constructed :161

As shown in below, the basis of the irrigated sawah platform in Corte d'Ivoire established by Taiwan team, which include the experimental fields of the Africa Rice headquarters at Mbe, Bouake.

Google earth image on 1st of January, 2019, showing the D3 area of Inland valley. GPS position is 7.866N 5.055W. Blue lines are irrigation canals. The bolt violet lines shows river. The white rectangular shows weir to intake water for irrigation canals. sawah system platforms might develop by government and manage by farmers. Sawah plot size is 150-300m^2 with good leveling ±10cm.

Figure 53 shows the rice fields and a dam lake. The photo on the upper left shows water hyacinth and dead trees on the dam lake. The upper right is the irrigated sawah platform fields downstream of the dam. The photo below is the Mbe valley with the experimental fields of Africa Rice Center, which is located downstream of the same dam. These Sawah platforms were originally built based on Taiwan teams' activities in 1962-73.



D2 Dam lake(Left) and Sawah System between the D2 dam and Africa Rice Center, August 2002

Figure 53

Sawah System Platform at Mbe valley of Africa Rice Center, August 1992

Figure 54

Photographs taken from both side of main road crossing Foro Foro inland valley: Sawah System and Weir (upper), Participant lady group and Dr. Nagumo, coordinator, Food for Work of WFP/MAFF Japan, August 2002

Figure 54 shows one of the Food for Work-type paddy field development sites jointly implemented by the International Cooperation Division of the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan with WFP (World Food Program) from 1999 to 2004. This was somewhat the first stage of the SMART-IV (Sawah, Market Access and Rice Technology in Inland Valley) program conducted by Africa Rice in 2000-19, which was also implement by the International Cooperation Division of MAFF. It was created and implemented based on the concept of our Sawah program. Dr. Nagumo was the coordinator who is currently a staff member of JIRCAS (The Japan International Research Center for Agricultural Sciences). According to

Dr. Nagumo, the engineers of the counterpart Côte d'Ivoire were well trained by the Taiwanese team, so the training of the farmers was smooth. The Food for Work method is a type of participatory development that lies between development that depends on external engineers, which is ODA style, and endogenous development that farmers carry out on their own.

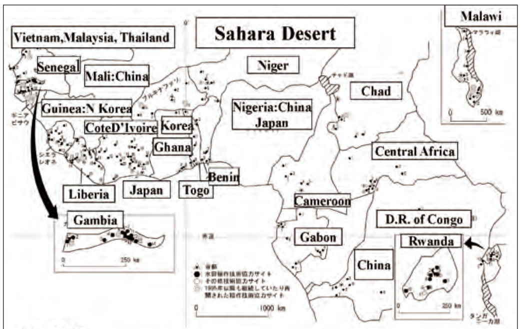


Figure 55

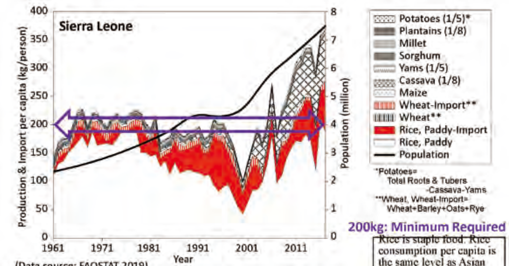
Asian and African Collaboration on sawah systems: Taiwan team is a pioneer for Sawah Ecotechnology transfer to Africa during 1960-75, but some in 1995-present.

Table 6 Acreage of reclaimed and cultured land and number of farmers trained by the Taiwan-Agricultural Technical Missions in the African countries (1961-2000).

Country	Acreage of reclaimed land (ha)	Acreage of cultivated land (ha)	No. of farmers trained
Botswana	158.57	95.01	252
Burkina Faso	2,617.23	3,473.00	5,660
Cameroon	329.53	1,637.39	772
Central African Republic	368.98	1,056.11	775
Chad	411.32	904.53	1,756
Dahomey(Benin)	780.00	1,067.90	1,621
Gabon	832.33	1,240.92	571
Gambia	470.00	1,683.00	8643
Ghana	216.32	161.35	374
Guinea-Buissau	3,707.50	3,707.50	3,681
Ivory Coast	9,669.95	50,958.33	3,384
Lesotho	0	180.14	3,314
Liberia	1,325.32	9,801.22	2,790
Libra	12.00	12.00	102
Malagasy	523.40	476.47	97
Malawi	1,474.86	5,418.26	1,295
Mauritius	3.00	68.58	291
Niger	1,590.50	1,123.75	8,620
Rwanda	1,188.65	994.22	4,246
Senegal	100.48	1,929.36	3,870
Sierra Leone	630.31	1,443.93	1,307
Swaziland	112.65	160.62	0
Togo	801.85	2,122.15	3,124
Zaire	1,506.58	9,861.62	6,482
Total	28,831.33	99,577.36	63,027

Sung-Ching Hsieh 2001.Agricultural Reform in Africa- With Special Focus on Taiwan Assisted Rice Production in Africa, Past, Present and the Future Perspectives-, Tropics,Vol.11 (1):33-58, http://www.kinki-ecotech.jp/download/Hsieh2003_Part5_pp.165-232.pdf

Figure 55 and Table 6 show the whole picture of sawah based rice cultivation promotion activities in all over the SSA by the Taiwan team from 1961 to 2000. The Acreage of reclaimed land in Senegal in Table 6 is an error of 2,400ha instead of 100.48ha, which Wakatsuki examined the original source and confirmed this error. Taiwan team developed 29,000 ha of irrigated sawah platform in 24 countries and trained 60,000 SSA farmers, extension officers and engineers. This activity seems to have formed the basis for sawah based rice cultivation that is progressing throughout the current SSA. Taiwan fought for hegemony at the United Nations with the mainland China. Subsequent agreements with China, which has acquired diplomatic rights, have prevented the SSA countries in question from assessing Taiwan's activities. For this reason, Taiwan's activities are buried in the history of the SSA countries. Taiwan did not work in Nigeria, but in East Africa such as Rwanda and Malawi, Taiwan dispatched a total of about 1,000 to 1,200 people a year in ten years, mainly for the promotion of sawah based rice cultivation. Sawah fields and dams developed at that time remain throughout the 24 countries in Table 6. You can check it on Google earth now



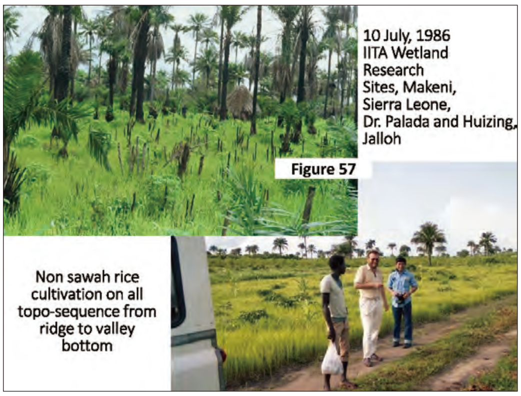
(Data source: FAOSTAT 2019)

Fig.56. Various Food Production & Import (kg/person) in Sierra Leone (No.7 rice producing country in SSA) during 1961-2017.

Cereal equivalent amounts of calories per kg are one fifth for Potato & plantain, one fourth for Yam and cassava (FAO Food composition data). In addition to these, postharvest and storage losses are estimated 2 times bigger than cereals for Cassava, 1.6 times for plantain, 1.3 times for Yam, and 1.0 for potatoes. Thus the cereals conversion ratios of potatoes and Yams are 1/5 and 1/8 for Plantains and Cassava.

Rice is staple food. Rice consumption per capita is the same level as Asian countries. Rice production had been decreased sharply during 1970's to 2000, particularly during 1989-1998, Population also decreased during this decade. But, Rice production is rapidly recovering in recent years.

Figure 56 shows food production and import data of Sierra Leone. They are rice-eating people. Many rices have been imported especially during the civil war in 1991-2001. During the civil war population curve is dented and population decreased. Such anomalies in the population curve have a high mortality rate per capita, comparable to Japan's record of 3 million human casualties during World War II. Figures 57 and 58 are typical rice farming landscapes in Sierra Leone. No sawah plots can be seen. It is a slash-and-burn rice field from the mountains top to the lowlands on the “satoyama” like topography. Here, Makeni, Sierra Leone and Bida, Nigeria were the first sites to start rice farming research at IITA in 1986.



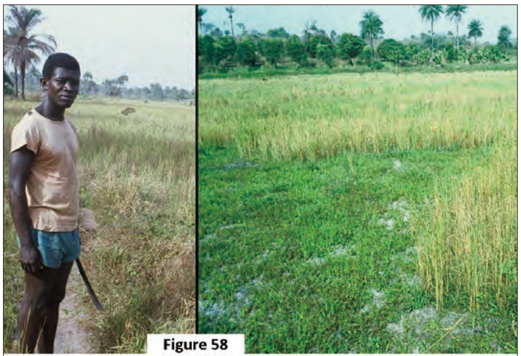


Photo No. 11 February 1988, Rogbom valley, Makeni, Sierra Leone.
Degradation of Inland Valley soil by Non-Sawah Paddy cultivation)

Fig. 58 shows the inland valley lowland. This is a part of the topo-sequences connected from Fig. 57, but it is non-sawah rice cultivation. Since there is no bunded sawah plots, clay is washed away by soil erosion, making the very sandy poor soils.

The next slide does not have the figure numbers, but it is Figure 59. Photo No. 14-16 show the land use in the rainy and dry seasons of Rogbom village, where the IITA's on-farm research site in 1986-88. The lower left is a micro quasi-sawah fields with a side of about 3m. The photo on the right below is taken during the dry season, February 1988. After rice cultivation these non sawah fields is completed, mounds are made and peanuts, cassava, etc. are cultivated. The Google image above shows these numerous mounds.

Figure 60 shows wetlands along the Gulf of Guinea, north of Freetown. It is a tidal irrigated rice farm in the mangrove belt. In 1986-88, there was Rokupr Mangrove Rice Research station of WARDA, West Africa Rice Development Association, at the time, and it was closed around 2000.

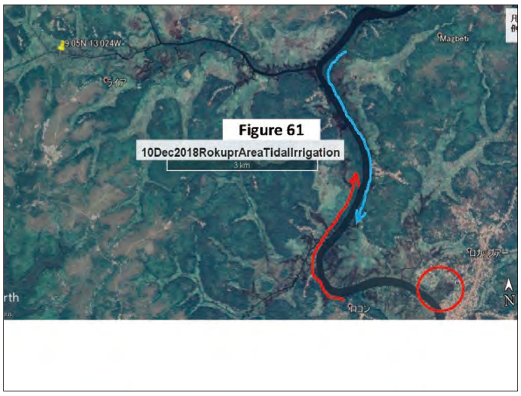


Figure 61 shows tidal irrigation system. Freshwater showing blue color flows down from the upper land side, and seawater shown in red color flows under the river water from the direction of seaside, which push up the freshwater on the surface. Incorporate this fresh water into the rice farm. As shown in Fig. 1, there are very few coastal lowlands in SSA, and the total area of such mangrove rice area cultivated in 1988 was Guinea Bissau 90,000ha, Guinea 64,000ha, Sierra Leone 35,000ha, Gambia 10,000ha, Senegal

10,000ha, and 5,000ha. Total estimated mangrove forest is 1million ha (WARDA 1988)

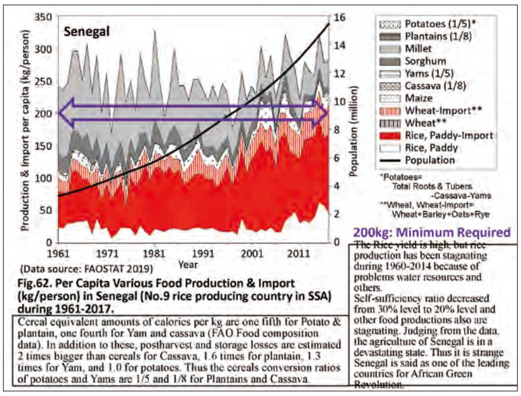


Fig.62. Per Capita Various Food Production & Import (kg/person) in Senegal (No.9 rice producing country in SSA) during 1961-2017.

Cereal equivalent amounts of calories per kg are one fifth for Potato & plantain, one fourth for Yam and cassava (FAO Food composition data). In addition to these, postharvest and storage losses are estimated 2 times bigger than cereals for Cassava, 1.6 times for plantain, 1.3 times for Yam, and 1.0 for potatoes. Thus the cereals conversion ratios of potatoes and Yams are 1/5 and 1/8 for Plantains and Cassava.

~~The Rice yield is high, but rice~~ production has been stagnating during 1960-2014 because of problems water resources and others. Self-sufficiency ratio decreased from 30% level to 20% level and other food productions also are stagnating. Judging from the data, the agriculture of Senegal is in a devastating state. Thus it is strange Senegal is said as one of the leading countries for African Green ~~Revolution.~~

Figure 62 shows changes in food production statistics in Senegal. Sixty years ago, millet was important, but now people are now rice eater. However more than 60% of rice consumed are imported. This level of importation should be a national bankruptcy, so I think there is still a problem with FAO statistics. In the last 60 years, the population has quadrupled and the per capita domestic rice production, which shown in white, has doubled (especially since 2005), so the country has increased production by eight times. Senegal has very productive rice farming, but unfortunately, although Senegal has some mangrove tidal irrigation area (Casamance region, south Senegal), the only major rice-growing lowlands are the limited floodplain along the and limited water resource of Senegal River.

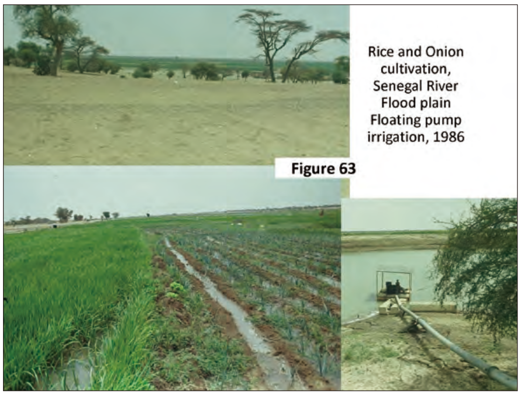


Figure 63

Rice and Onion cultivation, Senegal River Flood plain Floating pump irrigation, 1986

Figure 63 shows distant view of the green floodplain and the Senegal River flowing through the desert area. The two pictures below show the irrigated cultivation of rice and onions on the flood plain using floating pumping. These are photos taken in 1986.

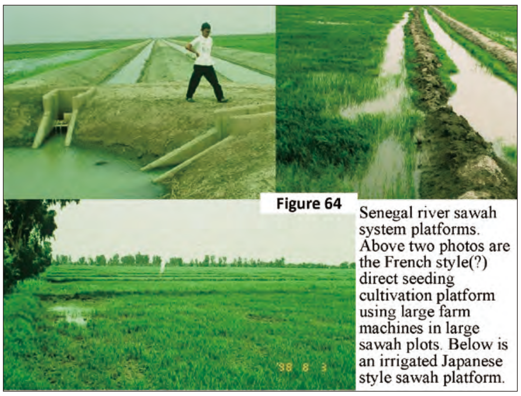


Figure 64

Senegal river sawah system platforms. Above two photos are the French style(?) direct seeding cultivation platform using large farm machines in large sawah plots. Below is an irrigated Japanese style sawah platform.

In the lower part, those were supported by the Japanese technical assistance. On the top, basically they were funded by a world bank or the French government.

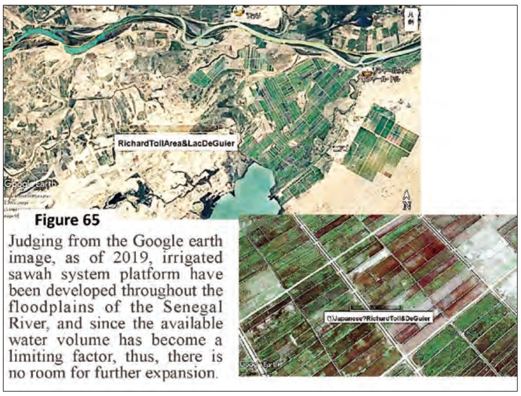


Figure 65

Judging from the Google earth image, as of 2019, irrigated sawah system platform have been developed throughout the floodplains of the Senegal River, and since the available water volume has become a limiting factor, thus, there is no room for further expansion.

As shown in Fig. 65, most of the rice-growing areas have well-maintained high quality sawah platform. Unfortunately, most of the country is dry and the amount of water available for irrigation and the lowland area are small for an SSA country.

This is the end of the overview of SSA's rice farming system. There is a great variety of sawah platforms, and the area of wetlands where irrigated sawah platform can be developed is very large. Currently, rice is cultivated in 2 million hectares of irrigated sawah platform. If the potential area of 50 million ha is fully developed in irrigated sawah fields in the next 50 years, it will be about 20% of the total wetland area of SSA of 240 million ha. If the paddy yield is 5 tons / ha, the paddy production will be 250 million tons, if divided by 200kg of minimum requirement of paddy for one person per year, SSA can produce paddy for 1.25 billion people (equivalent to the population of India). If Egyptian style high yield rice cultivation of 10t / ha is possible, it is possible with 10% use of total wetlands area in SSA.

This is the end of my overview this time

Takagi : Thank you very much for your presentation, Dr. Wakatsuki. When I was working, I was specialized in river water, therefore your presentation was quite insightful. Water management is something that I am greatly interested in. I hope that you will be able to discuss more in the next round. Mr. Shiratori, thank you very much for joining. Without further ado, could your start your lecture, please?

“Rice Development and Waterborne Diseases” by Kiyoshi Shiratori (Specially Appointed Professor of The Center for African Area Studies, Kyoto University)

Good evening, good afternoon, and good morning to you all. My name is Shiratori.

First of all, I would like to introduce myself. I am serving as the managing director of the NGO called the Africa Rikai Project. I was dispatched to Kenya from 1979-82 as a volunteer and I was stationed in Tanzania for eight years from 1994-2002 as a JICA expert. In Ethiopia, I worked for 10 years from 2004-15 in the Farmer Research Group projects, which is about the promoting participatory research approach among Ethiopian agricultural researchers. I reside in Japan from 2015, however I still work with the Project for Functional Enhancement of the National Rice Research and Training Center. I spent about six months every year in Ethiopia.

I am neither an expert of infectious diseases nor irrigation development. However, I have worked in project management, therefore I have some idea of who involves in development projects and how such projects will work. I will be mostly focusing on my experience in Tanzania on rice and waterborne diseases.

The projects I involved in Kenya, Tanzania, and Ethiopia were related to rice. As was mentioned by Dr. Wakatsuki as well, there are diverse rice ecosystems among different rice growing countries. Even within the same country, there are different ecosystems and socio-economic situations among different areas. I would like to give you the overall picture about the rice cultivation in three countries.

The first example lies in the lower Tana area in Kenya. I was an extension personnel running around villages in the area. The Tana River is the largest river in Kenya. A large part of the Lower Tana area is covered by wetlands, and therefore mosquitoes are quite prevalent through the year. Because it is so common, malaria was something considered as the common cold by the local people. Yet, I was free of malaria all through the years, therefore I was called a miracle in Lower Tana. However, right before my departure to Japan, I was infected with malaria and I was transported to a big hospital 120 km away from my station. I remember I was thinking in the bed with high fever that I was probably going to finish my life.

Lower Tana is in the lower part of the Tana River. There is rice production using tidal irrigation near the mouth of the river. In the upper part of the area, there are small-scale irrigation schemes developed in the 1970s. In the 1990s, large-scale irrigation was developed. Along the river side and the delta area, rice grown following flood recession. During the rainy season, villages are cut-off from roads. The rice cultivation in the small-scale irrigation, engine pumps are used to lift-up water from the river, however the water level in the river changes quite extensively, pump operations were often disrupted. Also, there is no repairing services available once the pump is malfunctioned, which affected rice production very much in the area. The large-scale irrigation with gravity developed in the 1990s, was destroyed by the El Nino in 1997, which changed the river course drastically resulting malfunctioning the scheme. The scheme constructed flood prevention banks so once the irrigation system stopped working, access to water for rice cultivation might have worsened and the farmers became more vulnerable.

The second case is the Lower Moshi in Tanzania. Compared to the lower Tana of Kenya, the altitude is higher, however the malaria is prevalent, and I was diagnosed with malaria several time during my stay. The malaria diagnosis needed cautions as any high fever tended to be diagnoses as malaria. The house helpers and the security guards I hired at home, initially got sick leave quite often but the frequency of sick leaves decreased because the monthly income they earn improved their health status and therefore they got malaria less frequently.
The Lower Moshi is a Japanese government supported irrigation scheme. You can see a

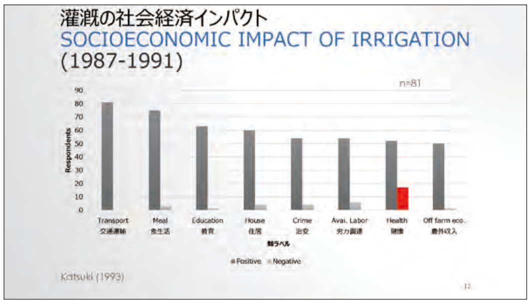
very beautiful canal and paddy fields and baobab trees there.
The Lower Moshi is on the foot of the Mount Kilimanjaro. The altitude is about 800meters. People of the Mount Kilimanjaro traditionally reside at 1,000-2,500 meters high having a highly integrated farming system, combining coffee, banana, and dairy farms. The Lower Moshi area at the foot of the Mount Kilimanjaro was less productive and very low population density. The people come down from the Mount Kilimanjaro during the rainy season to practice seasonal farming. Due to modern irrigation development, people settled, and affluent villages have appeared in the area. The annual precipitation is about 800 mm, which varies year to year. Irrigated agriculture sourcing springs and small rivers has established a very stable rice ecosystem. However, irrigation area expanded after the success of the Lower Moshi Irrigation Scheme, land distribution and water sharing became issues.

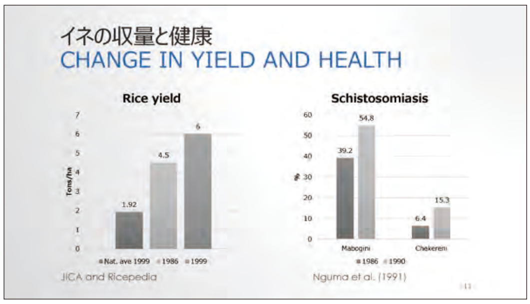
The third case is the Fogera plains in Ethiopia. The National Rice Research and Training Center is located at the edge of the Fogera plain. The Lake Tana, which is the source of the Blue Nile river, is 1,800 meters high. The Fogera plains is on the east bank of the lake. The area sometimes struggles with cold damage with hail. The area is considered as the higher limit for rice production. There is no malaria in this area.
The soil of heavy clay soil in the Fogera plain makes deep cracks, therefore no crop production is possible but cattle grazing during the dry season. The surface running water remain on the ground at the depth of 50 or more centimeters and no crop was grown during the rainy season. People of the highlands say “Do not wed your daughter to somebody from the Fogera plains.” as farmers in the area so poor. After North Korea introduced rice in the 1980s, the rice production rapidly expanded in the area by farmer to farmer dissemination without any government intervention The rice demand is growing mainly in the urban areas, which encourages farmers to grow more rice. In addition to the rice production in the plain, the surrounding slopy areas are also planted with rice these days. The highland people now want their daughters to marry somebody from the Fogera plain.
I have shown different rice growing areas in three countries. There are different rice ecosystems and livelihood of the people.

The Lower Moshi in Tanzania is the irrigation development project technically and financially supported by the Japanese government. There were several projects implemented in sequence and there is a on-going project now. The projects in the late 1980s to the early 1990s included activities related to waterborne infectious diseases. I would like to introduce the experience from the project.

Lower Moshi is situated in the outskirt of the Moshi, which is the capital town of the Kilimanjaro Region. It is an irrigation project where Japan has been engaged since the 1970s. A master plan for the comprehensive rural development in Kilimanjaro was developed in the 1970s. As a part of the master plan, irrigation facilities and agricultural development center, and a large-scale milling plant were constructed and agricultural machines such as tractors were provided. In parallel, technical cooperation projects were implemented for developing technologies, farmer training, and establishing and strengthening farmers' organizing. The technical cooperation for the Lower Moshi Irrigation Project continued until the 1990s. After 1994, based upon the Lower Moshi experience, Tanzanian government decided to extend the experiences of Lower Moshi to other parts of the country to promote and improve irrigated rice production. Just to summarize all these projects, the Japanese assistance in Kilimanjaro was quite generous and sustained ones.

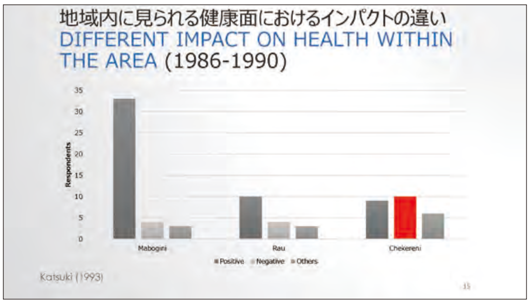
The JICA project implemented in the 1980s conducted a survey on socioeconomic impact of the irrigation projects. Their survey asked farmers in Lower Moshi if the impact of the irrigation development brought negative or positive changes during the period between 1986, start of irrigated rice production, and 1991. It resulted that changes on transport, meal, education, house, crime, available labor, health, and off-farm income were positive. However, with regard to the health, about 20% of the farmers responded that there were some negative impacts.





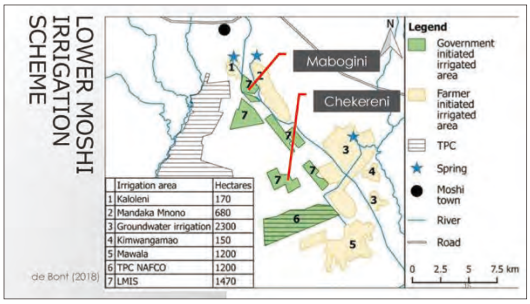
The Tanzanian Food and Nutrition Centre conducted a survey on schistosomiasis infections in two villages located inside the Lower Moshi irrigation area during the same period comparing 1986 and 1990. Mabogini near the source of irrigation water had the higher infection rates compared to that of Chekereni in both 1986 and 1990. However, the rate of change was larger in Chekereni, which was located at the end of the irrigation system. During the same period, the rice yield in Lower Moshi reached six tons per hector which was three times to as much as the national average of two tons. The high yield level has been maintained to date.

The productivity improvement brought farmers better income. Rice's relatively high price compared to other cereals helped farmers to sell the produce. The increase income enabled the farmers to take counter measures against waterborne diseases such as taking laboratory tests when they got high fever, taking medicine, and installing window screens to prevent mosquitoes. The rice farmers and other stakeholders from JICA and Tanzanian government shared an opinion that such positive impact was much larger than the risk of waterborne diseases brought in by irrigation development.



When we look at the impact on health by village, the results are quite different. Majority of farmers of upstream village of Mabogin, evaluated that there was a positive impact on health as well while more number of farmers in downstream village of Chekereni evaluated that there was a negative impact on health over those evaluated positive. Unfortunately, we do not have further analysis on the issue from the survey. The survey report states that there were farmers explaining increase of mosquitoes as the reason for the negative impact on health.

The map shows irrigation schemes in the southeast area of Moshi City. The green area with figure 7 is the Lower Moshi Irrigation scheme. After the construction of the irrigation scheme, farmer-initiated irrigated areas in yellow areas. The rice production in the region significantly grew. Nairobi was a large market situated relatively close to Kilimanjaro Region also encouraged farmers to produce rice. Mabogini was adjacent to the water source. It had wetlands and they were able to cultivate rice throughout the year two to three times. On the other hand, Chekereni was a settlement established after independence and they were situated at the downstream of the irrigation scheme, so they were able to produce rice 1 to 1.5 times in a year, so the economic gain was not as great as Mabogini.



It is not known what the trigger the JICA project to tackle action. Activities related to waterborne diseases were carried out by the JICA project in the latter half of the 1980s to the 1990s. The Kilimanjaro Agricultural Development Project (KADP) tried some measures to suppress the hatching of mosquito larvae. They tried a paddling method and immediate transplanting. Insecticide-soaked mosquito nets were also demonstrated. There was a good network among the JICA project, and hospitals and laboratories in the area. Active exchange of information on waterborne diseases took place From 1994 to around 2000, the Kilimanjaro Agriculture Training Center (KATC) project conducted survey on waterborne disease by inviting health experts on schistosomiasis host distribution, schistosomiasis infection among primary school children and children's behavioral patterns. Some measures to eradicate vectors from the irrigation area together with rice farmers. The results of these activities were converted into training materials and used in KATC's training program for farmers and extension workers.

I would like to raise a couple of points for discussion. It is not well summarized, but I just want to highlight the salient points.

Starting from rice development and its relationship with malaria, we need to have a comprehensive study on environment, agronomic practice, and socio-economics aspects. Such investigation needs to be carried out with farmers. Within a rice community, there are various groups of people and not every group benefit from rice production at the same level. In Ethiopia, we observe influx of migrant workers into rice production areas. Impact of rice production on health and livelihood may not be the same between farmers who reside the area and migrant workers. Compared with sugar cane irrigated area and savannah, irrigated rice area said to be least risk of malaria infection according to a research. The research also states that within the irrigation areas has lower risk of malaria infection than areas far from irrigated area. The same research further mentions that there is over estimation of malaria due to the tendency of suspected high fever cases being diagnosed as malaria We do not know such suggestions can be applied in many countries and irrigated areas. As diversified rice ecosystems exist, the necessary measures for waterborne disease would be also diverse as well.

We are still not sure if there are effective and efficient countermeasures against waterborne infectious disease which can be taken in rice development process. I felt that revisiting the issue of rice development and waterborne disease is important while I was going though information regarding to what JICA projects in Tanzania did and remembering my own experiences in Tanzania. It is not only about improvement of irrigation facilities and agronomic practices. Simply having discussions with farmers on the issue may be worth to find better solutions.

In Lower Moshi, the waterborne disease activities by the JICA project was not originally planned in the log frame, but since JICA operated for a long time, which enabled the project to recognize the importance of the issue. Established relationship with health institutions in the area for a long period of time may influenced the project. Of course, we did not find any decisive measure and the substance of the waterborne disease incorporated as a part of the training program at KATC does not go beyond the level of the general preventive measures. However, putting farmers a part of activities in Lower Moshi lead them to better understanding of the waterborne diseases. Findings of relationship between health of children and school attendance as well as their performance in subject made significant impact on farmers to understand the seriousness of waterborne diseases.

Activities conducted by KADP and KATC in collaborating with medical and research institutes were rather temporary ones. Such intersectoral collaboration is easy to implement while donor projects are implemented, but once donors left such collaboration may not be continued. Who would coordinate and which institute would bear the responsibility? When it comes to this point, it is not that easy. Rice yield (and income) versus risk of waterborne diseases may be a zero-sum relation and not possible to remove all the problem. KADP tried to suppress the hatching of the larvae by keeping water in paddy field within one week. This contradict to measure for better productivity and profitability by retaining precious water as long as possible. How are we going to strike the balance between productive and economic gain and lower number of malaria vector? Those should be determined by the farmers and what we can do is to provide information regarding the relationship between rice production and risks of waterborne diseases.

In many cases, rice is introduced to areas where waterborne diseases have been existed. The village of Mabogini, even before the introduction of the irrigation scheme, they had a high infection rate of schistosomiasis. Therefore, the rice introduction might not cause higher risk of waterborne disease. Because of economic gain, we may be allowed to tolerate the risk for waterborne disease. Or we may promote taking measures against waterborne diseases in rice development more aggressively for not only to minimize the risk but eradicating waterborne diseases. Such possibility may be considered.

Following being asked to make the presentation at this round table today, I inquired a number of incumbent experts who are involved in the rice projects in Africa if they have had experience in prominent cases of waterborne diseases in rice development areas. Based on their responses, waterborne diseases have very low profile in the on-going rice projects. The waterborne subject in KATC trainings program may remove the subject due to budget cut. In Ethiopia, the government has an intension to expand irrigated rice production in the eastern part, which may cause increasing waterborne diseases. I thought I need to raise the issue among Ethiopian counterparts.

Lastly, in 1997, in the JICA project, a schistosomiasis expert mentioned something like the following, which I would like to introduce. "It was an excellent happening that JICA dispatched an expert across his specialized field. The necessity of having health professionals in agricultural projects has been recommended by the WHO for over 20 years. I have also made this point at various opportunities while exchanging opinions with agricultural professionals, therefore it was not surprising to me being assigned as a health

expert in an agricultural project, but it was a pleasant surprise that JICA actually implemented it. I will be watching JICA and their future movements.” This was almost 20-plus years ago.
That concludes my presentation. Thank you very much.

Discussion and Q&A

Takagi : Thank you very much, Mr. Shiratori. While I was listening to his presentation, with Dr. Wakatsuki and Mr. Shiratori, it seems that all these lectures are interrelated. The next discussion will be to probably explore whether there is a desirable and ideal way of farm management in the future. I thought that could be a potential discussion in the future.
We have slightly over 20 minutes for discussion. I would like to invite Prof. Tanaka to take some inputs from before so that you could enrich the discussion of the overview. How is that Prof. Tanaka?

Tanaka : Dr. Wakatsuki and Mr. Shiratori, thank you very much for your presentations. They commonly mentioned that the large-scale introduction of Asian-rice cultivation began in the 1970s in Africa and its introduction and expansion progressively continues to date. Looking back at the development of rice cultivation in Africa, there have been two dimensions in it, just like in Asia; area expansion and intensification of rice-growing techniques in the areas already being established as wet-rice fields. In particular, in Dr. Wakatsuki's presentation, these two aspects, area expansion and technical improvement, were clearly shown with country-wide statistical data such as cultivated area, yield and production. Another aspect was also commonly pointed out by the two speakers; just to summarize in a succinct way, there are great diversities in rice cultivation and in its ecological and socio-cultural backgrounds in Africa as well. At the same time, taking these great diversities into account, it is also assumed that malaria infection status must be greatly diversified as well.
Dr. Wakatsuki's presentation did not step into the infectious situation of malaria in each African country, Mr. Shiratori, however, introduced three cases of JICA's technical cooperation projects, of which the case of Lower Moshi of Tanzania was presented in an extensive way. In fact, prior to the technical cooperation in Tanzania, Japan had started a pioneering project to extend the so-called "Japan-style" intensive rice growing techniques in Kenya. That was the starting point of Japanese cooperation to extend rice-growing techniques to African countries including Tanzania. As rice cultivation was quite a strong field of technical cooperation, the Japanese government extended cooperation to various countries in Africa, and East Asian countries advancing in rice cultivation, such as China, Korea and Taiwan, also joined in this frontlines. After that, the International Rice Research Institute (IRRI), located in the Philippines, also played an important role in extending and establishing wet-rice cultivation in wider scale. As such history describes, Japan played prominent roles in the development of intensive rice cultivation in Africa. Respecting such history of Japanese cooperation, Dr. Wakatsuki has tried to introduce and establish small-scale wet-rice cultivation to create a different approach for small-scale farmers based on the Japanese farmers' experiences.

As both Dr. Wakatsuki and Mr. Shiratori mentioned earlier, large-scale irrigation schemes have been involved in large-scale technical cooperation projects for rice development in Africa, sometimes private companies or corporations being involved in the large-scale irrigation schemes as mentioned by Dr. Wakatsuki. In Asia, on the other hand, small-scale farmers have long been engaged in rice cultivation. They are all experts equipped with traditional knowledge and technologies for growing rice. Therefore, none of large, private enterprises endeavor into the large-scale development of rice cultivation in Asia. Such difference seems to be a possible point of future discussion. In this regard, as Mr. Shiratori explained, it would be important challenge to organize research activities to understand what the actual situation of waterborne diseases was and what countermeasures to prevent them were taken in such locations as large-scale irrigation schemes were implemented. Mr. Shiratori also introduced a JICA's technical cooperation project which incorporated field research to detect the project's influence on the occurrence of waterborne disease including malaria. As Mr. Shiratori emphasized, I also think, such initiative of incorporating health surveys in the rice development project is a very significant and valuable challenge. What happened post-project onto the health conditions or the waterborne disease status? I think such review would be also important and significant in order to reach the reality of relationship between rice cultivation and malaria.

I am not sure how the discussion will develop in the second meeting, but before that it is also important to collect some question from the participants. There may be some questions related directly to rice cultivation, too. I hope that participants for today's session will raise any questions.

Takagi : Thank you very much, Prof. Tanaka. As was mentioned by Mr. Shiratori, how should JICA formulate the projects? Dr. Amameishi is here with us today. Being a staff of the JICA organization, what is your take in this particular issue? If you have any answer, could you elaborate?

Amameishi : Yes. This is Amameishi of JICA. Thank you very much for raising the question. Dr. Wakatsuki and Mr. Shiratori, thank you very much for your presentations. Mr. Shiratori, you have been quite active in the JICA organization for a long period of time. One of the projects with remarkable outcomes is the Lower Moshi project in Tanzania that you shared with us.

I was thinking while listening to your lecture of the rice situation in Africa. Recently the demand on rice is growing exponentially. I do not think the growth in demand will stop. It will continue to increase going forward in Africa.

As the presenters for today's session mentioned earlier, the price for rice is still expensive compared to maize. It is three times as high as maize for example, and yet the demand is growing. There is no end to the growing demand in rice. On the other hand, the pressure on the supply side on rice is now intensified. There will be more growth in supply, however Africa is relying on imports for rice. They may rely more on imports, but on the other hand, there will be more domestic production of rice and therefore since 2008 at JICA, working together with other international organizations, we started a doubling project of rice supply. In the first decade, there was a doubling of production, and we are aiming at further doubling production. We are greatly expecting a lot from the irrigated rice. Irrigated rice fields are very important and hydro rice is important.

The economics of the paddy rice and the waterborne disease – the relevance is very difficult. As was mentioned earlier, compared to maize, the income impact is quite large. The economic impact coming from paddy rice is significant. In rice cultivation processes, the prevention process of malaria is not really straightforward and simple. When we did a study session in May, Dr. Saito of the Africa Rice Center mentioned that their intermittent paddy rice. Controlling the water level effectively and swiftly seems to be quite effective in preventing malaria, however, think of the African situation where the irrigation level is not quite high. The very meticulous water level control may be very difficult in most of the African area.

Also, if they are producing twice the rice per year, then that could change the second round as the land rice or other farming products to dry the land or maybe control the fertilizers, and then perhaps the mosquito production could be reduced as well. These are the possible discussions so far, and yet it is not very simple. We are promoting the paddy rice, but in the process of rice cultivation, what would be the preventive measures to increase the offset of malaria. It is not straightforward such as in controlling parasites and so forth. Therefore, the malaria still remains at the negative side of the prevalence of paddy rice. As Mr. Shiratori mentioned earlier, when we develop the rice fields, we need to share the discussion. There are some risks for high malaria. What could be the preventive measures? We could involve the local farmers in the discussion. Also, in the case where there is the reduction in income because of the preventive measures of malaria, then there is some compensation made by the local governments, and there are countermeasures against malaria. A multidisciplinary approach is needed. That seems to be very important. So, listening to the two experts, I was thinking that this is a very complicated problem, but that was my impression so far.

Takagi : Thank you very much. We are running out of time, but the discussion that we are targeting is coming down to malaria in the end, so among the experts we have, we have Dr. Kobayashi from the University of the Ryukyus and also Dr. Minakawa from Nagasaki University who is an expert of vectors. Even though the time is limited, I hope you will speak for two to three minutes each after listening to other experts' presentations. I would like to hear a word from both doctors. Dr. Kazuki Saito from the Africa Rice Center, he made a presentation in the last meeting. I think he may be able to speak from a different angle today after listening to the presentations today. Please share your comment. We only have two to three minutes for each speaker, but I hope you will comment. Dr. Kobayashi first, please.

Kobayashi : Please allow me to speak first. Vectors will be covered by Dr. Minakawa, so I will speak from the perspective of regional health and the health system, agricultural development, and health development.
If you look at areas of data in parallel, agricultural development takes place first, and a regional health center is normally established after it is established. In that case, malaria, as Mr. Shiratori mentioned, one of the ways to look at it is as just the common flu, but not just malaria, we need to think about other feverinducing kinds of infectious diseases. When there are other infectious diseases, what should we do? In such a case, medical institutions are necessary. Maybe malaria may not be so severe, but it is important to have the adequate diagnosis.
In the case of Asia, the diagnosis can be done at the village level. That was the reason behind the success. For example, it can be done simply in villages through volunteers in the case of Asia, but in West Africa, I think it is relatively possible. The situation may be different depending on the region, but what I was surprised about was that in many cases, the villages are not centralized. In some communities, there is a distance from each house. So, compared with other communities or regions, it may be rather difficult. In such a case, of course we need to have bottom-up activities, but through a top-down approach, we need to cover both agricultural development and health development. I think we need to cover that. That is all.

Takagi : Thank you very much, Dr. Kobayashi. Dr. Minakawa, do you have anything to share with us?

Minakawa : Looking from the last meeting, as far as I understand the situation, through rice production, malaria decreased. We saw more reports in the past, but nowadays I think this was the research report, but we are hearing less of such cases. That is because in the past, with the improvement of the economic situation, bed nets, medicine, and test kits were now usable. There were positive aspects, but these days, bed nets are already penetrated, and medicine is also penetrated. Test kits and malaria countermeasures are already taking place. Because we have less benefits, rice production-induced economic gains are rather difficult to see.
Now with malaria, compared with the 1970s, 1980s, and 1990s, we have a significant decrease, even in Africa, but from around 2016,

we saw a flat situation. We do not see any further decrease from there, even in the number of cases and the number of deaths. Now we have tools available, but there are limitations to the tools. In order to eliminate, we need to increase gear one or two phases. Looking from a different perspective, through rice production, it is nice to have the economic gain as a result of that, but with the increase of rice production, we should prevent the increase of malaria. I think this is going to be important. If we have new tools or new policies, we may see the decrease. Therefore, with rice production, it is nice to have economic gains, but we need to ensure not to induce the increase of malaria.
In order to do that, it does not have to be rice production, we can apply in other areas as well, but we need to have monitoring, including of mosquitoes, patients, and malaria conditions in villages and communities where rice production takes place. Monitoring should be conducted. I am digressing a little bit, but in order to have weight loss for obese people, they always need to measure by scale, so psychologically they will become cautious and they will lose weight. So, this is good for losing weight. It is already proven. The same applies to malaria. If you are going to start rice production, monitoring should take place for both mosquitoes and patients. We should try not to increase from the status quo. That is all for my comment.

Takagi : Thank you very much. Dr. Saito, any comment?

Saito : Thank you very much. Prof. Tanaka, it has been a long time since the last time I got in touch with you. Dr. Wakatsuki, thank you very much for the presentation. It is very nice to see you, Mr. Shiratori. My name is Saito.
I am working for rice cultivation, and mainly think about how to reduce mosquito through agronomic interventions in field level. But, listening to Mr. Shiratori's presentation, I realize that solutions for trade-off between paddy development and risk for malaria could be explored through discussion with stakeholders. I also thank Dr. Minakawa for his brief introduction on what we presented in the last meeting. I agree to his comment on importance of monitoring of rice production the mosquito situation.

Takagi : Thank you very much. I only have three more minutes to be honest. Prof. Tanaka, can you once again join. We invited several experts to share some opinions. It seems that we have expanded the perspectives that we need to discuss going forward and we now have to discuss what would be the next step. If you could just give us a summarizing comment for a few minutes time, would it be okay?

Tanaka : I am not sure I can make a thorough comment or concluding remarks but listening to the presentations of the three speakers today, I would like to share my impression. First, I would like to say that I totally agree with Dr.

Kobayashi's view. In his talk, he emphasized that projects for agricultural development have precedence over the health development projects. Back in the 1970s and 1980s, I have also observed the same thing in rural Asia. Presuming economic benefit is usually an instinct of humankind. Once the rice cultivation is introduced into frontiers, many players economically will try to join the play fields, including those who will try to develop their own wet-rice fields. With the increase of population in the frontiers, the number of malaria patients also increases. Health initiatives usually come after that.

What was the reason behind this, or why malaria becomes prominent after new introduction of rice cultivation? I suppose that rather than having water in wet-rice fields, increase of stagnant water created in the human living space more significantly affects the occurrence of malaria.

Anyhow, the health service usually lags behind. Then, the next question will be whether the health service is provided well automatically after economic prosperity was obtained through the introduction of rice cultivation. In this connection, coincidentally, Dr. Wakatsuki mentioned at the outset of his presentation; he initially said, "I wanted to say that rice production promotion will result in the eradication of malaria" . Would that be really true? That relates to Dr. Minakawa's comment later. There is apparent economic development, and of course naturally you might think health service will be enhanced, then you will see lower malaria onset. However, it is also true that malaria still survives, and its infection continues to date in Africa despite obtaining economic gains from rice cultivation. There might be another tool required to completely eradicate malaria.

Then, what we need now is a thorough monitoring. When we do monitoring, what type of monitoring would be required? When we are to implement a thorough monitoring, we must take great diversities in rice cultivation into account, because it is assumed that the conditions susceptible to malaria are also diverse as well. Then we will have to have a lot of case studies. When you try to do a monitoring, you need to adjust your monitoring in a diverse way and you need an accumulation of experience in case studies of which monitoring would be applicable for particular conditions of a malaria-prevalent area.

Then, it is also important, as Dr. Saito mentioned, to look for any applicable rice-growing techniques available to mitigate the onset of malaria? For example, techniques of intermittent irrigation is expected to be effective countermeasures, but it is not easily introduced under the unstable hydrological conditions. It is also not well examined that water-saving cultivation really results in lowering malaria cases. In Japan, even in the mainland islands in Japan for example, we had a lot of malaria cases in the past, as well as schistosomiasis, but we succeeded in eradicating the infections. As we had such experience, maybe, referring to some

experiences like this could be useful for the cases in Africa as well.
Today, we paid a particular attention to rice cultivation. Listening presentations and comments, however, I came to know that it is also important to pay attention not only to direct relationship between rice cultivation and malaria but also to the way of living and the condition of living of people who are engaged in rice cultivation. In the next round of session, we would like to pay more attention to the countermeasures against malaria. Thank you very much.

Takagi : Thank you to both speakers, Dr. Wakatsuki and Mr. Shiratori. Thank you very much. Prof. Tanaka, thank you very much for giving us the wrap-up comment. Those people who have participated for two hours, thank you very much. Also, I would like to thank those people who commented. We would like to rework what we discussed today and on September 10, we would like to provide information for you. Thank you very much for your attendance today.

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

Event Discussion (second session)

Opening remarks

Takahiro Shinyo (Chairman, Malaria No More Japan; Chairman, Executive Committee of ZERO Malaria 2030 Campaign)

Shinyo : My name is Takahiro Shinyo and I am the Chairman of Malaria No More Japan. It is great to talk to you once again.

The COVID-19 pandemic continues. Having said that though, in Japan, there is a reduction in the number of new infections, however today, the report says that the new cases is 270 in Tokyo, therefore if we are rather not careful enough, we will have another peak as well. Recently, Japan was hit by Typhoon No. 10 and also No. 9. They have hit the western part of Japan, Kyushu and Okinawa. Dr. Takagi, Professor Emeritus of Nagasaki University, lives in Nagasaki, therefore his place was hit by the typhoons, however because preparations were quite well enough, the damages were relatively small. In this way, of course we are struggling not only with COVID-19, but also with earthquake, typhoon, and floods, as well as the extreme heat that are also hitting Japan, therefore we are suffering triple disasters and they can simultaneously potentially hit Japan. Probably Japan is the most susceptible for such kind of disasters, so be it infectious diseases or be it disasters, whatever happens, Japan has to be well-prepared to be able to overcome any impact that we may suffer from.

On the 25th of August, we were able to invite Dr. Takagi, Mr. Tanaka, Professor Emeritus of Kyoto University, Dr. Wakatsuki, Professor Emeritus of Shimane University and Mr. Shiratori, Special Professor of Kyoto University to talk about rice growing and cultivation in Africa, and the topic in regard to malaria. We were told how modern rice farming, also known as the "Green Revolution," has led to the development of paddy fields and rice cultivation for food production not only in Asia, but also in Africa, which has led to a stable lifestyle and a change in the environment. Rice enjoys higher prices compared to soybeans, for example. In Nigeria, rice is becoming the top core food in the local markets as well.

There were references about some relations with rice cultivation and malaria. There is a great need for a comprehensive examination of the cases. That topic needs to be examined together with the rice farmers. The problem is that there are some benefits in terms of economy from the cultivation of rice, but there are some increases in the case of malaria. How to strike a good balance between the two is the key. Rice cultivation and malaria are in a trade-off relationship. If rice cultivation is prioritized, then malaria cases will increase, and vice versa as well. Having said that though, as we have discussed during the previous meeting, it does not always have to be a trade-off relationship. Waterborne infection cases can sometimes be reduced if you implement the rice cultivation in a well-coordinated way.

For that to happen, participation from public health officials is going to be very important. The Japan International Cooperation Agency (JICA) has been promoting such efforts, and that was highly evaluated in the previous meeting. Back in the 1960s and 1970s, relatively speaking, agriculture development was the priority. That was a biased priority, however in recent years, be it rice cultivation, the public health system has to be well-developed altogether. That is one of the great contributions that Japan has been making so far. So when we visit the relationship of the rice cultivation and the malaria infections, it is not always that we have very well-thought-out data and tracking of data and so forth, therefore we need to further cooperate with statisticians and data analysts going forward.

In the round table today, we would like experts to deeply discuss rice cultivation and malaria from the perspective of health and health care services. The moderator continues to be Prof. Tanaka, and MC by Dr. Takagi. The keynote speakers are going to be Dr. Wakatsuki of Shimane University, and we are also very delighted to invite Dr. Kobayashi of the University of the Ryukyus. As for Dr. Kobayashi, he won the Zero Malaria Award that Malaria No More Japan is awarding. In Okinawa and so forth, we had prevalence of malaria, and schistosomiasis had also been observed in Japan. We overcame such issues and we would like to try to contribute to the improvement of the situations in Asia and Africa. From the health care point of view, Dr. Kobayashi is going to make contributions.

We are hoping to have a very stimulating discussion in regard to the relationship of rice production and malaria. I look forward to the discussion today.

Takagi : Thank you very much, Chairman. From now, as Dr. Shinyo introduced to us, we would like to have the lectures by the two speakers, and Mr. Shiratori will be speaking as the commentator for the discussion. He will talk about agricultural technology and health issues, and he will cover how those two can be linked with each other, after the two keynote speakers. As for Dr. Kobayashi, as Dr. Shinyo explained, he has received the Zero Malaria award of our association. Dr. Wakatsuki, continuing from the first-round table, will be covering the benefits of the sawah model and he will also cover the negative aspects as well. He will be continuing on his lecture from the first-round table.

In the previous round table, the participants, including myself, agreed in paddies, there are various modes and varieties. When they are incorporated into local lives, it will result in advanced rice culture with local adaptation. Today, by undestanding this perspective, we would like to slightly shift the points of argument to health and, if possible, to malaria and other infectious diseases from that context. We would like to touch the malaria issue and the rice productionin in a win-win manner, and understand what stages we are now.

Brief Presentation by Koji Tanaka
(Professor Emeritus, Center for Southeast Asian Studies, Kyoto University)

Tanaka : Thank you very much for the introductory remarks, Dr. Takagi. I heard that we have 23 participants in total from various backgrounds at this moment, to whom I would like to extend my sincere welcome. I am Koji Tanaka and will be serving as moderator for today's round-table meeting. Then, let me introduce myself briefly. I have studied on the development of rice cultivation in Asia from historical, cultural, and technological aspects. However, my experience in Africa is very limited. I have just been to Madagascar, Kenya and Sudan for short time, and never been to West African countries, which will be the core area for today's discussion. Anyhow, although I have already retired from university, I would like to play my role in this meeting based on my experience in Asia.

I think my first role as the moderator is to summarize the first session of this meeting for new participants and to share the objectives of the second session today. As Dr. Shinyo and Dr. Takagi have already touched upon it briefly, I would like to start this session with just a brief summary.

We had two keynote speakers, Mr. Shiratori and Dr. Wakatsuki in the first session, and they talked about a brief history of the development and expansion of rice cultivation in Africa. Both emphasized a great diversity in rice cultivation in Africa as a reflection of a variety of geographical settings and socio-ecological environments. In particular, Dr. Wakatsuki shared with us very detailed data to show that point. On the other hand, Mr. Shiratori presented on how Japan has contributed to the development of rice cultivation in Africa. In fact, as Japan has a long history of technical cooperation in the field of rice cultivation in Africa, he touched upon the relationship of rice cultivation and malaria and raised some related issues.

After two keynote speeches, Mr. Amameishi from JICA; Dr. Kobayashi from the University of the Ryukyus, today's keynote speaker, too; Dr. Minakawa from Nagasaki University; and Dr. Kazuki Saito from the Africa Rice Center raised some remarks and comments. As the two keynote speakers focused on issues just related to rice cultivation, they added constructive comments related to malaria or waterborne diseases in relation to rice cultivation.

Including these comments, the session was closed by proposing the following two points as an achievement: one is the need for monitoring and the other is the need for collaboration. In the course of expansion of rice cultivation, how did the prevalence of malaria increase and prevail, what was the relationship between rice cultivation and malaria? Then, it was proposed to organize more robust monitoring to approach and solve these questions. Another proposal was the need for actual collaboration between the experts in agricultural sectors and those in health and medical sectors.

Particularly, the need for involving the experts of waterborne diseases in this kind of cooperation was emphasized and proposed. I think that these two proposals raised in the first session will be the major topics for today's discussion.
Following the achievement of the first session, we asked Dr. Wakatsuki and Dr. Kobayashi to provide keynote speech today. Particularly, to Dr. Wakatsuki we asked to enhance the discussions by introducing the relationship between the expansion of rice cultivation and malaria infection prevalence in Africa. And, as Dr. Takagi mentioned earlier, we asked Dr. Kobayashi to talk about rice cultivation from the viewpoint of his expertise, malaria, and its prevalence. After their keynote speeches, Mr. Shiratori who was the keynote speaker at the first session is expected to respond to them. I particularly expect that he will be talking about the importance of involving farmers in the process of technical cooperation for developing rice cultivation in Africa, including some issues relevant to establishing participatory approaches.
As already mentioned, diversified rice cultivation systems were established in Africa within a much shorter period of time compared to that in Asia. Because of such rapid development, I suppose there must be more difficult situations in anticipating the countermeasures against waterborne infectious diseases, as well as malaria control. Also, in such diversified environments, we may need to look for sort of tailor-made or well-fitted location-specific countermeasures. Anyhow, time is limited, then, let's start the second session. As I have mentioned, in this session, Dr. Wakatsuki and Dr. Kobayashi will give keynote speeches, and Mr. Shiratori will follow them. After their presentations, the discussion will be open to the participants. Based upon the two consecutive sessions that we had so far and will have, I hope we will be able to develop the discussions toward the possible actions for us to be taken, if time allows. Then, let me ask Dr. Takagi to open the next session, please.

Takagi : Dr. Wakatsuki, this is the advanced version from the previous lecture. We hope that you would like to shift the perspective in relation to the lives of people. I would like to hand it over to you. Dr. Wakatsuki, the floor is yours.

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)

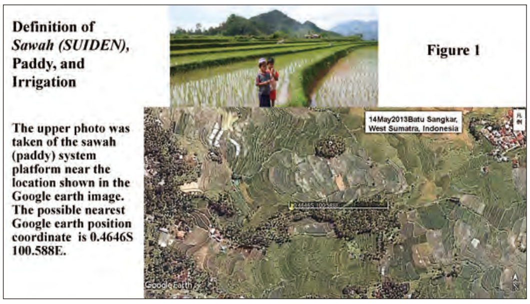


Figure 2 shows the distinction between irrigation, drainage and sawah(paddy) fields. In Asia, irrigated sawah(paddy) fields are developed in irrigated rice fields, but in SSA, sawah(paddy) fields are often not developed in irrigated rice fields. Basically, the irrigation system is a government or community-based 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.

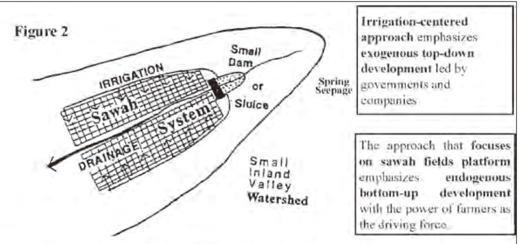


Figure 2. Sawah system with irrigation and drainage facilities for control of water in an inland valley watershed

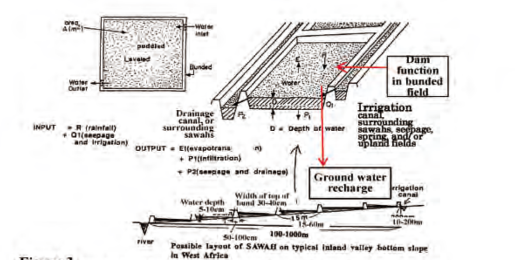


Figure 3 Sawah plot: A bunded, leveled, and puddled rice field with inlet of irrigation and outlet to drainage, thus control water and weeds as well as manage nutrients

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.

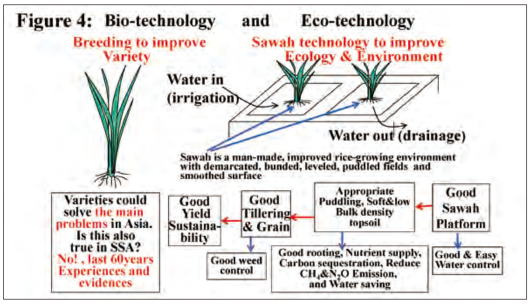
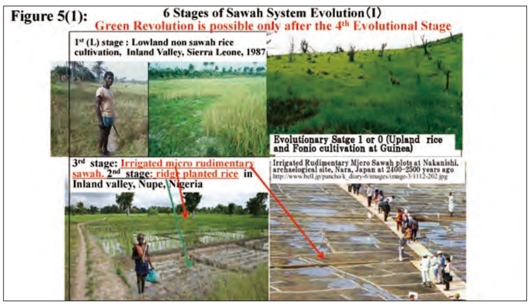
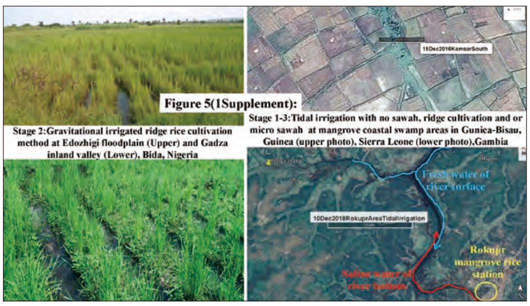


Figure 4 compares Biotechnology and Eco-technology. The improvement on the sawah platform research has virtually stopped in the last 50 years due to the focus on breeding in Japan because of the acreage reduction policy (GEN-TAN) on rice in 1970-2018.

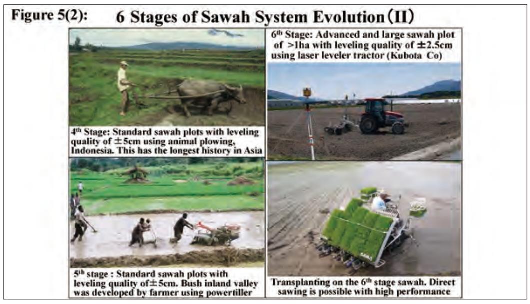
Biotechnology (breeding) is improving variety, eco-technology is improving rice growing environment, which core target is improving the water management platform, i.e., sawah. The purpose of eco-technology is how to improve the level of sustainable water control through the control of the in and out 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.

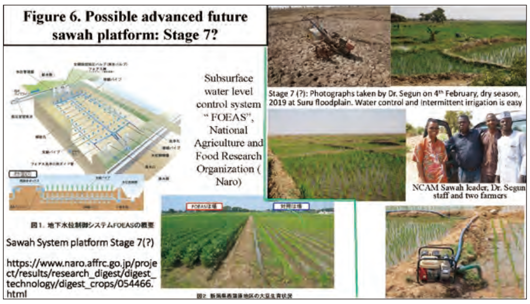


The upper and lower photographs on the left side of Fig. 5 (1 Supplement) are ridged rice cultivation in the Edozhigi irrigated scheme, Bida, Nigeria. On the right is the tidal irrigated rice fields of Guinea Bisau and Shera Leone on the Gulf of Guinea. Both look like large sawah plots, but they are 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.

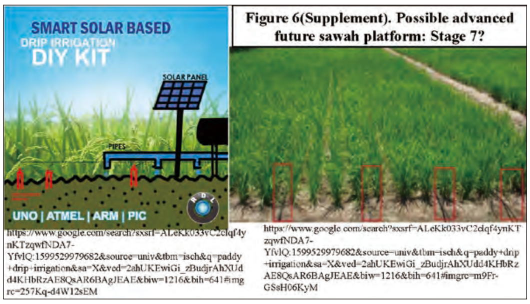


Figure 6(Supplement). Possible advanced future sawah platform: Stage 7?

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

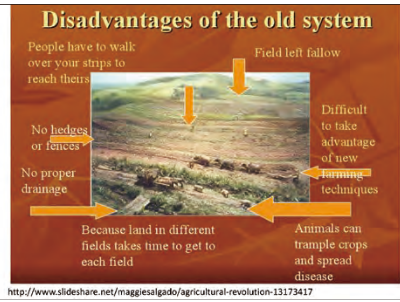
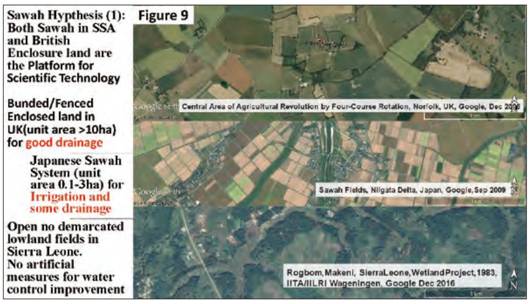


Figure 7 illustrates what happened before the enclosure farmland, which was the beginning of the British Agricultural Revolution. It seems that the farmland before the enclosure was like the farmlands of Sierra Leone, Guinea, and Nigeria, which are shown in Figures 15-17, 49, and 58 in my report on 25th 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.



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.

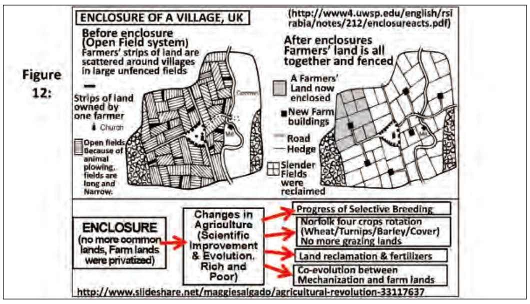


Figure 12:

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 6.882N 1.838W. 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 6.882N 1.838W.

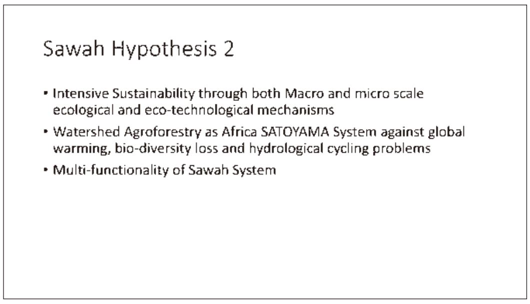
Fig 13 . Sawah hypothesis (1) for Scientific Platform: Farmers' Sawah should come the first to realize Green Revolution. Farmers fields have to be classified and demarcated ecotechnologically. Then scientific technologies can apply and evolve effectively. SSA's bushy open field systems have been long 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.



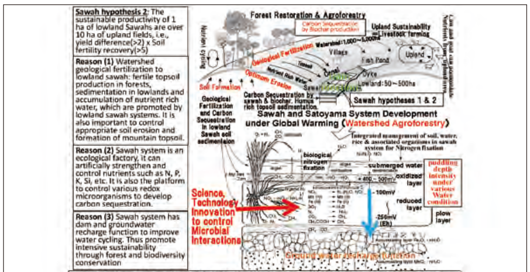


Fig 15. Sawah hypothesis (2): The platform for Sustainable Intensification through Watershed Eco-Technology for Watershed Agroforestry and African SATOYAMA

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 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 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 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>

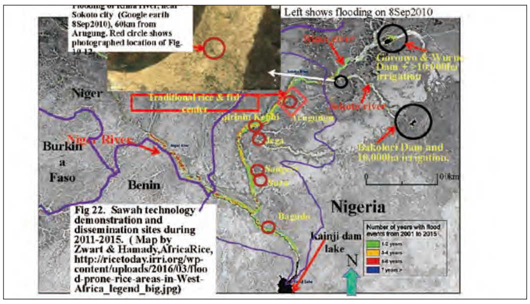


Fig 22. Sawah technology demonstration and dissemination sites during 2011-2015. (Map by Zwart & Hamady,AfricaRice, http://ricetoday.irri.org/wp-content/uploads/2016/03/flood-prone-rice-areas-in-West-Africa_legend_big.jpg)

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.

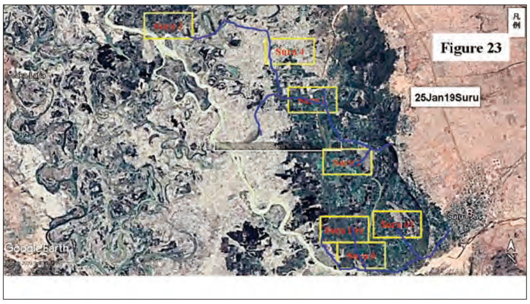


Figure 23

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.

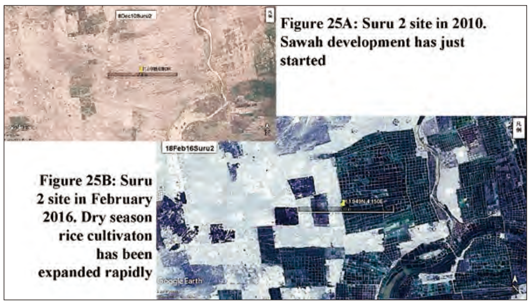


Figure 25A: Suru 2 site in 2010. Sawah development has just started

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:

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 28:

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

		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)
	Farmers								
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**

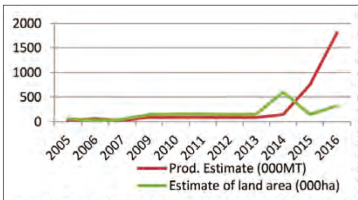


Figure 1. Trend of Rice(Paddy) Production and Land Area in Kebbi State. Data Source: Kebbi State Agricultural Development Project (2017)
(By Bello Shehu and Abubakar Lolo, 2017, Promoting Rice Productivity in Kebbi State: Linking Data and Policy , USAID, Michigan State Univ, IFPRI, and FMARD)

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?

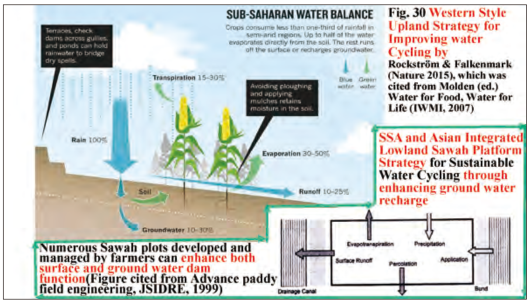


Fig. 30 Western Style Upland Strategy for Improving water Cycling by Rockström & Falkenmark (Nature 2015), which was cited from Molden (ed.) Water for Food, Water for Life (IWMI, 2007)

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).

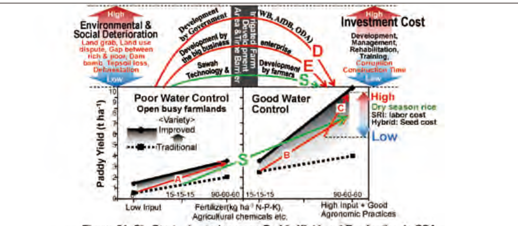


Figure 31. Six Strategies to Increase Paddy Yield and Production in SSA
A type strategy: Upland **NERICA** technology
B type strategy: **Asian Green Revolution technology**
C type strategy: **Hybrid seed and System Rice Intensification**
D type strategy: **Contractor based ODA** irrigation/drainage development
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	GDP2018Nominal $	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, 182)	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, 188)	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, 296)	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)	0.2	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	3.8(3.6, 106)	0.0	2,3,4, 5	4099	11669
15	Lao PDR	0.7(1.0, 164)		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 (5.8, 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			

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]													[illegible]	[illegible]	[illegible]
		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)	128	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)	91	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)	136	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	106	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)	188	116	172(2.4, 48)	104	71	209(2.7, 54)	75	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)	136	86	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	106	96(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)	59	44	56(3.9, 25)	27	58	70(4.2, 28)	19	26	4,5,6	1441	3535
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)	65	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	68	1,2,3	805	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	56	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)	58	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	7	20(1.3, 5.5)	105	7	35(1.3, 8.9)	90	7	1,2,3,4,5	1536	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)	19	33	1,2,3,4	822	2072
19	Mozambique	9.0(1.3, 6.9)	8.8(0.9, 4.3)	12(0.8, 4.6)	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, 6.4)	104	8.0(2.3, 6.7)	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	7	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)	60	51	12(1.0, 4.7)	51	63	11(1.7, 3.7)	48	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)	3	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	7	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	7	8.1(2.1, 4.0)	75	32	8.6(1.6, 5.0)	64	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)	60	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, 1.8)	31	78	3.6(1.3, 1.3)	33	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

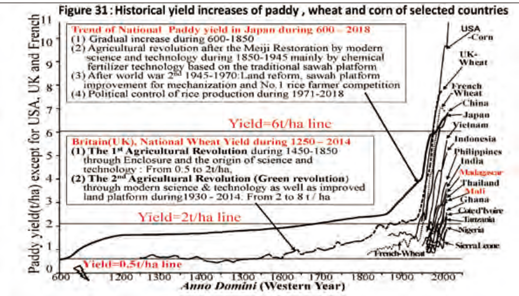
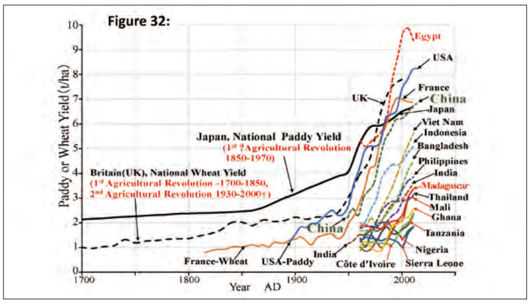


Figure 32 is a magnified view of the trend resolution of Figure 31. Britain has a very interesting trend. Britain had the lowest wheat productivity less than 0.5t/ha in the 1450 plague period. It took 400 years until to mark the yield 2t/ha in 1800. This is the so-called British Agricultural Revolution. 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).



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**

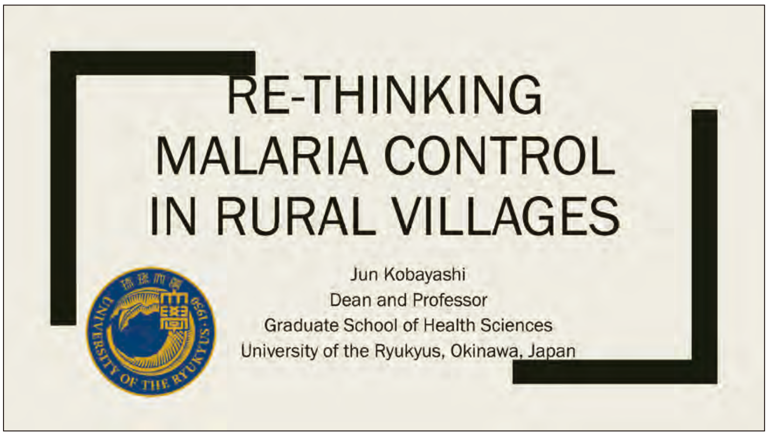
(4) **Rice cultivation is still minor for majority of eastern African Countries, which have domestic rice consumption 10 kg/person or less**

(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?



"How to evaluate variable environmental and economic factors in community-based malaria projects in Asia and Africa"

Jun Kobayashi

(Professor, Department of Global Health, University of the Ryukyus)

Kobayashi : Thank you very much for giving me the opportunity to speak among the eminent speakers. This is re-thinking. We have the outbreak of malaria everywhere, but I would like to focus on malaria control in rural villages.

In the first half, I will talk about the agricultural sector and the health sector, and how the two sectors can collaborate with each other. Often, we talk about cooperation. People do have conferences to cover harmonization, but I want to go one step further to integration because it is not meaningful unless we go that far. From my experience, I would like to explain how that will become possible. Agriculture is an area where I am not so knowledgeable about, so I would like to talk about how to ponder over that going forward.

In the second half – universal health coverage was advocated by Japan. This is related to the Japanese health care system. In the context of Africa, especially in rural areas, how are we going to apply that perspective?

Against malaria, inter-sectoral cooperation is already achieved. I was also involved in this process. One of them includes the cooperation with the education sector. The second one is the public security sector, such as the public safety sector. More recently, we do have the cooperation with the defense sector. Those are already ongoing. You might think this is something taken for granted, but it is time-consuming to achieve the cooperation. First, I would like to talk about education. This was mainly advocated by Japan. Japan is putting so much emphasis on education, starting from the period of Edo-era. Within education, health education is included. This is already incorporated from the pre-war period.

At the beginning, it was just to provide treatment at school, but it is something natural to have health education in Japan. However, this was not something common in other parts of the world, so we tried to be more specific.

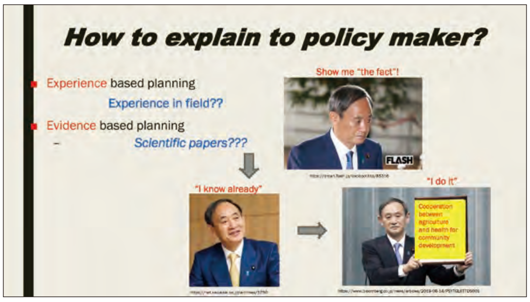
How malaria education would provide a stimulus to the community and not only to school was something we demonstrated. This is malaria education in school. This would not provide a stimulus to the community.

By using the extracurricular activities of the students, the students will become the messengers to stimulate the community. We advocated that. Evidence was produced, and as facts, this was submitted and recommended to policy makers.

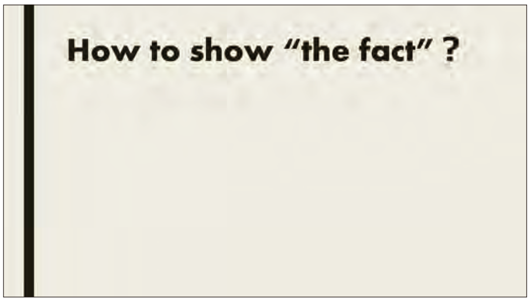
As a result, what we are seeing includes the movement of people. In immigrants and refugees, we see malaria as the issue. We need to make sure to educate the public security sector on how much damage malaria can create. This seems something taken for granted, but as we discussed in the previous session, if we look at the number of cases and the number of fatalities of malaria, they are very high in the world, but this is basically asymptomatic if you just look at the general public. According to the awareness in the rural areas and according to the awareness of the refugees, they just consider it as the common cold, so we need to make sure to deliver the facts.

This is an example in Asia. The malaria infection is spreading from the children to adults. Where are they now occurring? That became contentious. This is in a forest in Asia and it is illegal logging. This is continuing in Asia. They are trying to expand rubber farms. These are migrant farmers. We are seeing more cases among adults. We have been trying to provide an explanation to educate policy makers. More recently, we are seeing evidence that armies are becoming the carriers for asymptomatic malaria. It has been expressed as an easy-to-understand facts.

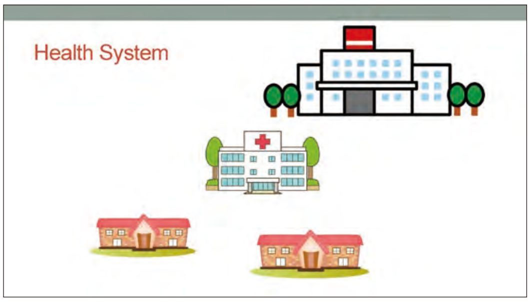
Now comes the title for today, the agricultural sector and the health sector. I think this is one of the agendas for today. How would the agricultural sector and the health sector relate to malaria? In the past decade, there was much attention paid to One Health. At the beginning, this was seen from the perspective of zoonosis. The agricultural sector is becoming more serious. This is related to antimicrobial resistance (AMR). This is the top agenda in health. AMR is not only for the use of humans, but contamination to the environment and to animals. The health sector is not sufficient to manage it on its own. They need to have cooperation from the other sectors, but at the beginning, there was barely any progress. To be specific, related to human health, it was significant, but to livestock and to the environment, people were not so conscious. With AMR, unless they are healthy people, it is not possible to have advanced treatment, including surgeries and operations. If you look at the Ministry of Agriculture, Forestry and Fisheries (MAFF) website, you can see the countermeasures of AMR. It is mainly led by the agricultural sector.



Given this background, how are we going to advocate about malaria? It seems like we have a participant from the cabinet office today as well, so I was wondering if I could use this picture. Chief Cabinet Secretary Suga often says, "Show me the fact!" In a specific case of coalfired power plants, the Chief Cabinet Secretary understood the decrease of that and there were looking at the facts. To be more specific, that was taken up. What exactly is the key message? I am more of an adventurer and I really like to go to remote areas. How are we going to convey those experiences? This is what we call the experience-based planning, but when we ask whether the policy makers have such experiences, they do not have such experiences. We often say that as evidence-based planning. However, just writing scientific papers does not mean that the message will be conveyed. With scientific papers, how are we going to convey the message the facts? Conveying the useful facts to policy makers can lead to a dramatic improvement.



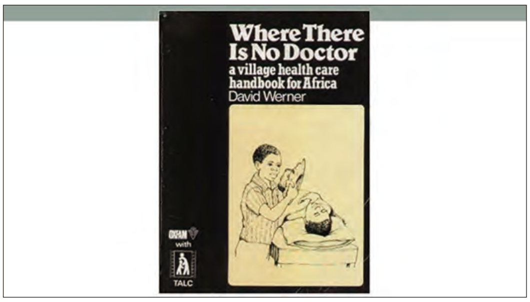
How are we going to show the facts? This is one of the experiences that I have.

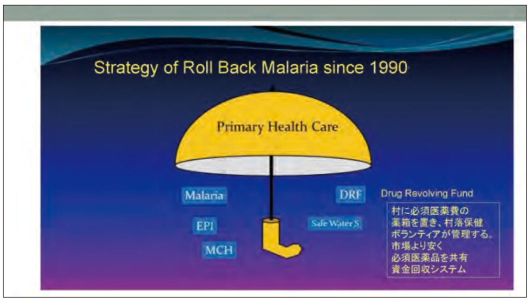


This is the very basics of public health. No matter which country you go to, we first check what kind of health system the country has established. Where is the core hospital? Where is the secondary hospital? Where are the leading and terminal hospitals? That is what it means.

It has been said before that this is a famous textbook that anyone involved in Global Health would be familiar with. This is like the bible, written by David Werner, Where There Is No

Doctor. What should we do if there are no doctors in some communities?

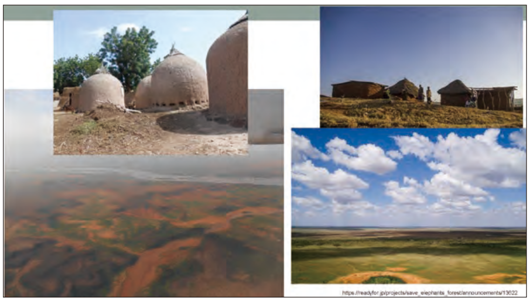




This strategy was made in the 1990s. These were the countermeasures against malaria. If there is no doctor, there should be a primary health care package. To be more specific, when there is no doctor, within villages, there should be volunteers who are developed as health volunteers. They will conduct health-related activities. For example, they will have health education be provided and maternity care. They will provide education, vaccinations, water, hygiene establishment, and malaria countermeasures. Not just bed nets, but the initial treatment was provided. This was very popular, and there was the drug-revolving fund. This is a system like Toyama's placement medicine in Japan. Inside the villages, they place a medicine chest which is low in terms of the price compared to the market. Antimalarial drugs are placed inside. Even without a doctor, initial treatment can be provided by the health volunteers. Even initial treatment for malaria is to be provided. In the 1990s, I was involved in that process. This was a five-year project. When I was there, it was fine, but since then, I looked at the five-year follow-up and this system was destroyed.

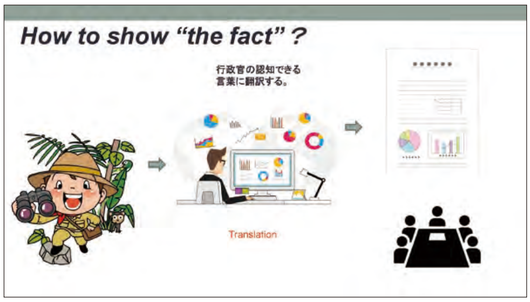
Why did that occur? In areas where I thought there were no doctors, there were minority ethnic groups. Once we began to understand their words – back then, I mastered the Lao language, and I was able to have direct communication. For them, they have doctors. The doctors we are considering have a doctor's license after passing the national examination, but there are traditional healers in the local communities. In their own words, they are actual doctors. Between the border of Laos and Vietnam, in the minority ethnic group, there are some specialists in gynecology, pediatrics, and elderly people. They have their own mountain, and they have herbal medicine in the mountain. They do this as their business. They are not just praying. Some would have a dramatic recovery. We thought that there was no medicine where there were no doctors, but when there is an illness, then there is medicine brought in. Even for Western medicine, there are people who would carry the medicine just like in Toyama. They are using such medicine or drugs.

At that time, there were problems of some pseudo-drugs. The counterfeit drugs were taken by those people who carried the medicine. What does that mean? Those people were according to the experts' papers that we read, but as a fact, this was not communicated to policy makers. From our perspective, what percentage of residents use the folk sector? How much access do they have to traditional healers? We tried to look at the epidemiological percentage and we published a paper. We tried to prepare one sheet of paper to allow for easy understanding by the policy makers. In the case of Southeast Asia, this is something taken for granted, and they should be involved in the actual treatment so that they avoid using counterfeit drugs. That was going quite successfully.

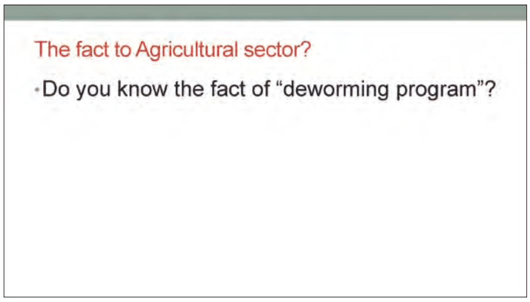


Now, what we need to consider is about Africa. On the left-hand side, this is where I visited in the field. This is a village in Niger. This is the Niger River. The villages in West Africa are in one location. Health volunteer strategies are promoted quite successfully, as they are so closely located with each other. Niger is a Muslim country. The kitchens are connected, and females are gathered. Because they are Muslims, they do not go out to public so often. It is easily imagined that this is a large network, and the countermeasures are quite well penetrated.

On the other hand, this is Kenya. I joined the field survey in Kenya as well thanks to Nagasaki University. This is just a copied photo, since I do not have good photos. In East Africa, why is there a higher infection rate of malaria? I think there are various factors. That is because houses are scattered. There are the functions of the villages, but even if volunteers are developed, there is so much distance between houses, just like in the case of Hokkaido. To go to the neighbor, there is much distance. In such places, is it possible to have the health volunteers functioning well? We need to think about that. I think this is an area where we have not been able to get the facts out unexpectedly.



I just summarize the first half, what kind of facts do we need to demonstrate as researchers, especially in the field? Especially the researchers who love the field, they just go to very deep parts of the villages, but we need to have translations so that evidence can be provided. We need to make sure the facts are understood by the policy makers. PowerPoints would not suffice because policy makers do not look at the PowerPoint slides. We just need to get the facts out in one sheet of paper so that policy makers can understand.

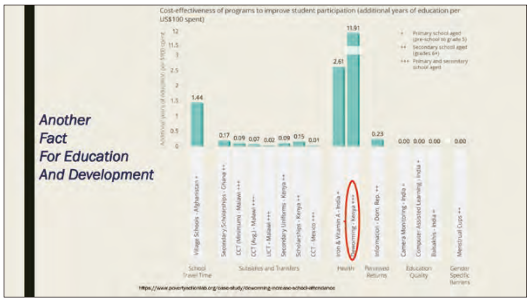


How are we going to deliver the facts? As I am beginning to run out of time, I will be very brief. Although the fatality is lower than malaria, there is also the soilborne parasite control program that I would like to talk about. I was involved in the Hashimoto Initiative, a program advocated by the Prime Minister, Mr. Hashimoto. When this was spread around the world, how we demonstrated the facts was different from the health sector and the education sector. It went well and successfully for the first time. This deworming program began in school. This went successfully in Japan. We tried to spread this to the world.

In fact, on the health side, we actually started the research from the 1950s. Rather than treating every resident, it is better to treat people at the school age because there are worm infections in children, and they are spreading. If we have the selective treatment to such children, it will have the same level of effect as treating all the residents. "Why don't we do this at the schools?" was proposed.

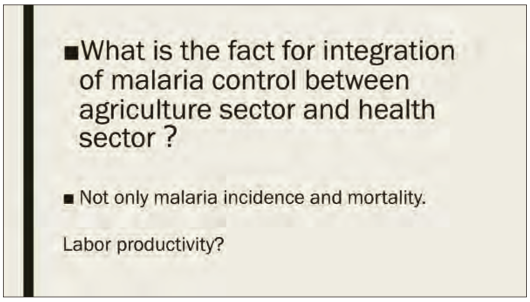
For schools, to be infected by the parasites, what are the conditions that the children are suffering? They are not visible. Not like malaria, and not like COVID-19, people do not die one after another, so what is to be presented at the school? The students are suffering from fever and diarrhea. Those are caused by bacteria. We do not know how they attracted them because they are not visible.

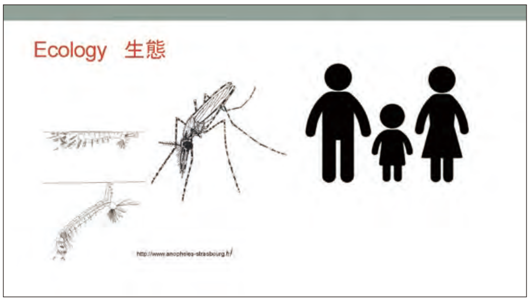
When we dewormed them, Japanese NGOs actively used this to their advantage. What comes out of deworming is visible. This is good for health education and this is easy for school-teachers to do. They did understand.



The next step would be to convey the evidence, facts to the policy makers for the effectiveness of the deworming program. With those facts, the World Bank picked up this program and all the education ministers across the world started to implement this program. The red here, Kenya is shown. If you invest $100, how many pupils will continue to attend the school? What would be the improvement of the number of school days? Of course, a lot of children go to elementary school, however the dropout rate is high. For how many days they continue to go to school and how well the attendance rate will improve are regarded as the benefits. There are programs providing scholarships, but then the return on investment is quite small. However, if we do the deworming program, then the return on investment is quite high, so the World Bank decided to invest in this program. So how to present the facts is especially important. COVID-19 is clearly the threat to all populations across the world. That is easy to communicate by health experts, to dispatch such information, but when a less-lethargic health issue is concerned, then involving people in education is especially important.

What do we have to show? As Dr. Wakatsuki mentioned earlier, in addition to malaria cases and mortality rates, it is necessary to show the relationship between labor productivity and malaria. However, since the environment is an issue, it is important to consider whether agricultural productivity alone is sufficient.



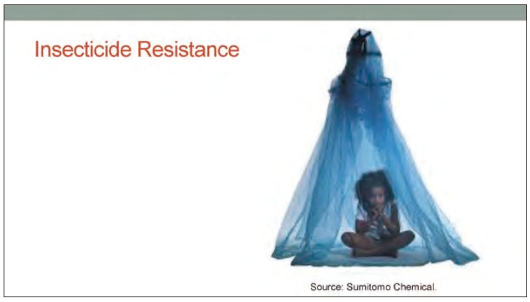


Next, we need to think deeply about the ecology. The human's ecology versus the mosquito's ecology – both must be considered.

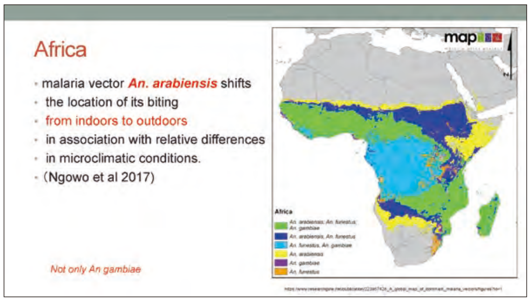
For the ecology of human beings, there are many incidents in Africa, and it is not the simple distribution of drugs or medication. There are some medicines that residents would prefer to take. For example, the malaria cocktail that the Cambodian people favor and that is effective for all kinds of malaria. However, white tablets would be more acceptable for people in Africa. Usually, people in our world would prefer the capsules with color, however the white tablets are popular in Africa because the anti-fever drugs are often white tablets. Therefore, it is easy for African people to accept. So, we need to have a deeper understanding about the ecology of people.

Also, healers. That is one ecology.

Also, the deforestation versus the lifestyle. We need to consider about that.



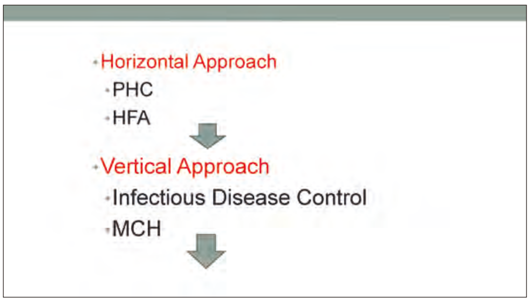
Also, insect bed nets.



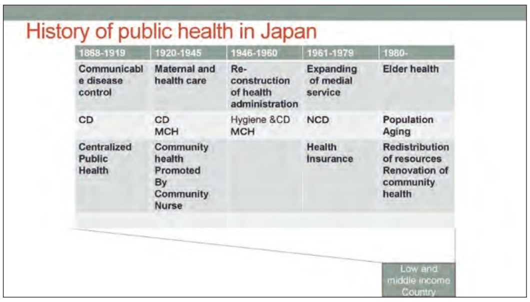
The use of bed nets is extremely effective, but now we need to revisit it. In Africa, in the old days, the vector was always Anopheles gambiae, however other vectors are emerging. Particularly, Anopheles arabiensis is important.

Because of the changes in variety, the sites of infection are changing from indoors to outdoors. Once that happens, bed nets alone would not be effective enough, so we need to seriously monitor how the situation changes.

Now, I would like to cover the last topic. Universal health coverage has been proposed globally.

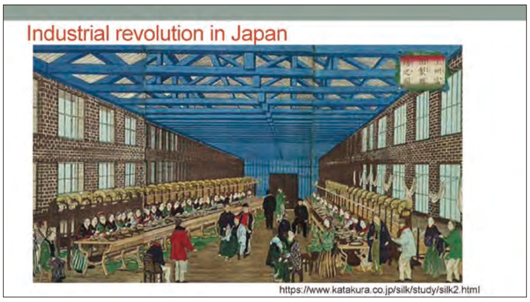


I will skip this slide because of the lack time.



The proposition of universal health coverage was based on the history of the public health system in Japan. The whole world is paying attention. Western countries have a longer history. Where the top-down infectious disease control worked quite well, it empowered the community to try to implement the system and it was passed to maternal and children health. After that, a similar public health system was now to be implemented in, for example, lifestyle-related diseases such as diabetes and so forth. Then, we talked about the reconstruction of the health insurance. We recognized the need for universal health coverage. Now, we talk about the health care for the elderly. We have a history of overcoming such issues step by step over 100 years, but in Africa, only in a matter of 20 years, everything is happening at once. It is not just communicable diseases, but also, they are seeing some aging of the population in Africa.

This is the core concept for universal health coverage. It is not just the health insurance issue, but at any rate, you need to think about how to ensure the health insurance. To think about the insurance, it is not a single way to look at this issue. We have the distinction in Japan of self-assistance, mutual assistance, joint assistance, and public assistance. This is as we have published a paper in English that we announced this concept to the world. This is not something common across the world. Of course, self-assistance and mutual assistance are practices everywhere, but the Japanese health insurance is not run by the government, it is built upon mutual help. That was mutual assistance and changed into joint assistance When you were in the farmland during Edo period, who would support your life in the case of an illness and so forth? It was not the shogun (tycoon) or the feudal lords, but it was the farmers who helped to support each other. In fact, one of the Edo shoguns, Tsunayoshi, was the first person to implement social security. He loved dogs so much and helped support dogs, but also others such as handicapped people and so forth. Many people helped each other under such a situation.



The industrial revolution took place in Japan and communities were built not only in the rural villages, but also in the urban cities. Associations of labor workers were formulated. That is the very basis of the social security system in Japan. Joint assistance has been built in this way.

The social security system, for example, in the Scandinavian countries, has high levels of service and benefits, and high burden. They believe that the government supports all through the years until the end, and a 40% or higher tax rate is applied. In Japan, if you are paying over a 40% tax rate, then you are making too much money. I would never be able to earn that much. Insurance is provided by mutual support.

That is a drastic idea to implement in Africa. It is not simple, but in the case of the support of farmers, can we implement insurance in the agricultural cooperatives or associations? That needs to be seriously explored in Africa. There are many issues such as government insurance and social security. Mostly, people working in the government, as well as the big companies, are supported quite well. For the rest of the population, how are we going to support? Would that be the public sector to support? Maybe the Japanese historical development of insurance starting from farmers. Would that be the model? We have the national health insurance and so forth. Would those be desirable ways? That needs to be explored going forward. That is all from myself. Thank you.

Takagi : Thank you very much, Dr. Kobayashi. Your talk focusing on the improvement on public health issues, and Dr. Wakatsuki's, which introduced the farmer-led rice production, sound they are two completely different topics. But if there is thread to connect the two and if they can be weaved together, maybe we will be able to have a new good idea.
I would like to ask Mr. Shiratori, as commentator, to speak about the farmers' perspectives and linking to the health perspective as well.

“Community Participation in Rice Development and Its Process from a Health Perspective”

Kiyoshi Shiratori (Africa Rikai Project / Specially Appointed Professor of The Center for African Area Studies, Kyoto University)

Shiratori : My name is Kiyoshi Shiratori. I was given the title “Community participate on in rice development and its process from a health perspective”, for which I will try to cover.

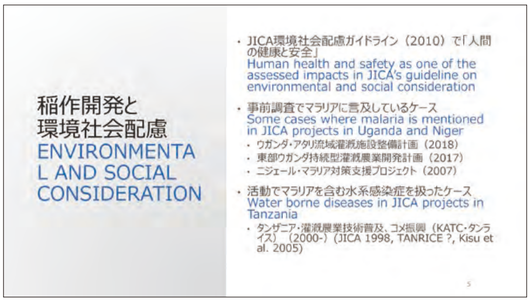
I have been involved in development cooperation for a long time. In Africa, I have worked in Tana River, Kenya as a volunteer. I was also in Kilimanjaro, Tanzania, the Ministry of Agriculture and Food, Ghana, and the Agricultural Research Institute, Ethiopia as an expert. The projects I was involved in Kenya and Tanzania were related to rice development. The work in Ghana was based on irrigation development. My current project in Ethiopia is to support rice research. All of them have been rice related activities. As my area of expertise is in the management of agricultural development, I will try to discuss rice production and malaria prevention from a practical project management point of view. I will also reflect my experiences in Tanzania, where issues related to waterborne diseases was a part of the project activity and in Ethiopia with the participatory agricultural research promotion.

It has been said that the rice production in Africa brought economic gain which contributes to the improvement of malaria prevention and treatment measures taken by farmers. Therefore, the rice production did not increase the risk of malaria infections. This is called the “paddy paradox”. Compared to those experiences in the 1980s and the 1990s, the status of malaria in Africa has dramatically changed after 2000, and there are opinions that the economic impact on malaria prevention may not be that high anymore. This means that, until the 1990s, the malaria infection rate was relatively high in general, under which the impact of the economic gain on malaria prevention and treatment was significantly effective. However, the malaria infection rate has declined drastically in general therefore rice production, which definitely brings an increased number of mosquitoes resulting in higher malaria risks.

If that is true, it may be problematic in Africa where the rice production area is expected to expand. In Africa, rice consumption is rapidly increasing but local production is not catching up to the demand and rice import is increasing. Among such countries, there is a tendency to promote irrigation development to increase local rice production for strengthening food security and preventing the outflow of foreign currency. In Ethiopia, irrigation development is being pushed and such newly developed areas may be at higher risk of malaria. However, as we discussed in the last round table, we need to consider the variations on technology levels, environment and rice ecosystems among different countries and areas.

The economic benefit of rice production is quite important to the national economy as well as farmers' household economy. So even if there are higher risks, promoting rice production is needed, and yet controlling malaria.

We had some initiatives to have malaria vector control through production management practices. Just like Dr. Wakatsuki said, we had chemical control, fish-rice farming system, duck-rice farming system, and Azolla to suppress hatching mosquito larvae. In parallel with rice production development, it is important to establish the health system for the community. Such measures to reduce malaria risks need to be considered for its priority from a technology and an institutional perspective. To rice-producing farmers, it is important that new technology, approaches and/or systems improve water, land and labor productivity, and profitability, based on which farmers make decisions. Furthermore, if we do this intervention under aid projects, its cost-effectiveness needs to be considered seriously.



Has the Japanese aid in rice development ever considered malaria risks? JICA has a guideline on environmental and social consideration. They stipulate human health and safety as one of the impacts to be assessed. I looked through JICA's project evaluation annual reports since 2007. I found two projects in Uganda referring to malaria risks at their preliminary survey. Another project in Niger, which was not an agricultural project, in its document mentioned integration of malaria control with the agricultural sector development under the National Marilia Control Strategy. Both documents are preliminary survey reports, and no information could be obtained whether any malaria control measures were taken during the implementation of the projects. Based on the information obtained from some people who are currently involved in rice development projects in Africa, ongoing rice development projects do not include any malaria related activities.

An exceptional case is the project in Kilimanjaro, Tanzania. Waterborne disease preventive measures, which was not the part of initial plan, were taken up in the project activities, which were surveys and training materials development. For malaria control in the project area, the irrigation rotation, in response to water shortage, must have worked on the mosquito prevention. For schistosomiasis, surveys of vector distribution with farmers group and infection tests of elementary school pupils were carried out and awareness of farmers was raised. Eventually, the activities had had a significant impact on the children's behavior patterns and treatment of the disease. As a part of the training for extension workers and rice farmers, a subject of "irrigated rice production and health" was included and continues to this day. It is not clear how the project in Tanzania started the activity on waterborne disease. One story explains that a Japanese TV program covered the issue of schistosomiasis spreading in the project area.

In any case, it seems certain that the relationship between rice development and malaria risk needs to be re-examined. There seems to be a need to accumulate evidence and examine it according to localities and levels of irrigation technology and make recommendations on how to handle malaria and what to do about it in rice development.

Consultative Group on International Agricultural Research (CGIAR) has had a research program called "Nutrition and Agriculture for Health (NA4H)" since 2012. The shift of the relationship between malaria and the irrigated rice today from the past, mentioned earlier, is the result of research conducted as part of this program. It is desirable that the importance of malaria control in rice development come to light by continuing the CGIAR research keeping productivity, profitability, and cost-effectiveness.

This kind of cross-sector research is rather difficult by research institutes under ministries of agriculture in African countries because of compartmentalized structures and priorities. It may be feasible at the university level. Therefore, CGIAR should take the lead by involving researchers from local research institutes. There is a way of including the health issue in rice development under the CARD (Coalition for African Rice Development) by taking health as one of the important factors to improve productivity and profitability. By that way, it should not be so difficult to include activities preventing health getting worse from malaria and hopefully be improved in agricultural projects.

Collaboration of the agriculture sector and health sector is desirable and placing a platform to facilitate information exchange and collaboration between the sectors and/or involving health experts in the rice production projects may be needed. But such an arrangement can be challenging considering the fact that, even in the agricultural sector alone, there is a gap between research and the extension. Setting up a platform does not bring its autonomous function.

In the Japanese livelihood improvement program, demarcation was the issue between agricultural extension offices and health care centers. In successful cases of collaboration, it was not because of functioning a multi sector platform, but because of the personal qualities and ability of extension workers and health advisors to promote collaboration with other institutions which was actually an important factor. Similarly, in agricultural projects, we need to have experts who have broader perspectives.

It is important that private sector involvement be considered as effective in establishing a health system in parallel with rice development. The public services in African countries are often not functioning well due to a lack of budget. Boosting private clinics and pharmacies may lead to the sustainability of health care services.

Lastly, I would like to talk about the usefulness of participatory approach for the development and adaptation of new irrigation technologies.

In many cases, agriculture in Africa is considered complex, diverse, and risk prone. Even in the case that modern water control is achieved through irrigation systems; a complex, diverse, and risk-prone agriculture continues to remain as an aspect of Africa. Especially, small farmers that own livestock and grow a variety of crops and maintain their households at complex, diverse, and high-risk situations. Their decisions as management strategies they develop are made far more beyond what we can imagine in most cases. When we are to support their farm management under such unusualness, proceeding technology development together with the farmers through a participatory approach can be helpful.

In our experience of participatory agricultural research in Ethiopia, we synergize farmers' localized knowledge and researchers' scientific knowledge, and we were able to incorporate factors unknown to us. By participating in such activities, farmers were empowered in problem solving capacities and raised farmers' ownership against further challenges.

The example of Lower Moshi in Tanzania, farmers realized the relationship between children's behavior in water and school attendance and the grades through participating surveys on schistosomiasis, which led them to take proactive prevention and treatment measures. The introduced technology is not always used in a complete form in Africa. In restricted environments, the best approach needs to be selected or developed. In such a process, participatory research is useful. From that perspective, against the challenges we have for malaria control and rice development, I think a participatory approach is well worth considering.

Thank you very much.

Discussion

Takagi : Thank you very much, Mr. Shiratori. We were able to hear the three presentations that we asked them to prepare. We were able to have all the speeches today. The topics were quite broad and diverse, and yet, in fact, the target of topics was common across the three speeches, they sounded to have a common strategy. We need to ask the local people and farmers who are actually living in the field, and how we can get them understand and work together to create our ideal situation because real operators in paddies are never us but local farmers. No matter how hard we try, we cannot do it. That is something that I thought. We started to see some of the strategies desirable to have. In that situation, could you elaborate on that, Prof. Tanaka?

Tanaka : By the way, more than 20 participants are joining this session. However, we only have over 10 minutes until the scheduled time of closing. Should we spare some time for soliciting comments?

Takagi : Well, my idea is that we would like to fully utilize the chat system and maybe we can respond later.

Tanaka : Then, very simply I would like to relate the three speeches to each other and try to come up with a sort of conclusion.
In Dr. Wakatsuki's speech, he emphasized the importance of establishing the so-called sawah system in Africa. As the word “sawah” means wet-rice fields in Asia, he pointed out the significance of water control in rice cultivation by using this word. However, in contrast to the long experience in Asian rice farmers, African farmers had to learn water management technologies in quite shorter time. That is something related to Dr. Kobayashi's report on infectious disease control, as well as the health and hygiene system development. Japan took about hundred years to prepare such a health system, but it was too short for African farmers to materialize it. This is also the reality mentioned by Dr. Kobayashi. Dr. Wakatsuki's presentation also indicated the importance of establishing sawah system through the participation of farmers by following the Asian development model. He defined this unique approach as the Sawah Hypothesis. According to him, to establish the sawah in Africa, that is the establishment of wet-rice fields equipped with well water-management system, will be probably the best way to control malaria. I think, this was the main message of his presentation.
On the other hand, Dr. Kobayashi's comment was something that we need to explore at Malaria No More Japan for the future. I think we receive very concrete advice, which is how to present the facts. In response to the results of the first session, Dr. Wakatsuki showed the country-wide statistical data today on the increase of rice production and the mortality cases of malaria. However, as rice cultivation in Africa is diversely developed and highly localized despite short time period for the development, we need to collect more

microscopic, location-specific data for communities, and we need to show and demonstrate the facts. The field scientists, whichever agronomists, or infectious disease specialists, are highly expected to play their roles in collecting and monitoring such data and presenting these facts to the communities. I think, Dr. Kobayashi's impressive message in his presentation was that he pointed out the importance of choosing the most appropriate object or organization to which we are going to present such facts. We will have to present the facts in a way that we can convince the persons or organizations concerned to follow them up. I think we have learnt from Dr. Kobayashi's speech that we should be very strategic in such efforts.
Following two keynote speeches, I think Mr. Shiratori seemed to propose the action to put Dr. Wakatsuki's and Dr. Kobayashi's propositions together. As there must be increasing expansion of rice cultivation in Africa in the future, we will have to reexamine the reality of so-called "paddy paradox". The relationship between the expansion of rice cultivation and the prevalence of malaria infection needs to be reinvestigated. I think, this is the most important message of Mr. Shiratori's comment. Of course, in the process of implementing the reinvestigation we need to solicit the participation from the local farmers. The Sawah Hypothesis is one of such models that Dr. Wakatsuki has been implementing from the past as well. As Dr. Kobayashi advised earlier, we need to resummarize the experiences so far and to formulate them as good practices. Also, we need to present them in a way that the audience would fully understand the importance of these facts. Combining the discussions from three speakers, I think we could get positive suggestion as an achievement of today's second session that Malaria No More Japan needs to take more practical actions going forward in Africa. I am not sure whether we will rely on the government's funds or the private sector's funds, they seem to emphasize that it would be very necessary for MNMJ to organize and implement more practice-oriented or selective action programs. Of course, the programs should be planned through the interdisciplinary collaboration, at least, including experts from the fields of agriculture, malaria disease, and social behavioral sciences. As a conclusion, I also would like to suggest that MNMJ is going to establish a strategic action to materialize such practical programs.
It was extremely hard to connect all these three speeches, but that is my version of a five-minute summary. Thank you. We would like to entertain comments from the participants.

Takagi : In the remaining time, if you would like to comment, please feel free to raise a comment. Although the time is limited, we would like to entertain questions. Any comments?

Secretariat : Dr. Takagi, in the chat, we have comments from Professor Jo Lines. Is it possible that we ask comments to Dr. Jo Lines?

Lines : We are interested in all of this, but now I would like to comment on just one point: the farmer participation. On our side, we are used to health discussions with people about health problems and mosquitoes in general. People understand malaria is transmitted by mosquitoes. I want to know what farmers say about mosquitoes when it is a discussion about farming, not about health!

Takagi : Dr. Kobayashi, would you please respond.

Kobayashi : Should I respond?

Takagi : Yes, would you please respond? I think it is better that you respond.

Kobayashi : Yes, I think this is an important comment. This is what people on human ecology always make discussion. There are areas where they know more than we do. On the other hand, Malaria is related to mango, because mango season is the rainy season and people feel that they get infected with malaria when they eat mangoes. Understanding of the residents in the community, not only of malaria, but we need to look at all the health behaviors related to malaria. Also, malaria-carrying mosquitoes. Many of the children may be aware of that. There are people who say that malaria is infected by drinking water and food. I think this is an especially important comment. This is a neverending research agenda we will continue to have.

Takagi : Thank you very much for your comment. We only have two more minutes. Would anyone like to express their opinion verbally? If you have any, please raise your hand.

Tanaka : Responding the chat, I would like to introduce my experience in Asia. The question was what farmers say about mosquitoes when they talk about farming activities. They never talk about mosquitoes in Asia. This is my answer. They barely talk about it. With malaria, of course fever happens, and when farmers cannot go out in the field, they are just suffering from malaria and they are struggling. Once they recover, they just go right back to farming activities. When they talk about farming activities, farmers would not think about mosquitoes. They never think about mosquitoes because there are other water sources in the neighborhood of their own house, rather than in the farming field. Therefore, they get mosquito bites when they are at areas closer to home. Therefore, Asian farmers when they talk about farming, they never talk about mosquitoes at all.

Takagi : I agree with you. As Dr. Wakatsuki mentioned earlier about mosquitoes, I tried to insert my comments as well. Just roughly speaking, the malaria-transmitting mosquitoes in Asia are not of rice paddy breeders. Usually,

they are from temporary water sources or also there are some water streams. The situation is completely different from Africa. In the case of Africa, there is Anopheles gambiae, where some will breed in temporary water sources, but some are in the sawah as well. There are plenty of mosquitoes in Africa in the doubling game. There are many sources of mosquitoes in Africa, therefore the countermeasures must be diversified as well. It is sort of like moving pieces of a puzzle. From that point of view, in Southeast Asia, it is easier to work with and yet there are some difficult problems.
Time is running out. I tried to mention earlier that it is quite a shame that we need to conclude this topic at this juncture. We need to of course refine the theme. We will select members, get together and try to refine this topic. I wish to have another opportunity if timing allows. I would like to continue with these efforts and discussions going forward. Earlier, we talked about the concept of strategies of what to do, but in order to make that into practice, we need more energy and better and deeper discussions to explore this topic more, so I hope to have your support and cooperation for future discussions as well. It is very unfortunate that it already past two minutes after 7:00 p.m., so at this juncture, unfortunately we need to close this session today. Thank you very much.

Appendix1 : Speakers' Profile

Dr. Takahiro Shinyo

(Chairman of the Board, Malaria No More Japan; Dean and Professor, Integrated Center for UN and Foreign Affairs Studies, Kwansei Gakuin University, Trustee of Kwansei Gakuin)

Dr. Shinyo graduated from Osaka University with a bachelor's degree in law in 1972 and joined the Ministry of Foreign Affairs of the Government of Japan. In 2002, he became Consul-General of Japan in Dusseldorf. In 2005, he headed the Global Issues Department of the Ministry of Foreign Affairs. In 2006, he became the Ambassador Extraordinary and Plenipotentiary at the Permanent Mission of Japan to the United Nations. In 2008 he became the Ambassador Extraordinary and Plenipotentiary of Japan in the Federal Republic of Germany. He obtained his doctoral degree in law in 1996. In March 2012, Dr. Shinyo retired from the Ministry of Foreign Affairs. He became the Vice President of Kwansei Gakuin University (KGU) and the Head of the Organization for Worldwide Collaboration. He was awarded the Grand Order of Merit of the Federal Republic of Germany and Ordre National de la Légion d'honneur, Chevalier of the French Republic. In April 2017, Dr. Shinyo became the Dean of the Integrated Center for UN and Foreign Affairs Studies of KGU.

Mr. Kiyoshi Shiratori

(Managing Director of the Africa Rikai Project [NPO]; Research Professor [part-time], Center for African Area Studies and Visiting Professor, Graduate School of Asian and African Area Studies, Kyoto University [part-time])

Mr. Shiratori obtained a BSc and a MSc in development studies from East Anglia University. After working in Kenya as a member of the Japan Overseas Cooperation Volunteer, he then went on to working with Japan International Cooperation Center, Foundation for Advanced Studies of International Development and Kaihatsu Management Consulting Co. Inc. He worked as a development worker in several agricultural projects in Tanzania, Ghana, and Ethiopia. He is specialized in rural and agricultural development, participatory agricultural research, and institutional development.

Dr. Jun Kobayashi

(Professor, Department of Global Health, University of the Ryukyus)

Prof. Dr. Kobayashi has more than 20 years' experience in global health and is the author of more than 100 publications in international scientific journals.
He has made contribution in strengthening the capacity of infectious disease control and school health in low and middle income countries under the Japanese Official Development Assistance (ODA) program with a point of views both of a practitioner and a researcher. He received 3rd merit of labor from the Lao government in 1999 for making contribution in malaria control. From 2000, he had joined the core member of Hashimoto Initiative, mentioning the importance of deworming and other infectious disease program in school. He made numerous contributions in the human resource development for policy management in Asia and African countries. He has been a chair of Japan consortium for global school health research (JC-GSHR), a think-tank and the focal point of Japan for global promotion of school health, since its inception in 2008.
He is currently Dean, Graduate School of Health Sciences, University of the Ryukyus, which is 2nd oldest school of health sciences in Japan. He is also the program leader of Okinawa Global Health Program in this school, which was newly founded in October 2015 to promote human resource development contributing in the public health issue in the region.
For his research in school health based disease control, which helped decreasing malaria incidence in Southeast Asia, he received "the Zero Malaria Award" from Malaria No More Japan in 2016 and "Aikawa Masamichi Award" from Japanese Society of Tropical Medicine in 2017. His contribution in the practice of global health, such as promoting the school health in developing countries and assisting to Myanmar migrant, was granted with the encourage award from Ooyama foundation in 2013.

Dr. Masahiro Takagi

(Board Member of Malaria No More Japan, Professor Emeritus, Department of Vector Ecology and Environment, Nagasaki University)

Masahiro Takagi, PhD; Professor Emeritus, Nagasaki Univ.; Board Member, Malaria No More Japan; Executive Adviser, West Japan Building Service inc.; 1967, Bachelor, 1969 master's degree, Kyoto Univ., 1980 PhD, Mie Univ.; 1973-1985 Assist. Prof., Mie Univ., 1985-1988 Senior Investigator, National Inst. of Infectious Diseases; 1988-1997 Assoc. Prof., 1997-2010 Professor, 2007-2009 Vice Dean, Inst. of Tropical Med., Nagasaki Univ.; 2006-2008 Advisor to the President, 2008-2010 Vice President, Nagasaki Univ.; 2008-2010 Director, Center for International Collaborative Research, Nagasaki University; 1980-1981 WHO Scientist (Entomology) in Fiji; 1982-1983, 1985-1986 JICA Expert in Indonesia; 1995-2001, 2005-2008 Board Member, 1998-2001 Editor in Chief 2008-2010 President of The Japan Society of Medical Entomology and Zoology; 1997-2002, 2006-2011Board Member, 2000-2002 Editor in Chief of Japanese Society of Tropical Medicine; 1996 Award from The Japan Society of Medical Entomology and Zoology, "Ecological study on the abundance of vector mosquitoes in relation to environmental factors"

Prof. Koji Tanaka

(Professor Emeritus, Kyoto University)

Mr. Tanaka graduated from the Graduate School of Agriculture of Kyoto University with master degree in 1972. He started his academic careers as a research associate at the Faculty of Agriculture, Kyoto University in 1973, and moved to the Center for Southeast Asian Studies (CSEAS), Kyoto University in 1979. Since then, he has conducted various studies on Southeast Asia in the fields of agriculture and natural resource management as an associate professor and professor. He was appointed as the Director of the CSEAS in 2002 and took the directorship of the CSEAS and the Center for Integrated Area Studies until his official retirement in 2010. After retirement, he served Kyoto University as a special assignment professor until 2015 as well as the Director of the Hakubi Center for Advanced Studies and the Director of the University Research Administration Office. After leaving Kyoto University, he was sent to Myanmar until November 2017 as the chief advisor to coordinate the JICA technical cooperation program granted to Yezin Agricultural University to support the reformation of its education and research management systems.

Dr. Toshiyuki Wakatsuki

(Professor Emeritus, Department of Environmental Management, Faculty of Agriculture, Shimane University)

Toshiyuki Wakatsuki (Professor Emeritus of Shimane University), Professor of Shimane University and Kinki University. 1977 Doctor of Agriculture, Kyoto University (Soil Science), 1980-81 Visiting Researcher, Wageningen University (Volcanic Ash Soil in Kenya), 1982-85 JSPS KAKENHI member, " Volcanic ash soils and agroecology in Kenya, Tanzania, and Indonesia", 1986-89 JICA Expert (Rice Cultivation), 1992-98 KAKENHI Coordinator and Leader, "Restoration of Inland Valley Ecosystems in West Africa", 1997-01 Leader of JICA/CRI Joint Study Project on "Integrated Watershed Management of Inland Valleys in Ghana and West Africa", 2002-17, KAKENHI- A, S, and Special Promoted Research, etc. Leader of "Research and Development of Sawah Technology and Implementation in SSA", 2002-19 JICA African Rice Cultivation Trainee Lecturer, 2018-21, KAKENHI "Academic Survey on Rice Revolution in Kebbi, Nigeria by Endogenous Sawah Platform Development"

Appendix2 : pre-study session “Rice Production and Malaria in Africa”

Some research shows the data of the increase case of malaria in the process of agricultural development, especially rice production. Rice production project, which was implemented for income-generating scheme, might cause the negative impact on the local residents' economic empowerment. We organize this study session to share the data and situation by using statics and past research data. Through this closed discussion, we aim to focus on the issues on the agricultural development and global health.

Organizer : Malaria No More Japan

Date : 15 May 2020, from 1:00pm to 3:00pm

Venue : Set-up ZOOM online conference system

Language : Japanese /English *simultaneous interpreter will be introduced.

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

Keynote Speakers : Dr. Jo Lines (Professor of Malaria Control and Vector Biology, London School of Hygiene & Tropical Medicine)

Dr. Kazuki Saito (Africa Rice Center; Japan International Research Center for Agricultural Sciences (JIRCAS))

Commentators : Dr. Shigeyuki Kano (Board Member, Malaria No More Japan; Director, Department of Tropical Medicine and Malaria, Research Institute, National Center for Global Health and Medicine (NCGM))

Dr. Masahiro Hashizume (Professor, School of International Health, Graduate School of Medicine, The University of Tokyo)

Dr. Mika Saito (Assistant Professor, Graduate School of Medicine, University of the Ryukyus)

Dr. Noboru Minakawa (Professor, Institute of Tropical Medicine, Nagasaki University)

Kenichi Shishido (Vice President, JICA)

Takao Toda (Vice President, JICA)

1 : 00 pm open

1 : 01 pm brief explanation about this study session from Malaria No More Japan

1 : 05 pm Keynote Speech “malaria and its negative impact” by Dr. Jo Lines (Professor of Malaria Control and Vector Biology, London School of Hygiene & Tropical Medi-cine)

1 : 25 pm keynote speech “rice production and malaria in Africa” by Dr. Kazuki Saito (Africa Rice Center; Japan International Research Center for Agricultural Sciences (JIRCAS))

1 : 45 pm comments and discussion

2 : 40 pm close

Appendix3 : Slides of pre-study session

Dr. Jo Lines (Professor of Malaria Control and Vector Biology, London School of Hygiene & Tropical Medicine)

Dr. Kazuki Saito (Africa Rice Cen-ter;Japan International Research Center for Agricultural Sciences (JIRCAS))

Kallista Chan (Research Assistant of Vector Biology and control, London School of Hygiene & Tropical Medicine)

The following is the joint report material.

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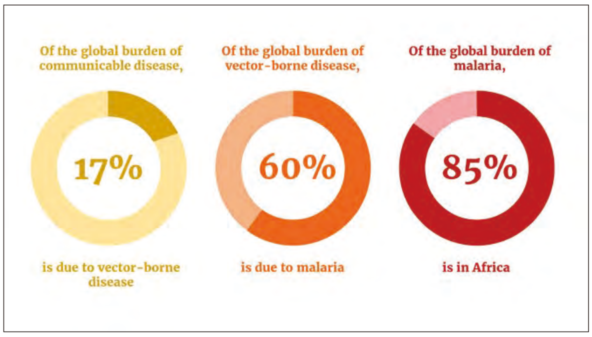

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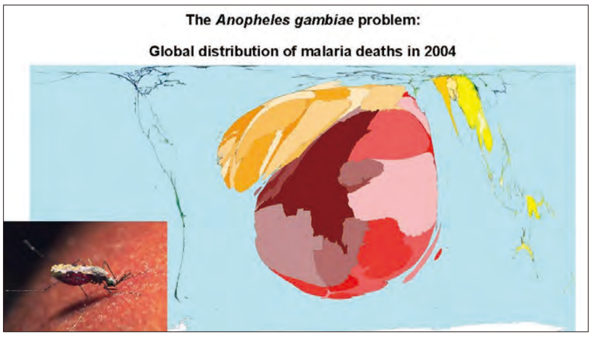

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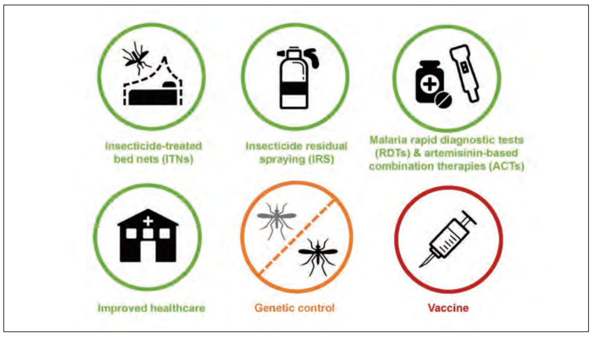

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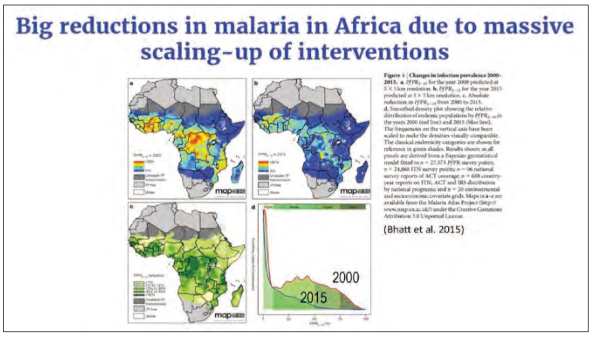

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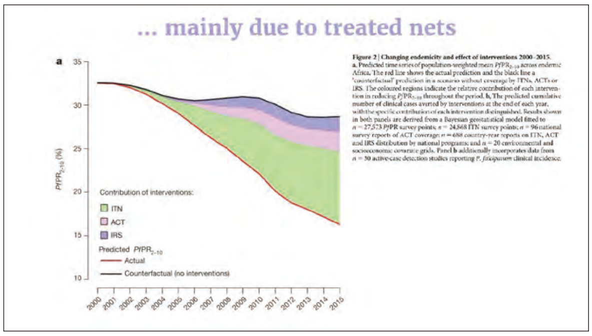

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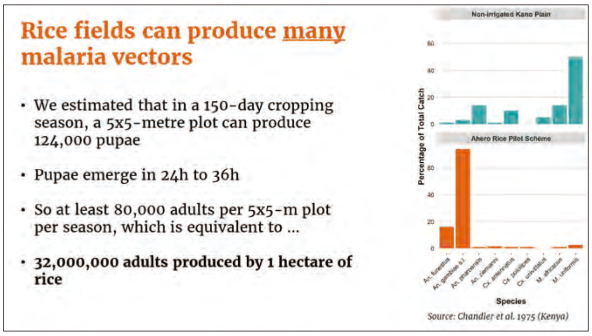

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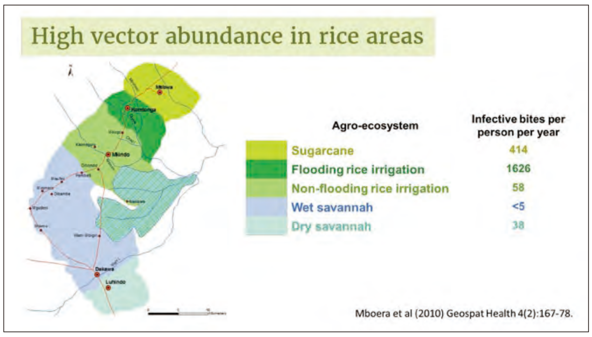

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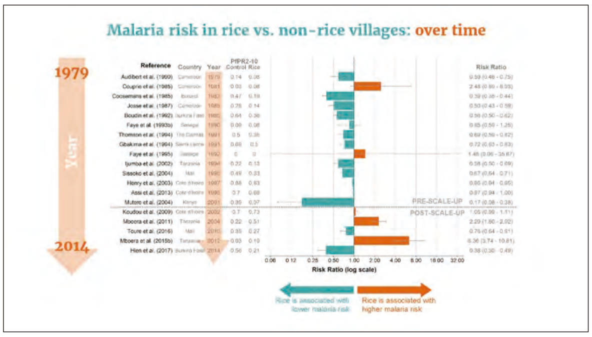

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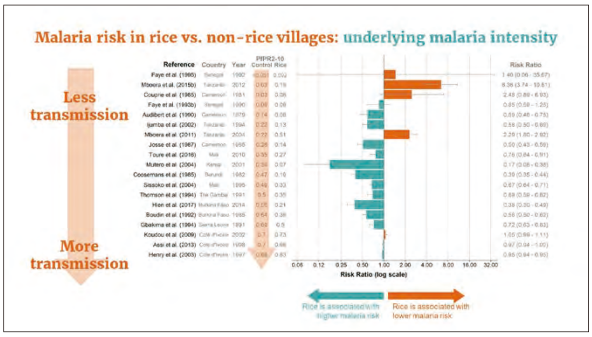

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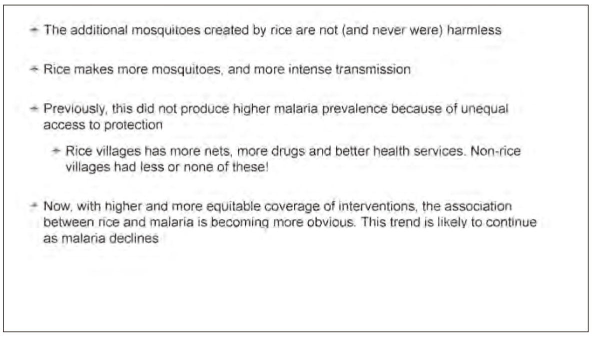

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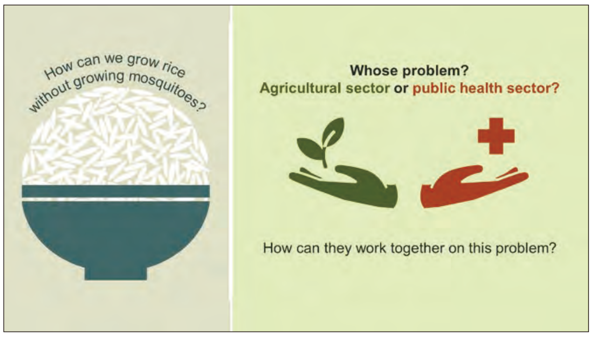

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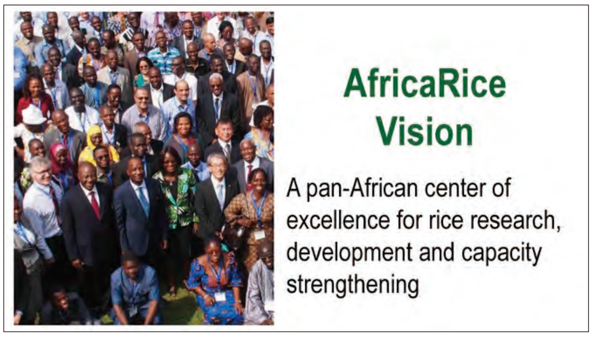

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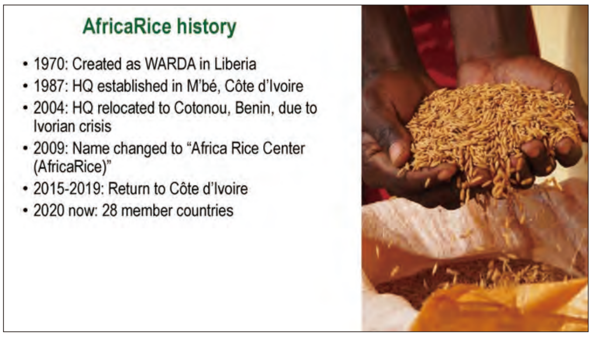

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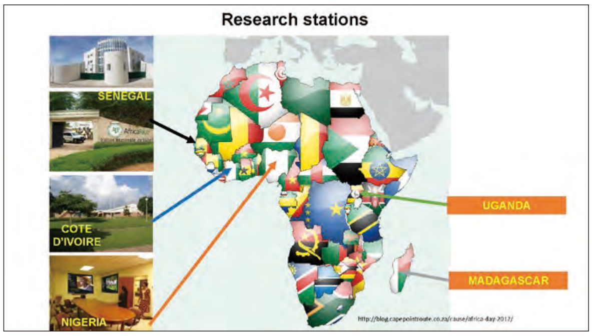

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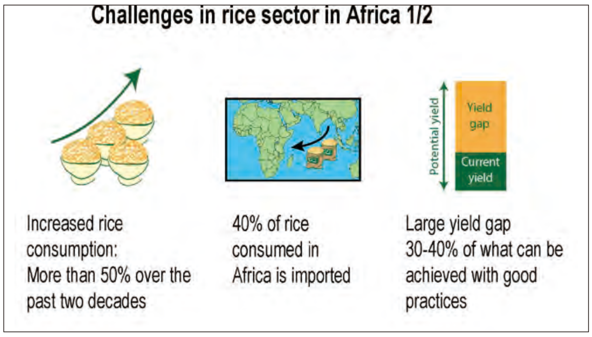

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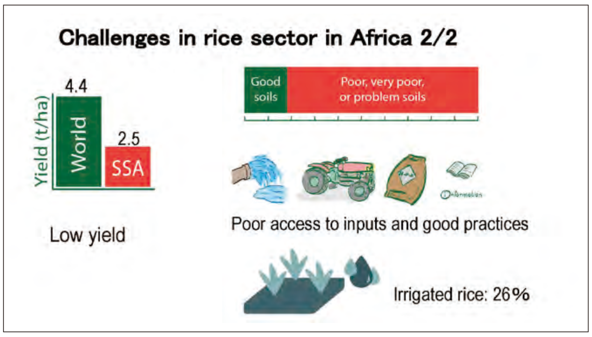

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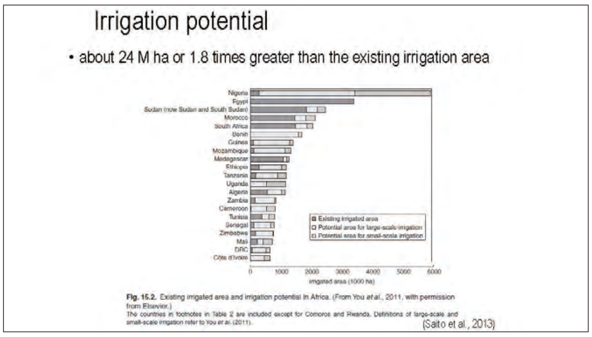

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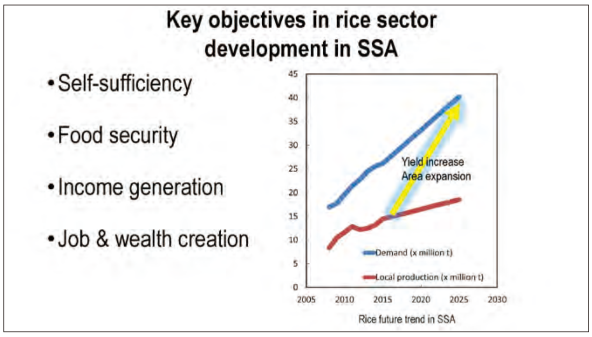

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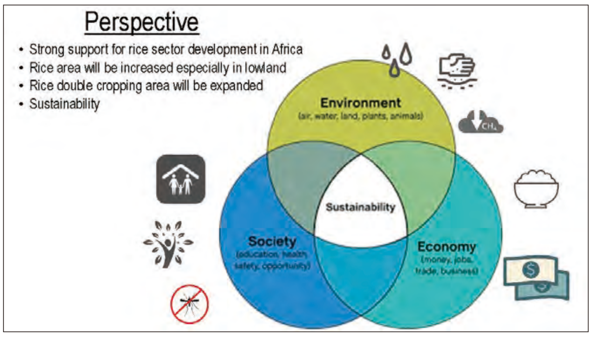

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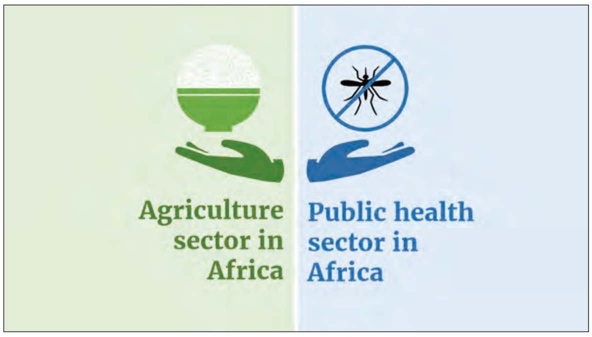

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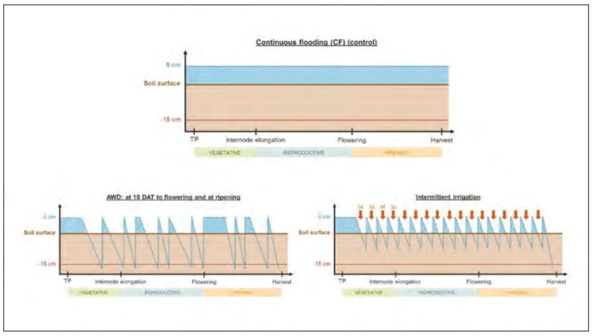

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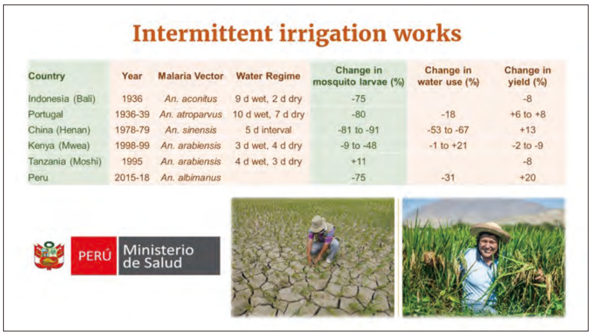

Country	Year	Malaria Vector	Water Regime	Change in mosquito larvae (%)	Change in water use (%)	Change in yield (%)
Indonesia (Bali)	1936	*An. aconitus*	9 d wet, 2 d dry	-75		-8
Portugal	1936-39	*An. atroparvus*	10 d wet, 7 d dry	-80	-18	+6 to +8
China (Henan)	1978-79	*An. sinensis*	5 d interval	-81 to -91	-53 to -67	+13
Kenya (Mwea)	1998-99	*An. arabiensis*	3 d wet, 4 d dry	-9 to -48	-1 to +21	-2 to -9
Tanzania (Moshi)	1995	*An. arabiensis*	4 d wet, 3 d dry	+11		-8
Peru	2015-18	*An. albimanus*		-75	-31	+20

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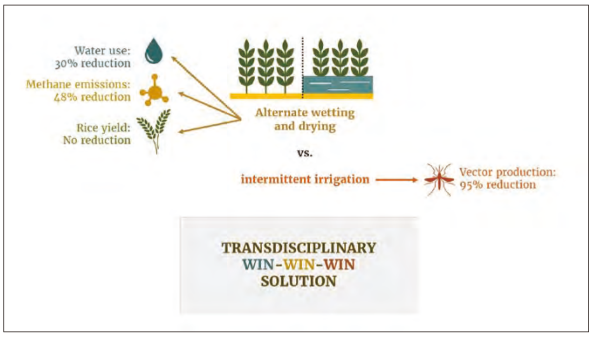
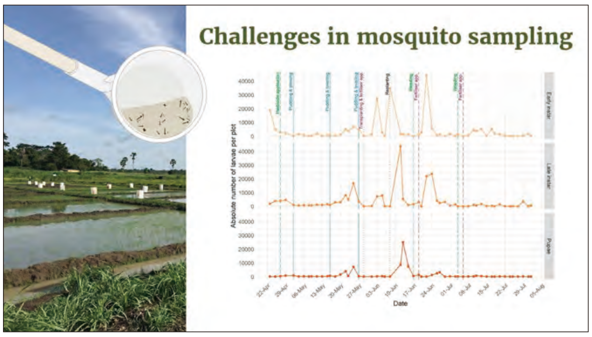

Water use:
30% reduction
Methane emissions:
48% reduction
Rice yield:
No reduction
Alternate wetting
and drying
vs.
intermittent irrigation
Vector production:
95% reduction
TRANSDISCIPLINARY
WIN-WIN-WIN
SOLUTION

30


Challenges in mosquito sampling
Absolute number of larvae per plot
Date

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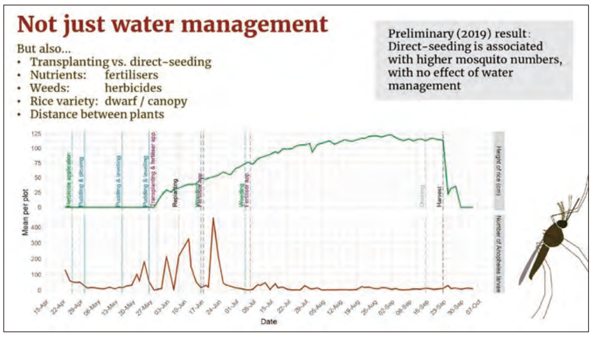
Not just water management
But also...
• Transplanting vs. direct-seeding
• Nutrients: fertilisers
• Weeds: herbicides
• Rice variety: dwarf / canopy
• Distance between plants
Preliminary (2019) result:
Direct-seeding is associated
with higher mosquito numbers,
with no effect of water
management
Mean per plot
Date

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Summary
• In SSA, rice production will
increase in area and intensity
• The number of mosquitoes
from rice will also increase
• We need to grow rice without
growing mosquitoes!
• Such methods do exist but
have problems
• Need to improve and integrate
• Let's be part of the solution!

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Thank you
AfricaRice
CGIAR
LONDON
SCHOOL of
HYGIENE
&TROPICAL
MEDICINE
CGIAR
Agriculture for
Nutrition
and Health

Appendix4 : ZERO Malaria 2030 Campaign

Malaria No More Japan (MNMJ) has launched "ZERO Malaria 2030" Campaign on the "World Malaria Day" on April 25, 2017. It is a platform for industry-government-academia-civilian collaboration, working for "a world without malaria" from Japan through events and information dissemination. Since 2019, it has held a roundtable to discuss various themes regarding how the industry-government-academia-civilian collaboration for malaria should be.

Executive Committee Members of ZERO Malaria 2030 Campaign (as of June 2020)

【Chairman】 -Dr. Takahiro Shinyo, Chairman of Malaria No More Japan

【Members】 -Mr. Masatomi Akana (Senior Vice President and Chief Government Relations Officer, , Eisai Co., Ltd.)

-Mr. Masataka Uo (Founder and CEO, Japan Fundraising Association)

-Mr. Akio Okawara (President and Chief Executive Officer, Japan Center for International Exchange (JCIE); Director, Friends of the Global Fund, Japan)

-Dr. Shigeru Omi (President, Japan Community Health Care Organization (JCHO))

-Dr. Kiyoshi Kita (Dean of the School of Tropical Medicine and Global Health, Nagasaki University)

-Mr. Yasumasa Kimura (Director, UNICEF Tokyo Office)

-Mr. Tetsuo Kondo (Director, UNDP Representation Office in Japan)

-Ms. Catherine K. Ohura (CEO & Executive Director, Global Health Innovative Technology Fund (GHIT))

-Hon. Prof. Keizo Takemi (Member of House of Councillors, WHO Goodwill Ambassador for UHC)

-Japan Civil Society Network on SDGs (SDGs Japan)

【Observer】 -Dr. Hiroyuki Noda (Councilor, Coordination Office of Measures on Emerging Infectious Diseases, Cab-inet Secretariat)

【Supporting Companies】 -DENTSU INC.

-Earth Cooperation

-TechMatrix Corporation

-Sysmex Corporation (Supported reception party on October 10, 2017.)

http://zero2030.org/marala/index.html