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

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" .

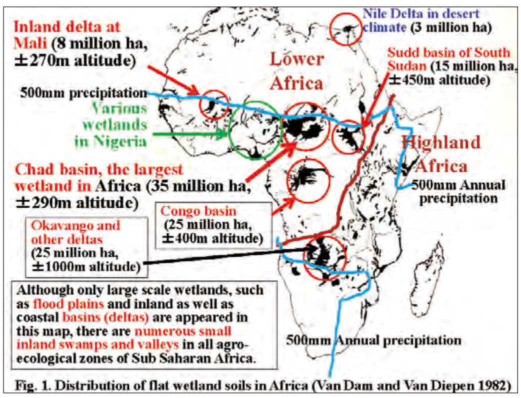


Fig. 1. Distribution of flat wetland soils in Africa (Van Dam and Van Diepen 1982)

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..

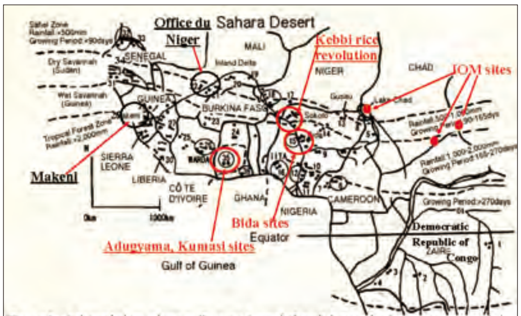


Figure 2. Selected sites where soils were Sampled and rice ecologies were surveyed in Western and parts of Central Africa during 1986-1998. Red circles shows Kebbi State of Rice Revolution in 2010-2019 based on the sawah technology development at Bida and Adugyama area in 1986-2017. Three red marks shows 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.

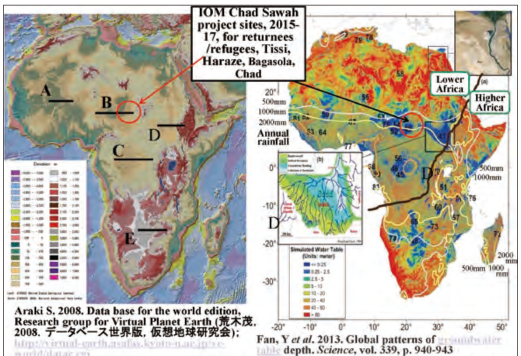


Fig. 3. Distribution of inland basins in various altitudes with shallow groundwater for possible future application of sawah technology in Sub Saharan Africa

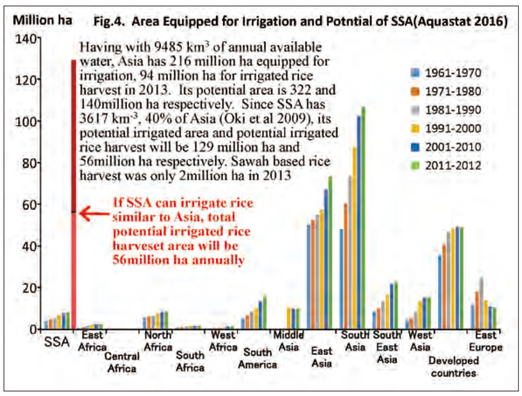


Figure 4 shows the changes in the irrigated area of each region in the world over the past 50 years. We can see that irrigation development has hardly progressed in the eastern, central, western and southern parts of SSA. As we saw earlier, the total area of lowland area is about 240 million ha (Table 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.

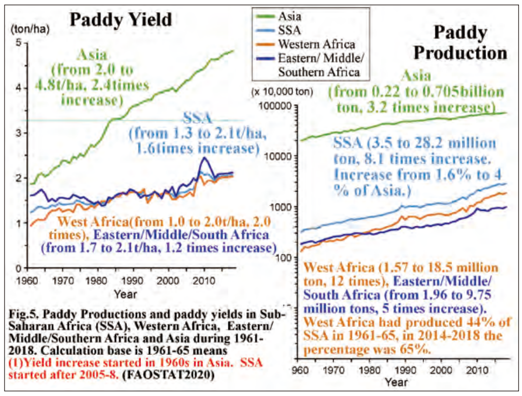


Fig.5. Paddy Productions and paddy yields in Sub-Saharan Africa (SSA), Western Africa, Eastern/ Middle/Southern Africa and Asia during 1961-2018. Calculation base is 1961-65 means (1)Yield increase started in 1960s in Asia. SSA started after 2005-8. (FAOSTAT2020)

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.

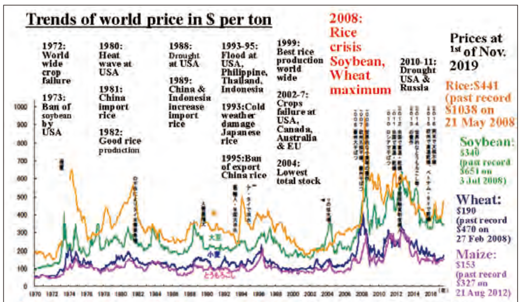


Fig.6. Trends of world trading prices of Rice at Thai (milled 2nd class FOB), Soybean, Wheat and Maize at Chicago commodity exchange during 1961-2019 (Ministry of Agriculture, Forestry and Fishery, MAFF, Japan, 2019 http://www.maff.go.jp/j/zyukyu/jki/j_zyukyu_kakaku/attach/pdf/index-146.pdf).
Note : 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.

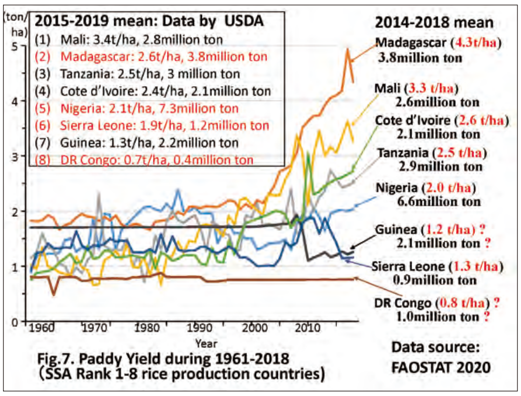


Fig.7. Paddy Yield during 1961-2018
(SSA Rank 1-8 rice production countries)

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.

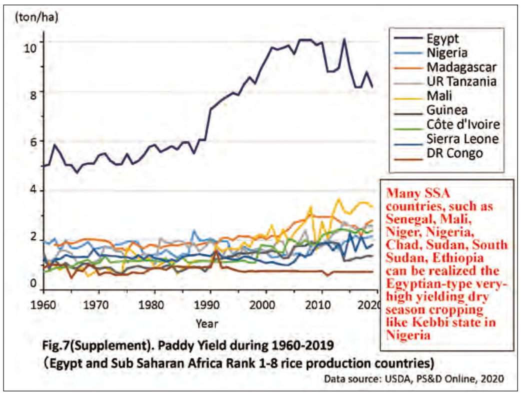


Fig.7(Supplement). Paddy Yield during 1960-2019
(Egypt and Sub Saharan Africa Rank 1-8 rice production countries)

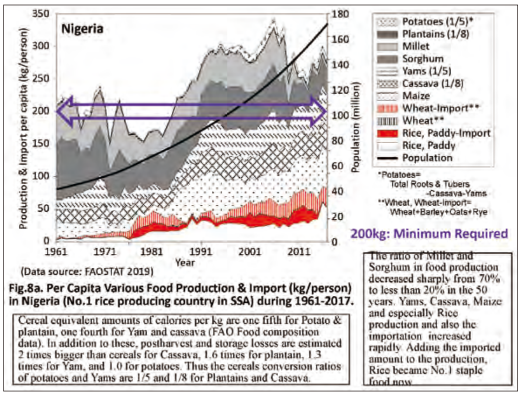


Fig.8a. Per Capita Various Food Production & Import (kg/person) in Nigeria (No.1 rice producing country in SSA) during 1961-2017.

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 ratio of Millet and Sorghum in food production decreased sharply from 70% to less than 20% in the 50 years. Yams, Cassava, Maize and especially Rice production and also the importation increased rapidly. Adding the imported amount to the production, Rice became No.1 staple food now.

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

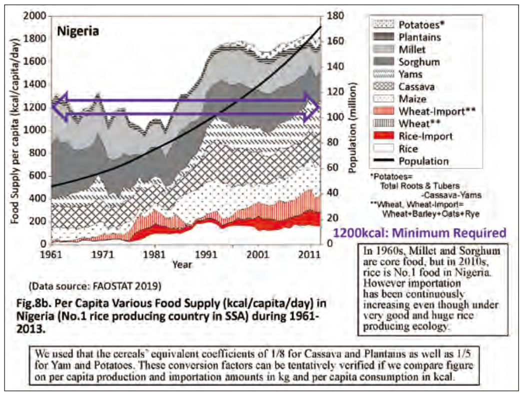


Fig.8b. Per Capita Various Food Supply (kcal/capita/day) in Nigeria (No.1 rice producing country in SSA) during 1961-2013.

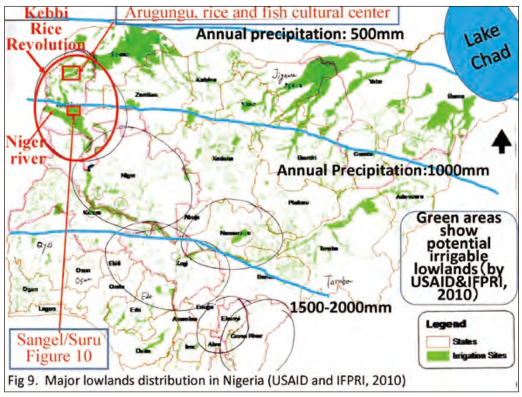


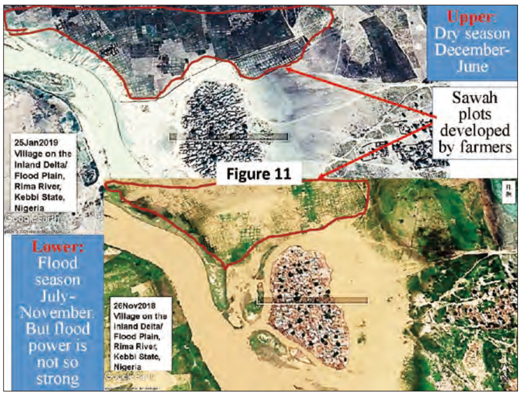
Fig 9. Major lowlands distribution in Nigeria (USAID and IFPRI, 2010)

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.



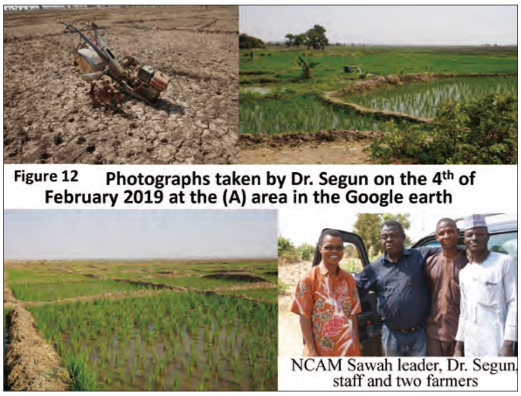


Figure 12 Photographs taken by Dr. Segun on the 4th of February 2019 at the (A) area in the Google earth

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

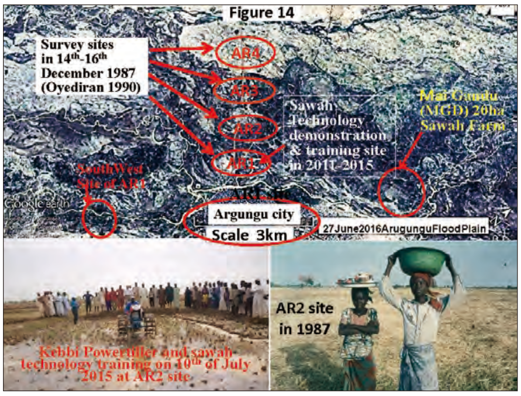


Figure 13 is almost the same site as Figure 12. It is a floodplain during the rainy season in September 2019. Rice is cultivating. Although pump irrigation costs are lower, but drainage is difficult, water and weed management are difficult, thus yields are lower than in the rainy season. Therefore, farmers 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 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.

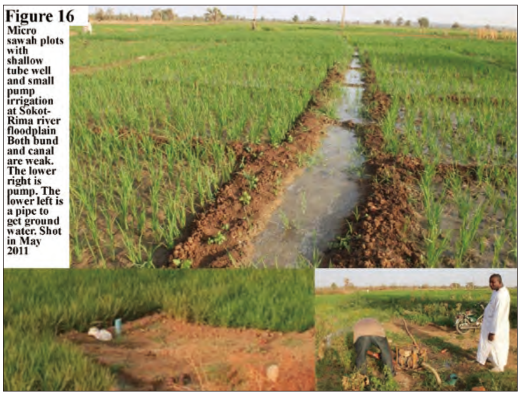


Figure 16 Micro sawah plots with shallow tube well and small pump irrigation at Sokot-Rima river floodplain Both bund and canal are weak. The lower right is pump. The lower left is a pipe to get ground water. Shot in May 2011

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

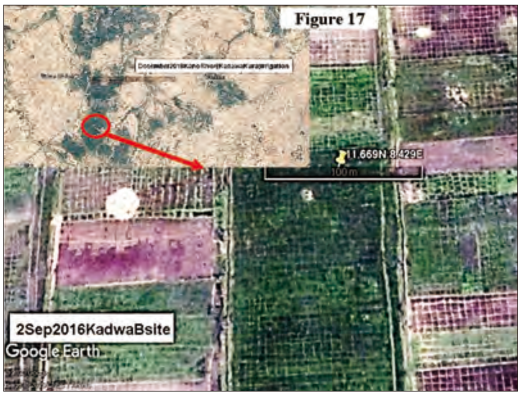
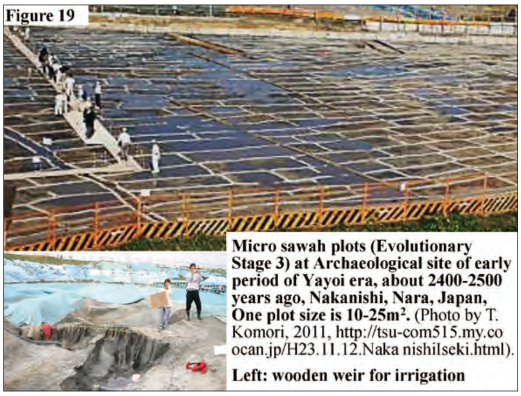


Figure 18

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 10-25m^2. (Photo by T. Komori, 2011, http://tsu-com515.my.coocan.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.

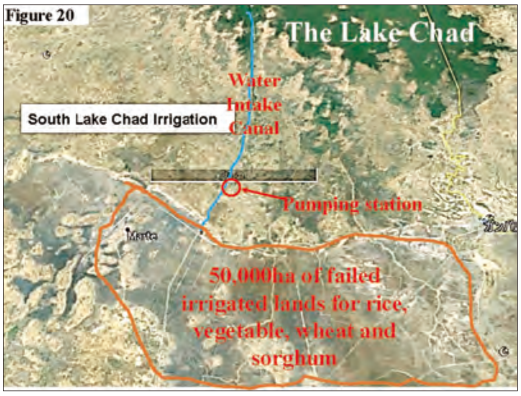
Figure 20


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.

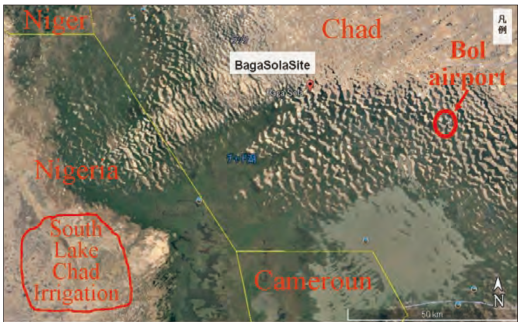


Figure 23 IOM project for the Reintegration Support for the Chadian Returnees (Refugees) from Nigerian Boko Haram

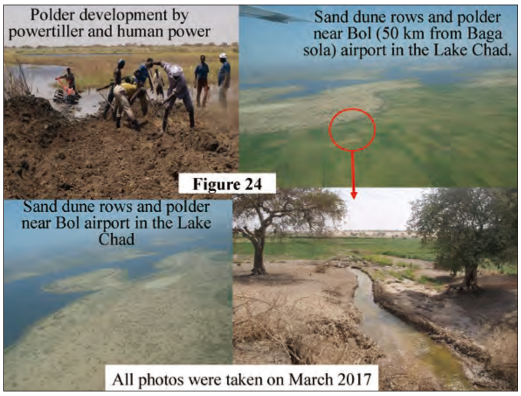


Figure 24

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.

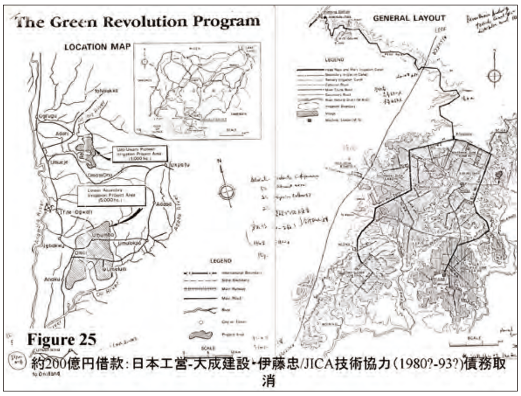


Figure 25
約200億円借款：日本工営-大成建設・伊藤忠/JICA技術協力（1980?-93?)債務取消

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.

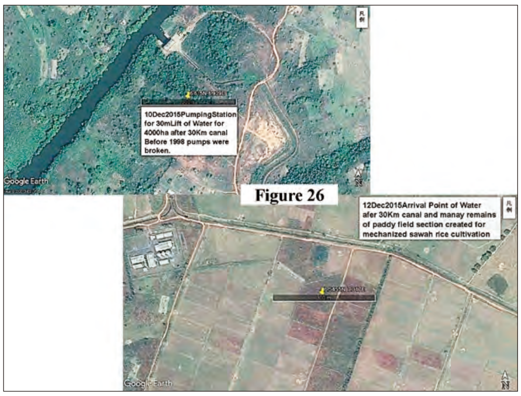


Figure 26

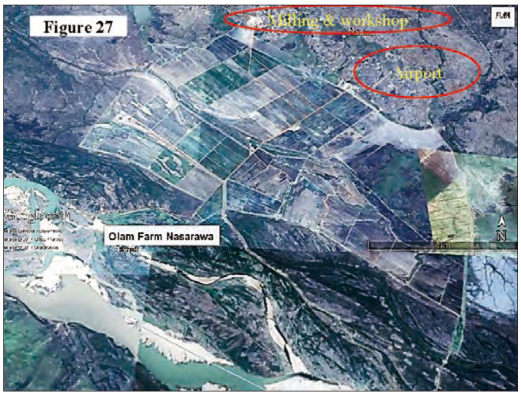


Figure 27

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 28

Figure 29

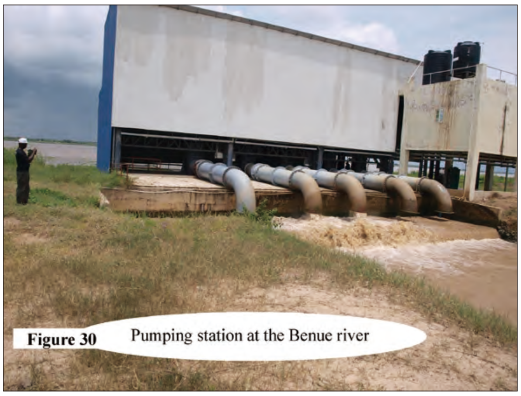


Figure 30 Pumping station at the Benue river

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.

Figure 31

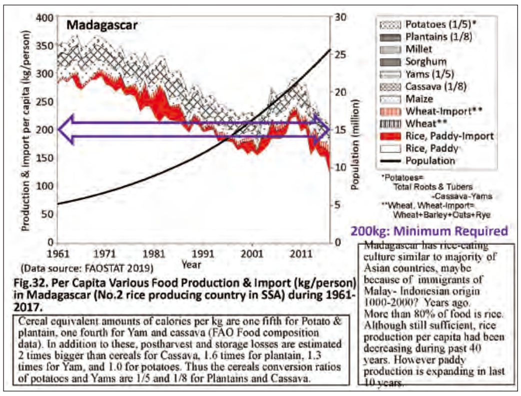
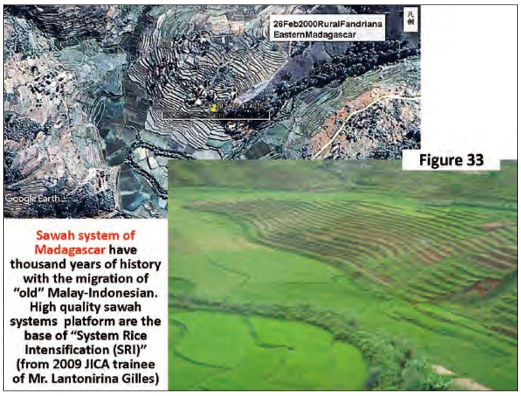
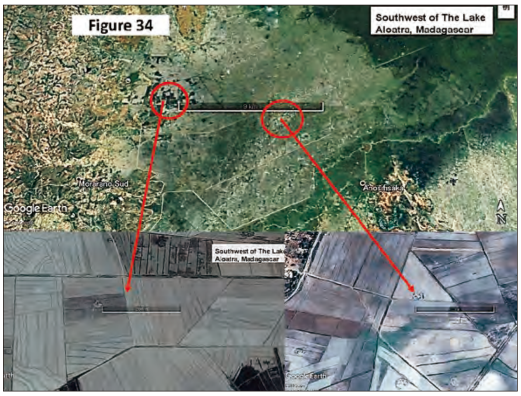


Fig.32. Per Capita Various Food Production & Import (kg/person) in Madagascar (No.2 rice producing country in SSA) during 1961-2017.

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.





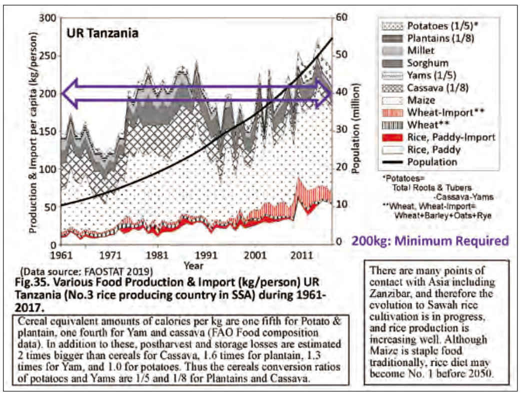
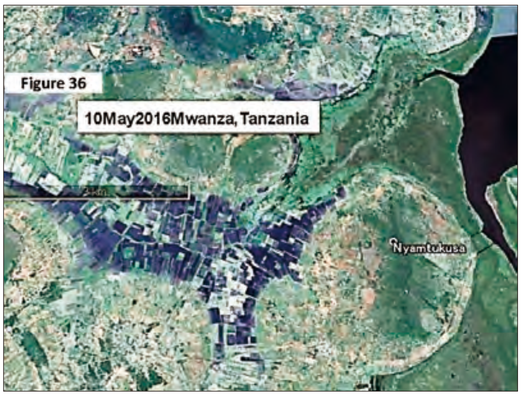


Fig.35. Various Food Production & Import (kg/person) UR Tanzania (No.3 rice producing country in SSA) during 1961-2017.

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.

There are many points of contact with Asia including Zanzibar, and therefore the evolution to Sawah rice cultivation is in progress, and rice production is increasing well. Although Maize is staple food traditionally, rice diet may become No. 1 before 2050.

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.

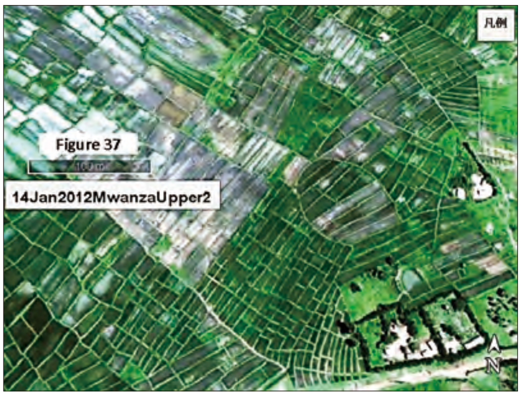


Figure 37 is the upper reaches of the lowlands along a relatively large river flood plains that appears purple in Figure 36. It is an elongated rectangular sawah plots field developed on the lower slopes of mountains and plateaus. These sawah plots even on relatively sloping areas can be cultivated by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

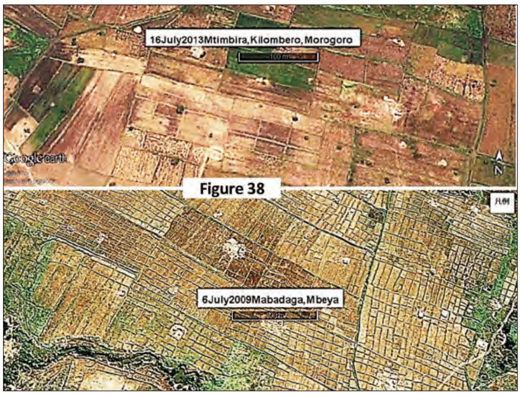


Figure 38

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.

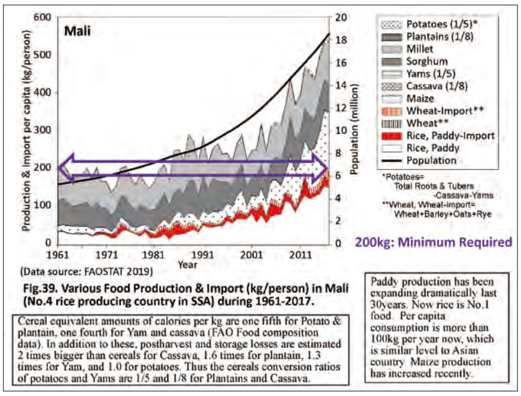


Fig.39. Various Food Production & Import (kg/person) in Mali (No.4 rice producing country in SSA) during 1961-2017.

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.

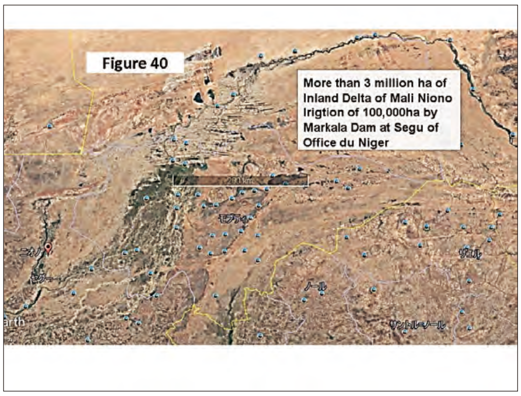


Figure 40

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.

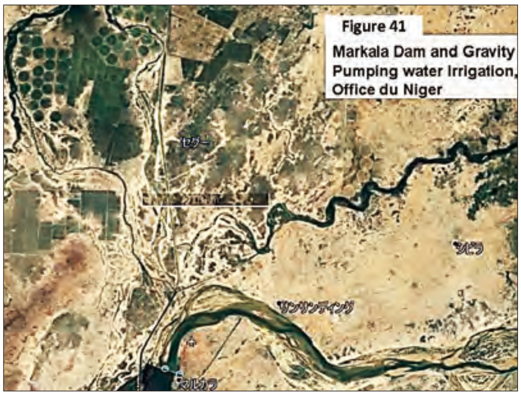


Figure 41
Markala Dam and Gravity Pumping water Irrigation, Office du Niger

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.

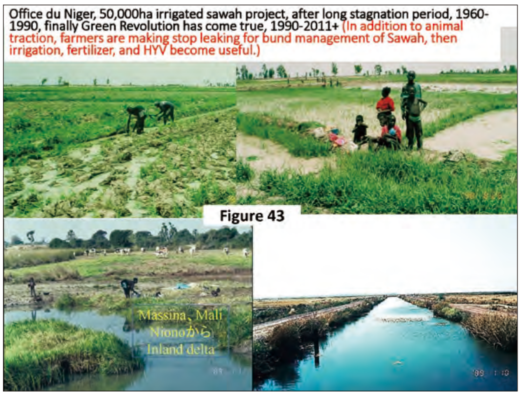


Figure 43

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	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	94,100	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	10,861	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 (73/74–89/90); → 94/95: 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.

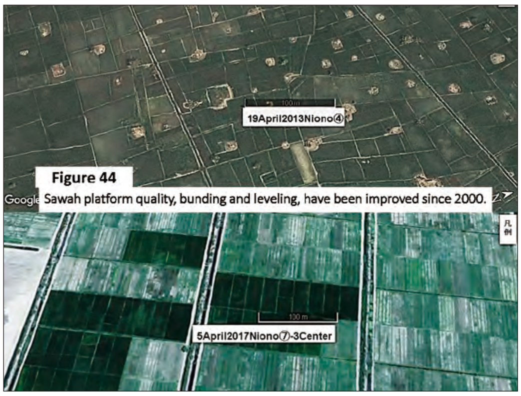


Figure 44

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)

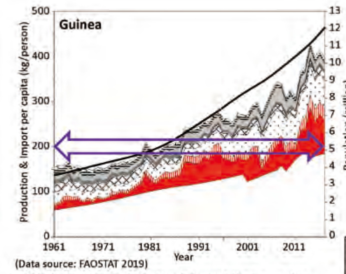

Figure 45


Figure 46

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)

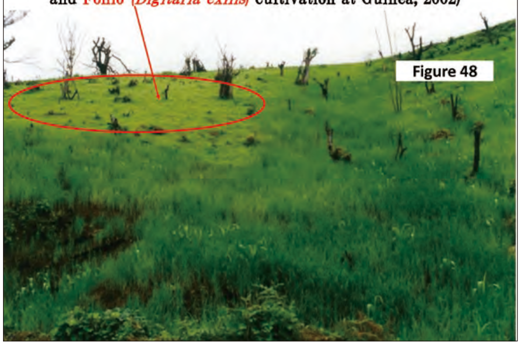


Figure 48 shows upland rice cultivation in shifting cultivation on the Guinea Plateau, which has been destroying forests. A grain called fonio, which is often cultivated in degraded soil, was also cultivated.

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.

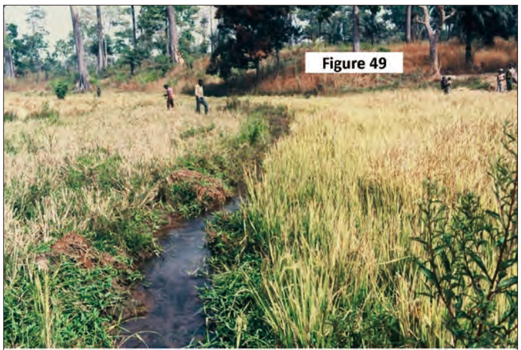
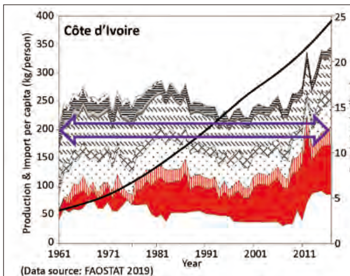


Photo No. 6, January 1989, Kissidougou, Guinea. Non sawah rice cultivation, Inland Valley, Evolutionary stage 1



(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.

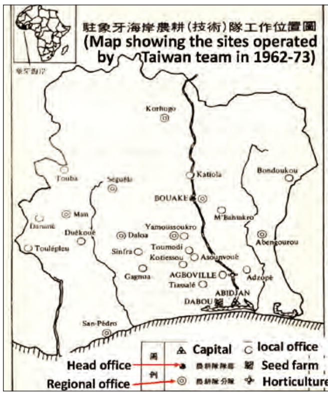


Figure 51
During 1962-73, Taiwan had operated nation-wide irrigated sawah rice platform development at 24 sites: (1) Experts dispatched: 180 person, (2) No. of farmers trained : 3384, (3) Irrigated sawah developed: 5475ha, (4) No. of Dam constructed :161
As shown in below, the basis of the irrigated 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 150-300m² 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.

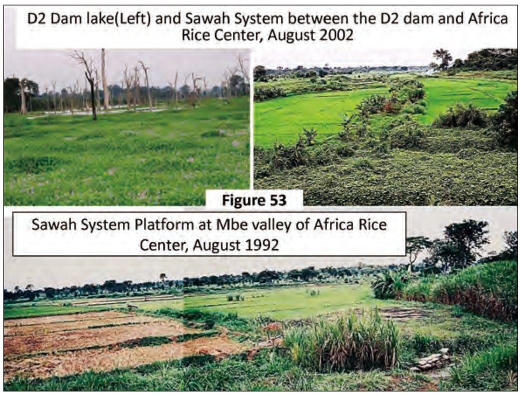


Figure 53

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'lvoire 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.

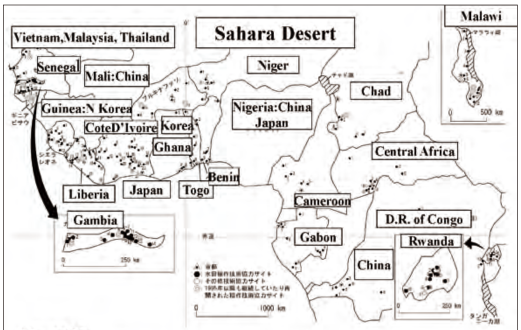


Figure 55

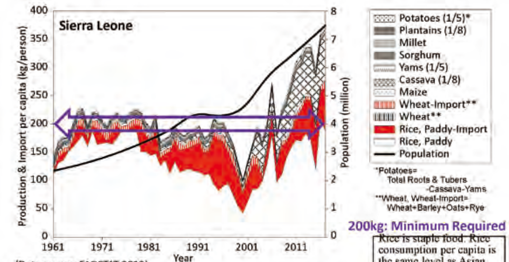
Asian and African Collaboration on sawah systems: Taiwan team is a pioneer for Sawah Ecotechnology transfer to Africa during 1960-75, but some in 1995-present.

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.

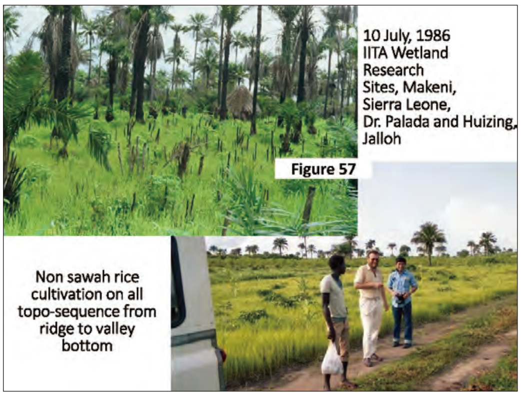


Fig. 58 shows the inland valley lowland. This is a part of the topo-sequences connected from Fig. 57, but it is non-sawah rice cultivation. Since there is no bunded sawah plots, clay is washed away by soil erosion, making the very sandy poor soils.

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.

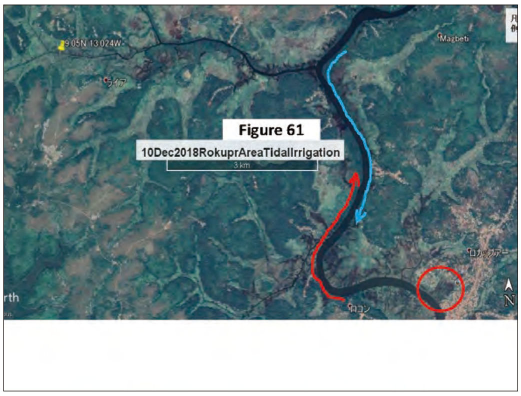


Figure 61 shows tidal irrigation system. Freshwater showing blue color flows down from the upper land side, and seawater shown in red color flows under the river water from the direction of seaside, which push up the freshwater on the surface. Incorporate this fresh water into the rice farm. As shown 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)

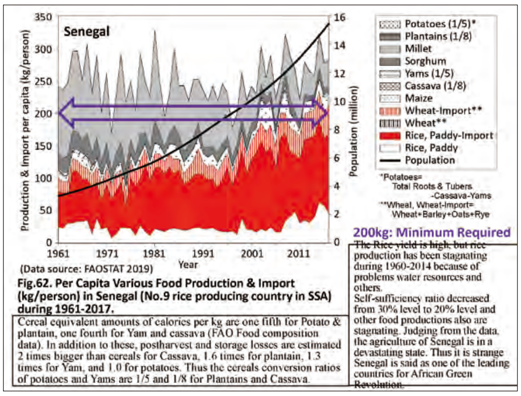


Figure 62 shows changes in food production statistics in Senegal. Sixty years ago, millet was important, but now people are now rice eater. However more than 60% of rice consumed are imported. This level of importation should be a national bankruptcy, so I think there is still a problem with FAO statistics. 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.

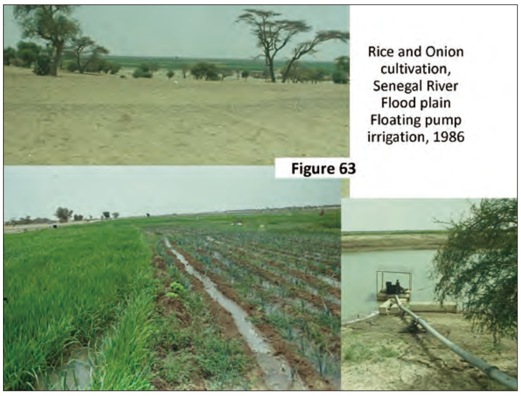


Figure 63

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.

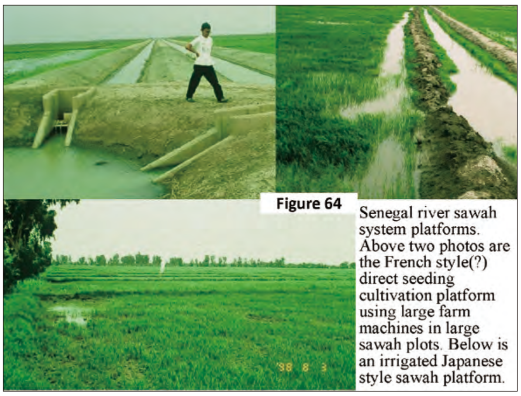


Figure 64

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.

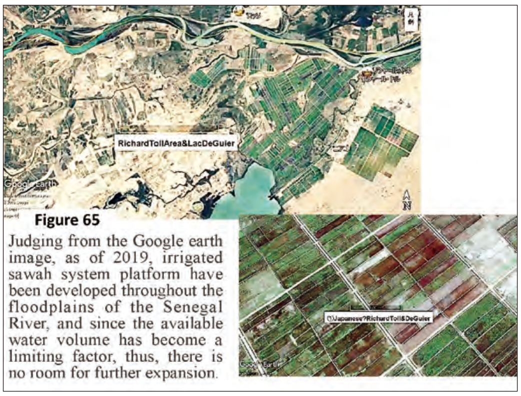


Figure 65

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?