

Sawah Technology (5Supplement) Google earth observation on endogenous sawah system development throughout the Kebbi state, during 2010-2017

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1. Panoramic view of Kebbi state

Figure 1 shows the panoramic view of Kebbi state (Google Earth 2018, Times Atlas 2007). The total area of floodplains and inland deltas suitable for sawah system development is estimated to 400 - 500 thousand ha. The Rima river flood plains have the largest potential for irrigated sawah systems in Kebbi. According to the official report, Kebbi state has been cultivated 380,000 ha of wetland rice in 2013, of which the Rima river flood plains occupied 50%, Niger river 35%, Zamfara river 4%, and remaining 11% including Ka river (Dakingari 2013). According to the report by Abdullahi et al (2014) on the “Assesment of water availability in the Sokoto Rima River Basin”, which comprises of four states, Sokoto, Kebbi, Katsina and Zamfara, two large scale irrigation schemes are operating in the basin, i.e., Goronyo in Sokoto and Bakalori in Zamfara. Both schemes are irrigating about 20,000 ha agricultural lands, mainly for rice cultivation. However, Kebbi state has no such large scale irrigation schems.

As desribed in the Sawah Technology (5) Kebbi Rice Revolution, Nigerian NCAM team performed sawah technology training and demonstration in cooperation with the World Bank assisted Fadama III at the six locations in Kebbi state duing 2011-2014. The six locations are core rice centers in Kebbi state, i.e., Arugungu, Birinin Kebbi, Jega, Sangulu, Suru, and Bagudo. These are shown in Fig. 1. In addition to thoses sites, this report will evaluate the expansion and improvement of small pump irrigated sawah system platform by farmers’ self-help efforts. The state of the development of new sawah systems by farmer's own power that started from 2011 can be clearly observed by comparing Google Erath's 2009 or before and 2016-2018 pictures taken by chance before and after our sawah technology training and demonstration. Figure 2-95 below show how much power and speed of myriad power of Kebbi farmers’ self-help development.

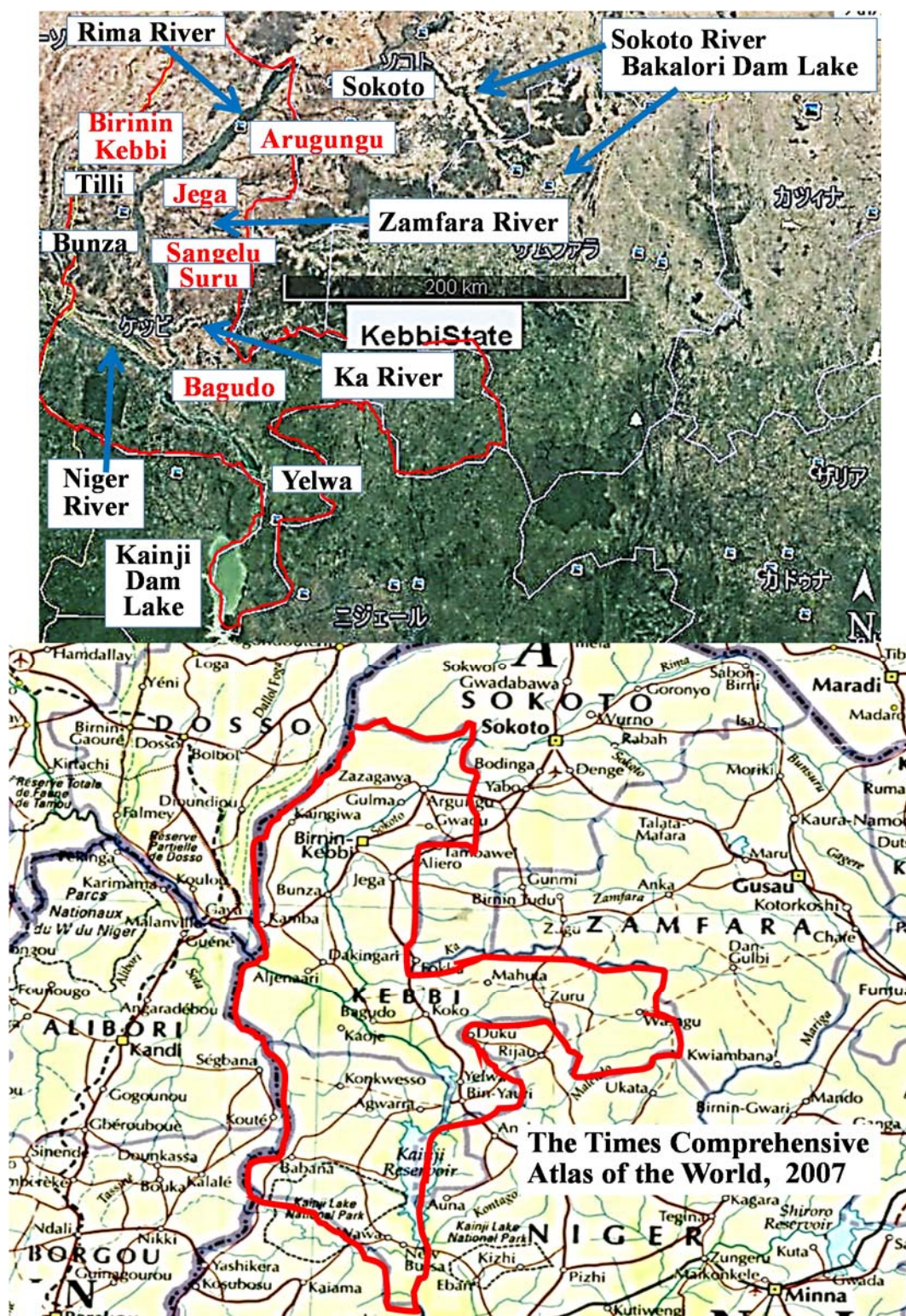


Figure 1. Panoramic view of Kebbi State, The above is Google 2018 and the below is Times Atlas 2007

2. The Rima River floodplains from the Sokoto state border to Arugungu city area: 40,000 ha

Figure 2. Flood plains in the F, G, H, I, J region near the surrounding flood plains A, B, C, D, E and Sokoto state boundary in addition to Arugungu (AR), the center of rice cultivation in Kebbi province Progress of paddy rice cultivation between 2009/2010 and 2016/2017 It is shown in Figure 3-21 by Google Earth below. The area of the flood plain in Kebbi Province in the picture is about 40,000 ha.

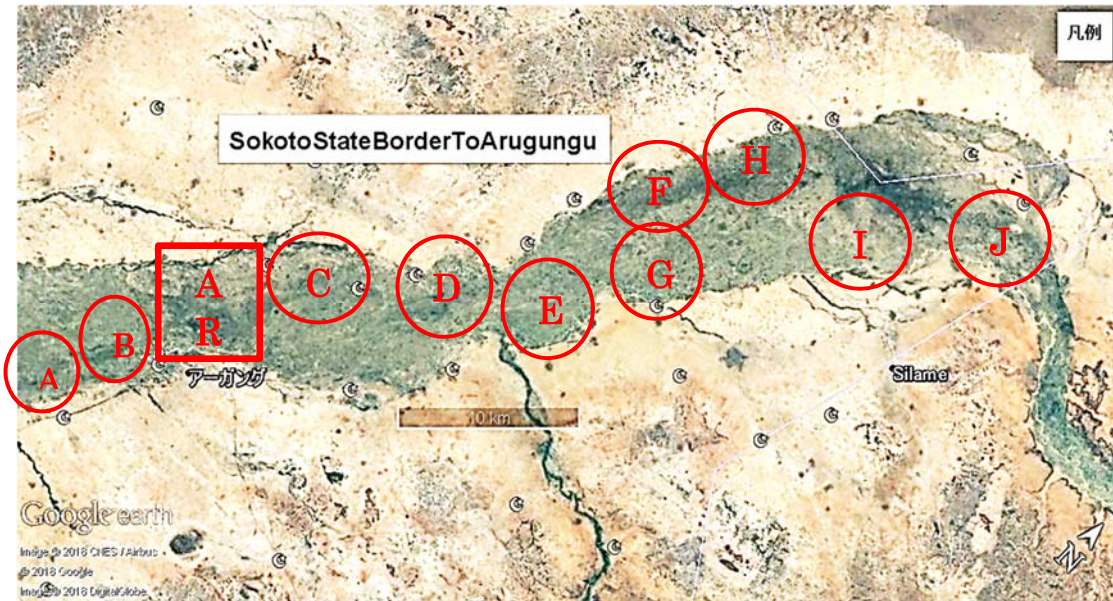


Figure 2. and the rice cultivated rice plant. The upper portion near I and the boundary of Sokoto state in Fig. 2 appear to be black, which means that the forests remain with high specific height.

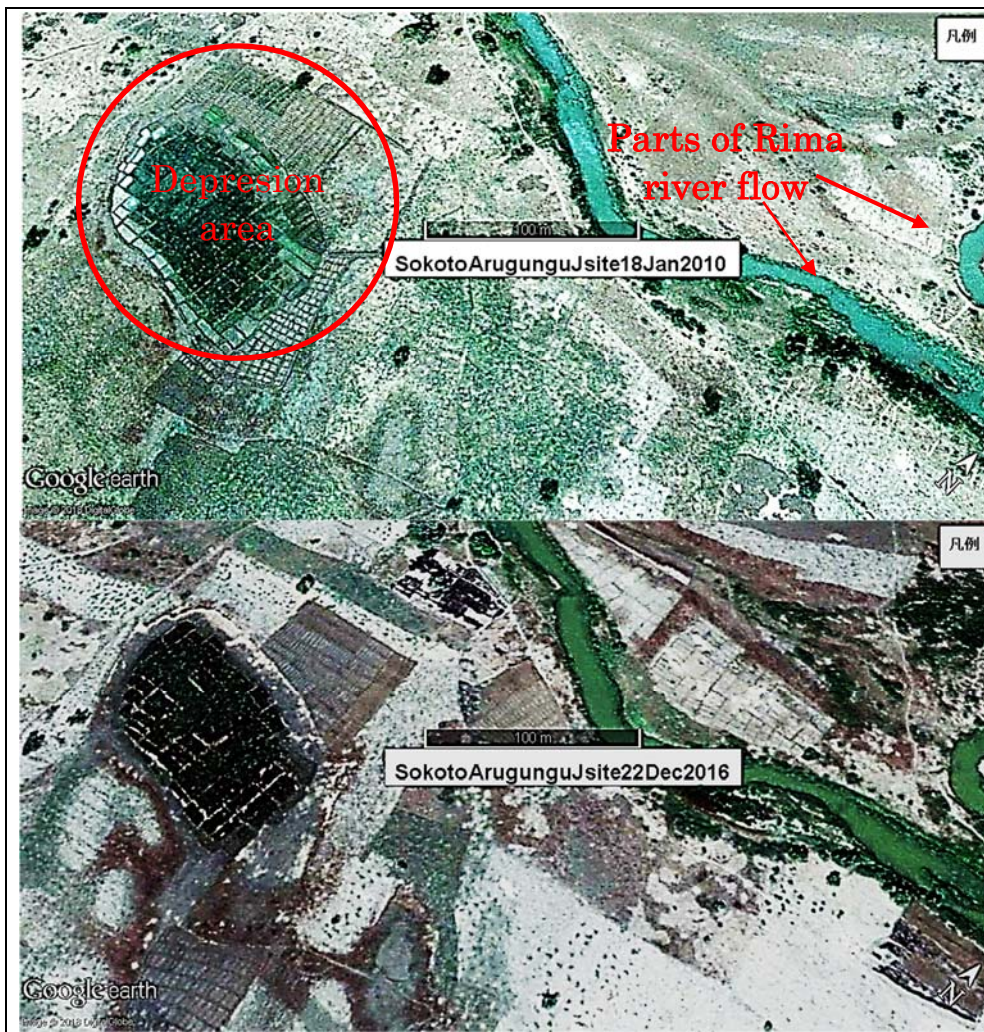


Figure 3. Google earth images in 2010 (above) and 2016 (below) near the J area of flood plain of the Fig.2, near the Sokoto state border. Total area shown in the photograph is about 10 ha.Length of the scale marker is 100 m.

In 2010 image, micro rudimentary sawah plots and ridge rice plantings can be identified in the swamp area.

In 2016 image, the rice cultivation area expanded but mostly rice fields are micro rudimentary sawah plots and ridge cultivation, which are similar to the Sokoto state majority.

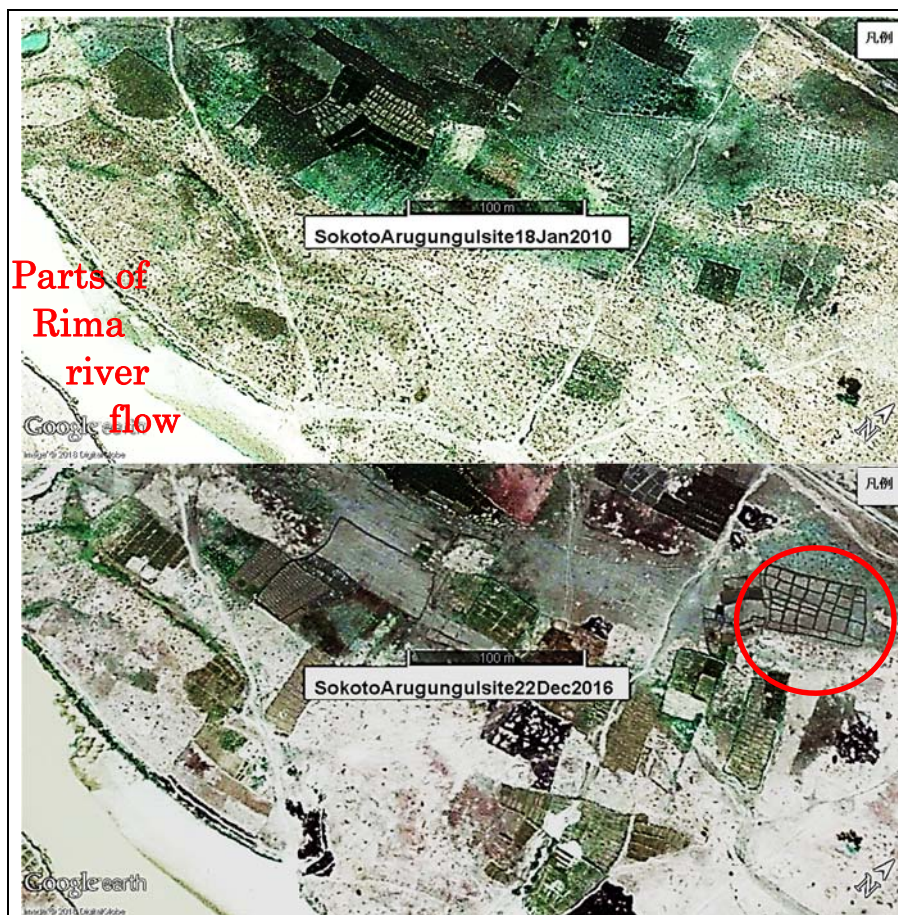


Figure 4. Evaluation of the progress of sawah platform improvement in 2010 (above) and 2016 (below) by Google images near the flood plain I near the Sokoto state boundary of I area of Fig. 2. The total area shown in the photograph is about 10 ha. The length of the scale marker is 100 m. In 2010, micro rudimentary sawah plost and ridge rice cultivation are common in the depressional part of the floodplain. In 2016, the rice cultivation area expanded, but mostly micro rudimentary sawah and ridge rice planting except for red cicled area, which seems a new sawah plots?



Figure 5. Evaluation of the progress of sawah platform improvement in 2010 (above) and 2017 (below) by Google earth images at the floodplain H (Fig.2) near the Sokoto state boundary. The total area shown in the photograph is about 10 ha. The length of the scale marker is 100 m. In 2010, almost no sawah plots are recognized. In 2017 about 80% of this flood plain are occupied by sawah plots, mean size about 100 m². These were developed by farmers' self-help efforts, which is clear all sawah plots are developed based on the land use demarcation of 1 acre to 1ha size. It is impressive that almost all seasonal river bottoms are occupied by sawah plots.



Figure 6. Evaluation of the progress of sawah platform improvement in 2009 (above) and 2016 (below) by Google earth images at the floodplain G (Fig.2). This location is the area approaching to the rice center of Kebbi, i.e., Arugungu. The total area shown in the photograph is about 10 ha. The length of the scale marker is 100 m. Almost 100% of the flood plains were occupied by ridge rice cultivation in 2009. In 2016, however, sawah plots based rice farming became major although still micro sawah plots and less than 50 m² size and ridge rice cultivation. The sawah bunds are strengthened and clearly identified.



Figure 7. Evaluation of the progress of sawah platform improvement in 2009 (above) and 2016 (below) by Google earth images at the floodplain F (Fig.2). The location is just middle between Arugungu and Sokoto state border. The total area shown in the photograph is about 10 ha. The length of the scale marker is 100 m. In 2009, non sawah rice fields, micro sawah plots and ridge rice cultivation were common. In 2017 60% area are covered with the standard sawah plots of 100 m² size, the rest are non-sawah, micro sawah and ridge rice cultivated cultivation.



Figure 8. Evaluation of the progress of sawah platform improvement in 2009 (above) and 2016 (below) by Google earth images at the floodplain F (Fig.2) near Arugungu floodplain E. The total area shown in the photograph is about 10 ha. The length of the scale marker is 100 m. In 2009, non-sawah rice fields and ridge rice cultivation were all over the flood plain. In 2016, 70% area are covered with standard sawah plots of 100 m² mean size. The rest areas are non-sawah and micro rudimentary sawah.



Figure 9. Evaluation of the progress of sawah platform improvement in 2009 (above) and 2016 (below) by Google earth images at the floodplain F (Fig.2) near Arugungu floodplain D. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2009, although more than 80% are non sawah, it can be seen that the development of micro rudimentary sawah system started with 5 places of floodplain, each 0.5-1 ha. In 2016, more than 80% area are covered with sawah plots, mean size is about 70 m², with clear bunding systems. But still some minor areas have ridge rice planting.

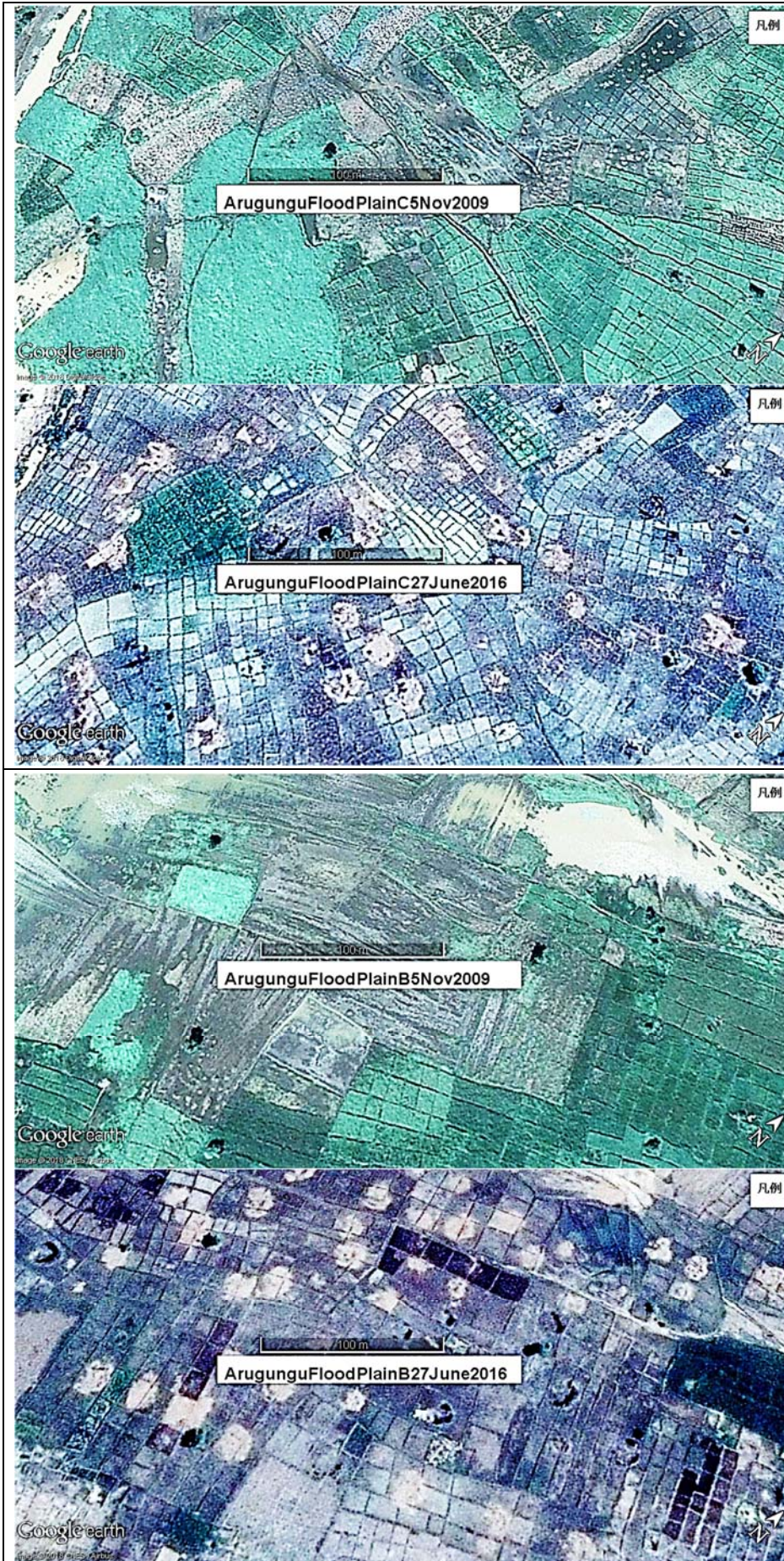


Figure 10. Evaluation of the progress of sawah platform improvement in 2009 (above) and 2016 (below) by Google earth images at the floodplain C (Fig.2) near Arugungu floodplain. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2009, about 40 % of the area is occupied by sawah plots. In 2016 almost 100% land are covered with standard sawah plots. Mean size of the sawah plots is about 80 m².

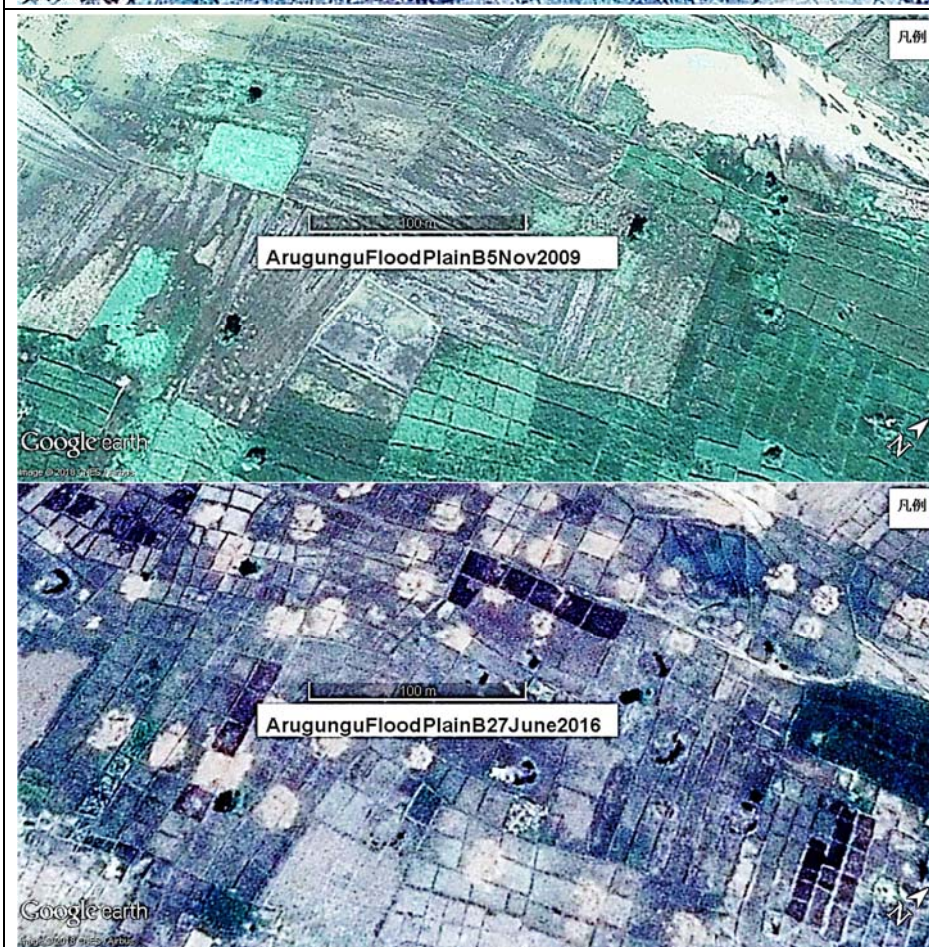
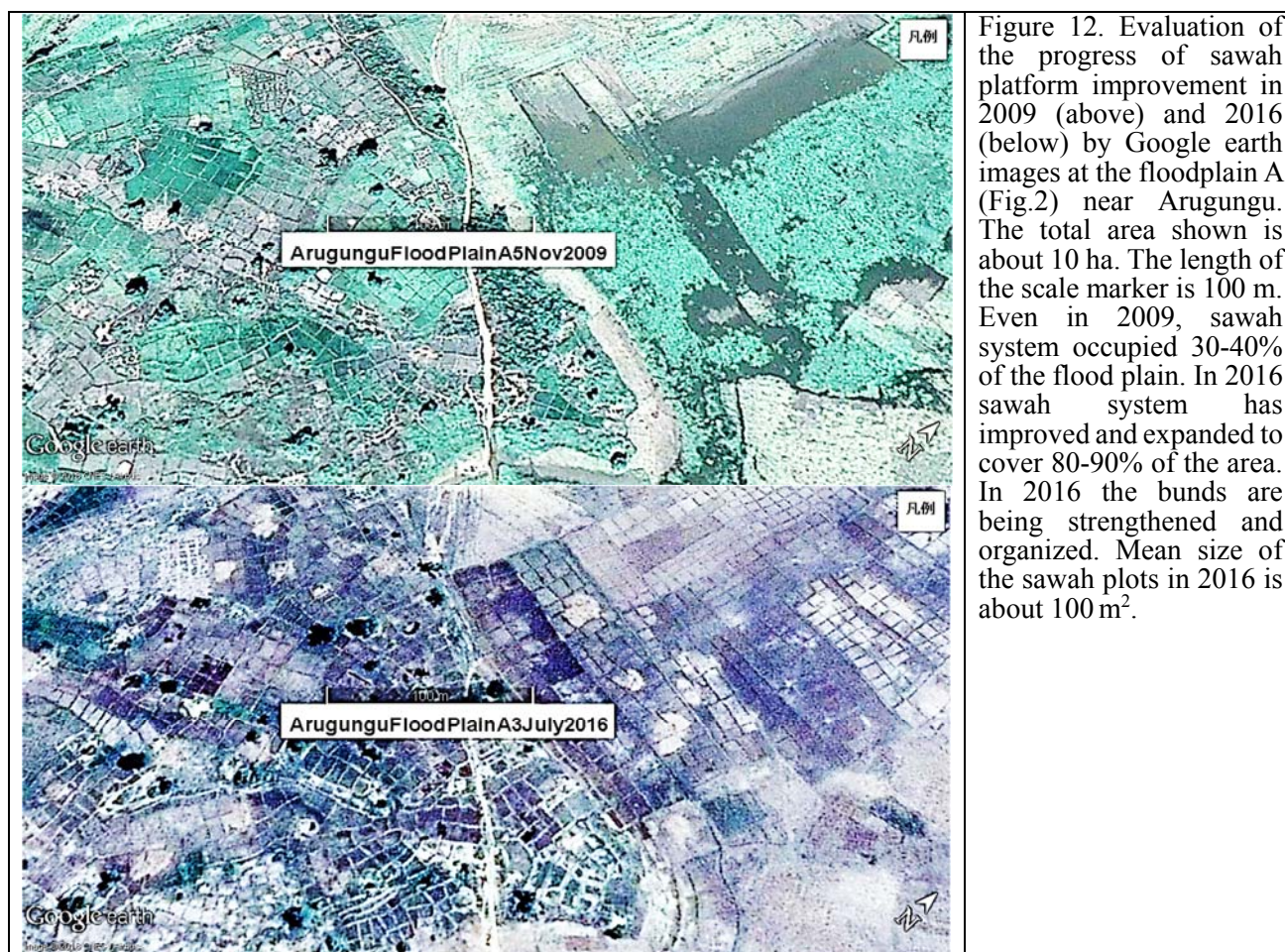
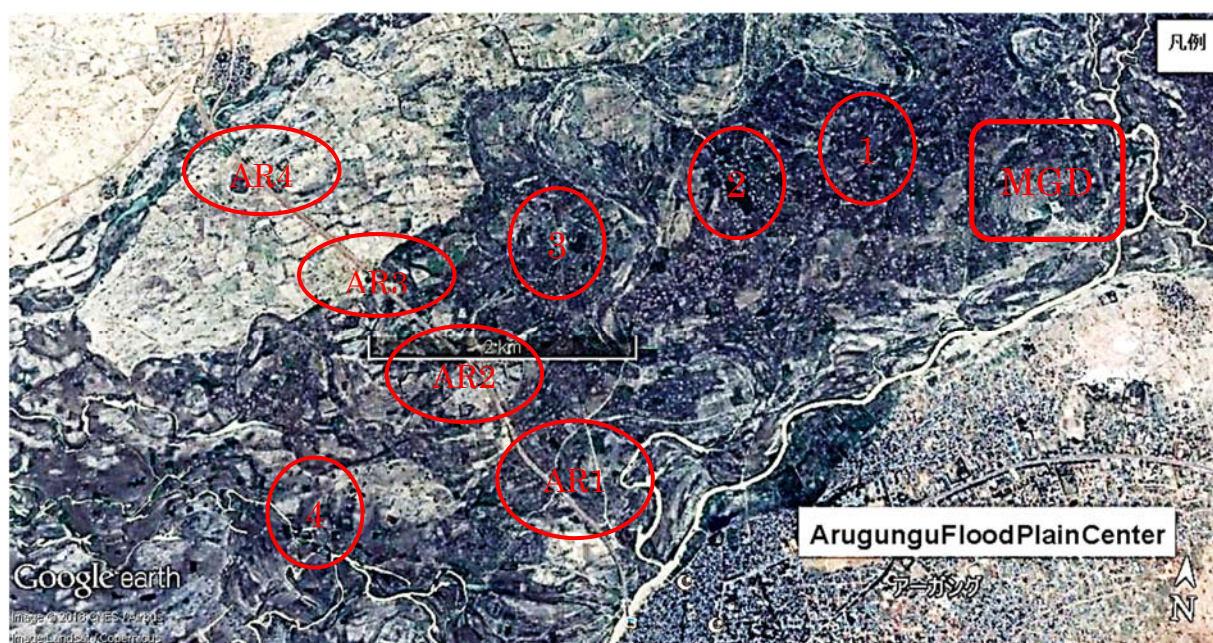


Figure 11. Evaluation of the progress of sawah platform improvement in 2009 (above) and 2016 (below) by Google earth images at the floodplain B (Fig.2) near Arugungu. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2009, about 30 % of the area is occupied by sawah plots. In 2016 almost 100% land are covered with standard sawah plots. Mean size of the sawah plots in 2016 is about 150 m².



3. An expanded observation of the Rima river flood plains near Arugungu City: 5,200 ha



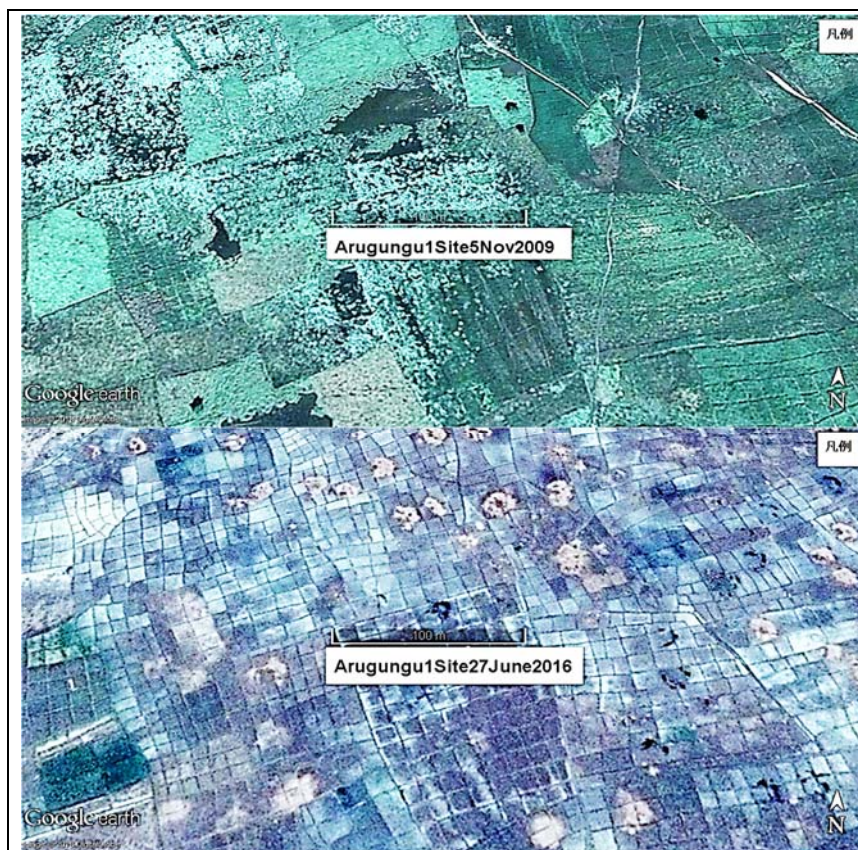


Figure 14. Evaluation of the progress of sawah platform improvement in 2009 (above) and in 2016 (below) by Google earth images at the Arugungu (1) site (Fig.13). The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2009, rudimentary sawah system occupy about 10% land. In 2016, 100% land are occupied by improved standard sawah plots. Mean size of the sawah plots in 2016 is about 140 m².

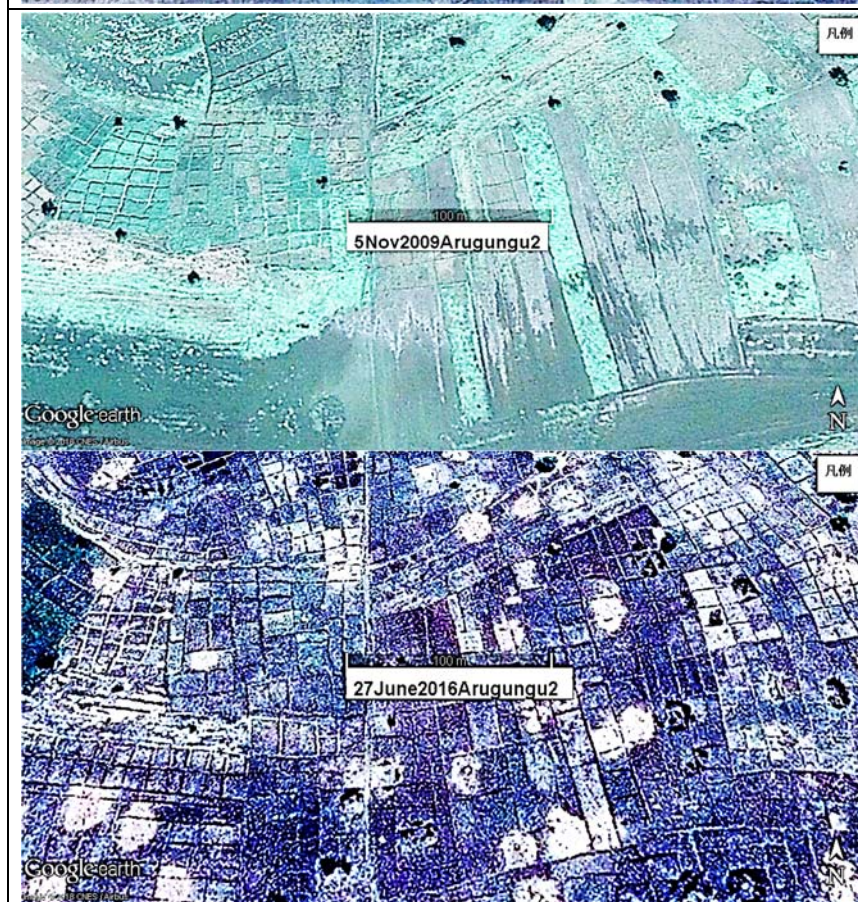


Figure 15. Evaluation of the progress of sawah platform improvement in 2009 (above) and in 2016 (below) by Google earth images at the Arugungu (2) site (Fig.13). The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2009, rudimentary sawah system occupy about 10% land. In 2016, 100% land are occupied by improved standard sawah plots. Mean size of the sawah plots in 2016 is about 160 m².

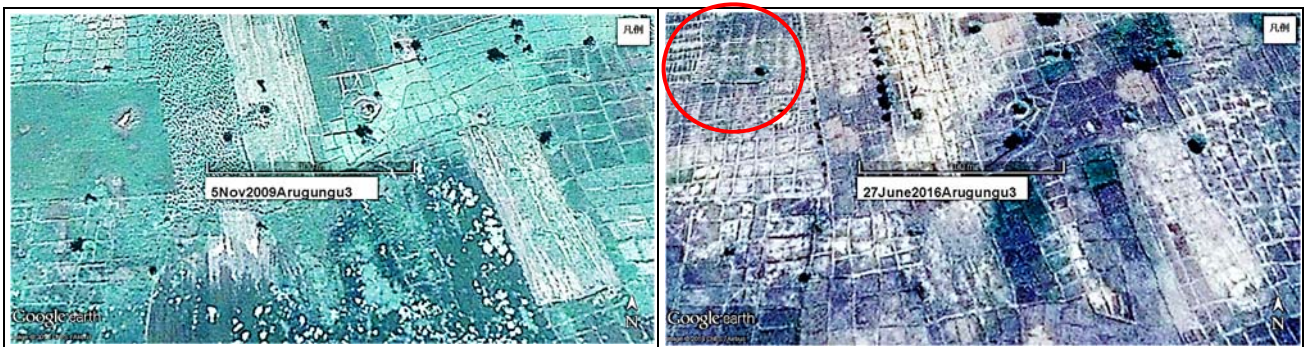


Figure 16. Progress of sawah platform during 2009 (left) and 2016 (right) by Google earth at Arugungu (3) site (Fig.13). Scale marker is 100 m and area is 10ha. In 2009, about 20% land is sawah system. In 2016, 100% land are improved sawah plots. Mean sawah plots size in 2016 is about 160 m^2 . However red circle area is ridge rice planting.

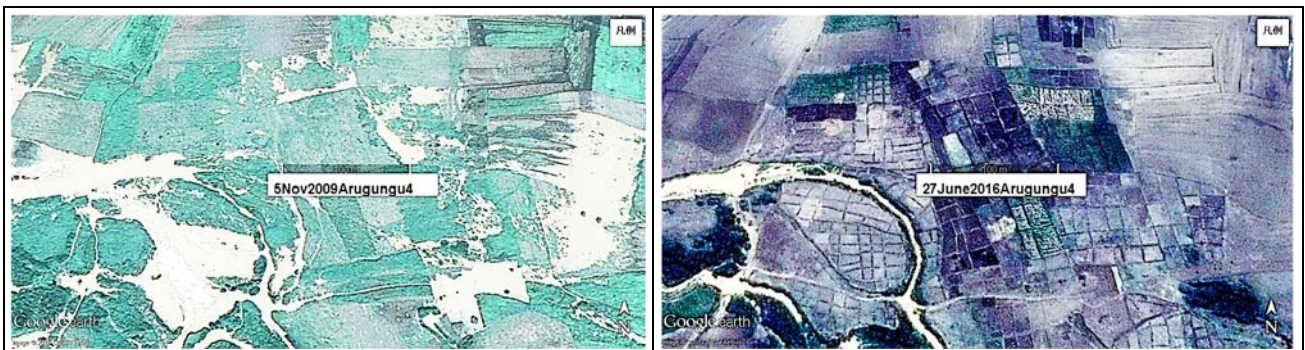


Figure 17. Progress of sawah platform during 2009 (left) and 2016 (right) by Google earth at Arugungu (4) site (Fig.13). Scale marker is 100 m and area is 10ha. In 2009, there is no sawah system. In 2016, 50% land are improved sawah plots. Mean sawah plots size in 2016 is about 150 m^2 .



Figure 18. Progress of sawah platform during 2009 (left) and 2016 (right) by Google earth at Arugungu (AR1) site (Fig.13). Scale marker is 100 m and area is 10ha. In 2009, 30% land, left side of the road, are belong to Emir's standard sawah system. Other is micro rudimentary sawah or non sawah files. In 2016, 100% land are improved standard sawah plots with good bunding and leveling. Mean sawah plots size in 2016 is about 200 m^2 .



Figure 19. Progress of sawah platform during 2009 (left) and 2016 (right) by Google earth at Arugungu (AR2) site (Fig.13). Scale marker is 100 m and area is 10ha. In 2009, 15% land is micro rudimentary sawah and remaining is non sawah files. In 2016, almost 100% land are improved standard sawah plots with good bunding and leveling. Mean sawah plots size in 2016 is about 140 m^2 .



Figure 20. Progress of sawah platform during 2009 (left) and 2016 (right) by Google earth at Arugungu (AR3) site (Fig. 13). Scale marker is 100 m and area is 10ha. In 2009, 10% land is rudimentary sawah plots and remaining is non sawah fields. In 2016, 80% land are improved standard sawah plots with good bunding and leveling. 10% land, which are shown in three red circles, are ridge rice planting. Mean sawah plots size in 2016 is about 120 m².

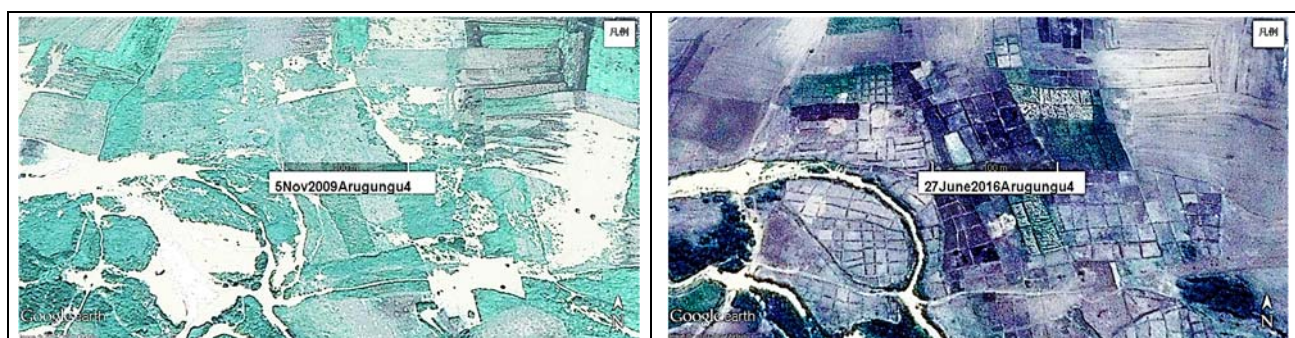


Figure 21. Progress of sawah platform during 2009 (left) and 2016 (right) by Google earth at Arugungu (AR4) site (Fig. 13). Scale marker is 100 m and area is 10ha. Mostly in non-sawah fields in 2009, 30% in standard sawah plots in 2016. As can be seen from Fig. 13, it is estimated that this area is comparatively high topographic position among floodplains, suitable for upland crops rather than paddy cultivation. Mean sawah plots size in 2016 is about 120 m².

4. The Rima River floodplains from Arugungu to Birinin Kebbi area: 56,000 ha

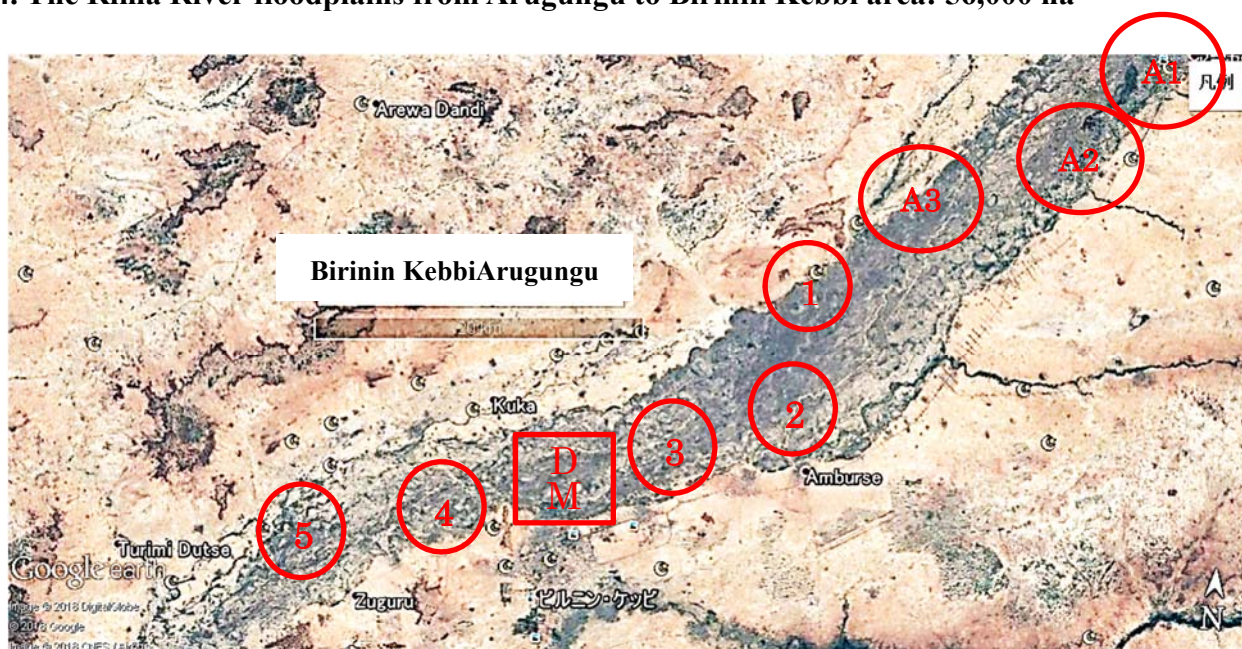


Figure 22. The Rima river floodplains from Arugungu area to Birinin Kebbi area. The scale marker length in the figure is 20 km. The area of the floodplain in this picture is about 56,000 ha. DM is irrigated rice farmland by Kebbi state government and details are described in Fig.23 and 24A and B as well as Fig.24(1) and (2) in **Sawah Technology (5) Kebbi Rice revolution**. Progress of sawah system platform between 2009 and 2016 of the area shown in the Fig.22 are described in the following Figure 23-30 below. If we compare the progress of sawah platform improvement between the Fig.13 (Arugungu) area and the Fig.22 (Birinin Kebbi) area, Arugungu area is more advanced than Birinin Kebbi area.

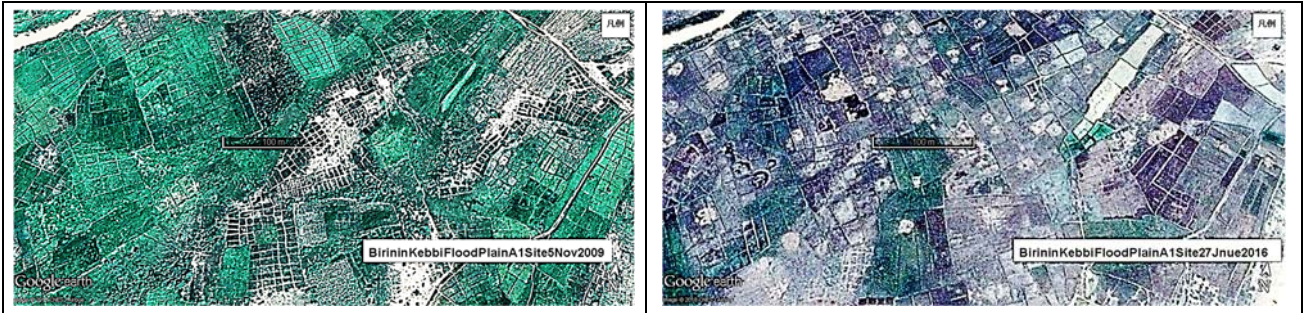


Figure 23. Evaluation of the progress of sawah platform improvement on 2009 (left) and 2016 (right) by Google images near A1 site of the Rima River floodplain very near to Arugungu shown in Figure 22. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2009, almost all area is covered with micro rudimentary sawah plots. Mean sawah plots size in 2009 is about 40 m^2 . In 2016, 90% area is covered with standard sawah plots. Mean sawah plots size in 2016 is about 300 m^2 .



Figure 24. Evaluation of the progress of sawah platform improvement on 2009 (left) and 2016 (right) by Google images near A2 site of the Rima River floodplain shown in Figure 22. The total area shown is 10 ha. The length of the scale marker is 100 m. In 2009, non-sawah fields and rudimentary sawah are halfway, and in 2016 sawah plots improvement is underway with an area of 80%. Mean sawah plots size in 2016 is about 60 m^2



Figure 25. Evaluation of the progress of sawah platform improvement on 2009 (left) and 2016 (right) by Google images near A3 site of the Rima River floodplain shown in Figure 22. The total area shown is 10 ha. The length of the scale marker is 100 m. In 2009, all area is non sawah field. In 2016 sawah platform improvement began and standard sawah plots covered about 70% of the flood plain. Mean sawah plots size in 2016 is about 100 m^2



Figure 26. Evaluation of the progress of sawah platform improvement on 2009 (left) and 2016 (right) by Google images near Site 1 of the Rima River floodplain shown in Figure 22. The total area shown is 10 ha. The length of the scale marker is 100 m. In 2009, 10% area is rudimentary sawah field and remaining is non sawah fields. In 2016 sawah platform improvement began and standard sawah plots covered about 80% of the flood plain. Mean sawah plots size in 2016 is about 60 m^2



Figure 27. Evaluation of the progress of sawah platform improvement on 2009 (left) and 2016 (right) by Google images near Site 2 of the Rima River floodplain around Birinin Kebbi city shown in Figure 22. The total area shown is 10 ha. The length of the scale marker is 100 m. In 2009, almost all flood plain in this area is non sawah fields. In 2016 sawah platform improvement began and although still rudimentary sawah plots covered about 70% of the flood plain. Mean sawah plots size in 2016 is about 50 m^2



Figure 28. Evaluation of the progress of sawah platform improvement on 2009 (left) and 2016 (right) by Google images near Site 3 of the Rima River floodplain around Birinin Kebbi city shown in Figure 22. The total area shown is 10 ha. The length of the scale marker is 100 m. In 2009, almost all flood plain in this area is non sawah fields. In 2016 sawah platform improvement began and although still rudimentary, sawah plots covered about 40% of the flood plain. Mean sawah plots size in 2016 is about 50 m^2



Figure 29. Evaluation of the progress of sawah platform improvement on 2009 (left) and 2016 (right) by Google images near Site 4 of the Rima River floodplain around Birinin Kebbi city shown in Figure 22. The total area shown is 10 ha. The length of the scale marker is 100 m. In 2009, almost all flood plain in this area is non sawah fields. In 2016 sawah platform improvement began and although still rudimentary, sawah plots covered about 40% of the flood plain. Mean sawah plots size in 2016 is about 50 m^2

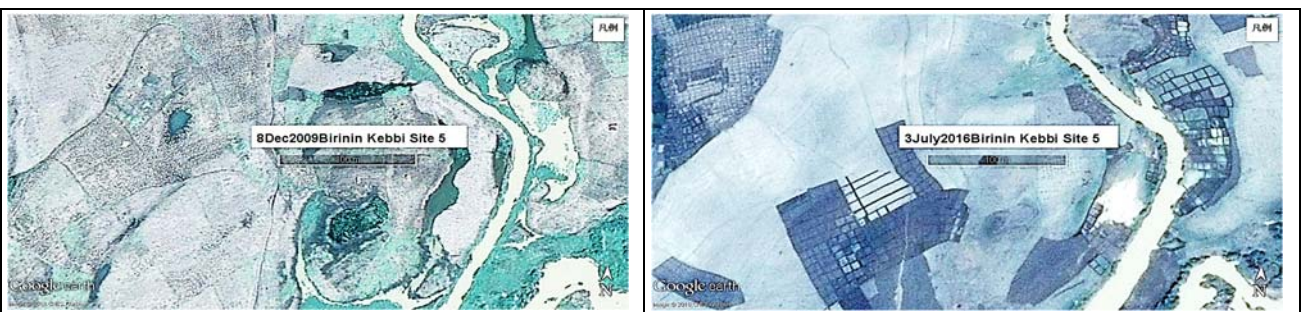


Figure 30. Evaluation of the progress of sawah platform improvement on 2009 (left) and 2016 (right) by Google images near Site 5 of the Rima River floodplain around Birinin Kebbi city shown in Figure 22. The total area shown is 10 ha. The length of the scale marker is 100 m. In 2009, almost all flood plain in this area is non sawah fields. In

2016 sawah platform improvement began and although still rudimentary, sawah plots covered about 20% of the flood plain. Mean sawah plots size in 2016 is about 40 m².

5. The Rima River flood plain from Birinin Kebbi to Zamfara River junction: 25,000 ha

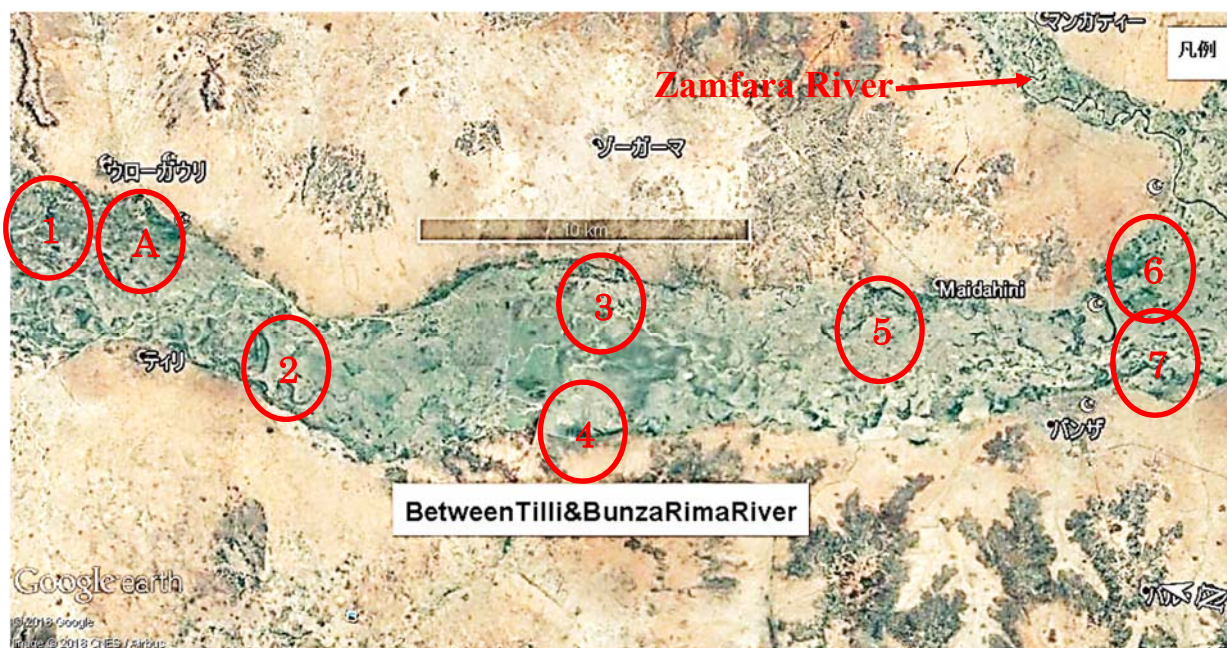


Figure 31. The Rima River flood plain from Birinin Kebbi to the Zamfara River junction. The scale marker length in the figure is 10 km. The area of the floodplain in this picture is about 25,000 ha. The following Figure 32-39 shows progress of sawah system platform improvement between 2009/2010 and 2016 by Google Earth images. As shown below, sawah system development within this figured area is below the average progress in Kebbi state.



Figure 32. Evaluation of the progress of sawah platform improvement between 2010 (left) and 2016 (right) by Google images near Site 1 of the Rima River floodplain from Tilli to Bunza shown in Figure 31. The total area shown is 10 ha. The length of the scale marker is 100 m. Both in 2009 and 2016, almost 100% area are covered with non sawah and ridge rice cultivation.



Figure 33. Evaluation of the progress of sawah platform improvement between 2010 (left) and 2016 (right) by Google images near Site A of the Rima River floodplain from Tilli to Bunza shown in Figure 31. The total area shown is 10 ha. The length of the scale marker is 100 m. In 2010, about 5% area is micro rudimentary sawah. In 2016, 40% land has rudimentary and standard sawah plots. Sawah plots size in 2016 is 20-60m².

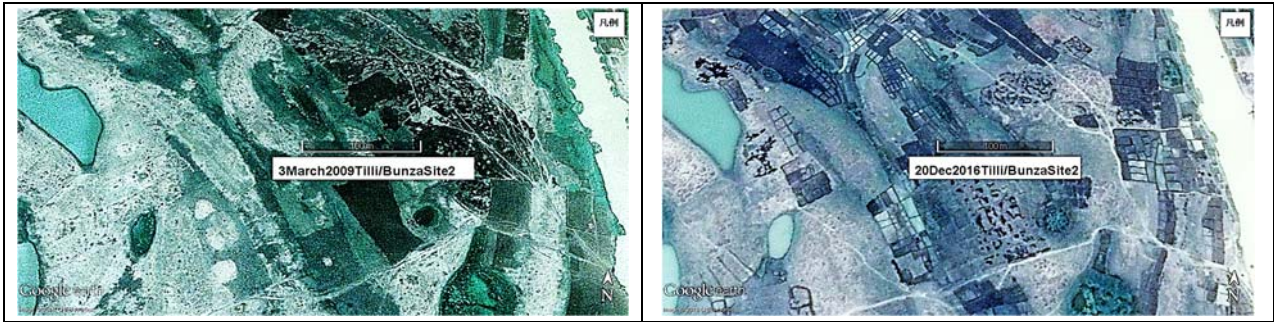


Figure 34. Progress of sawah platform improvement between 2009 (left) and 2016 (right) appeared in Google images near Site 2 of the Rima River floodplain from Tilli to Bunza shown in Figure 31. The total area is 10 ha. The length of the scale marker is 100 m. In 2009, 100% of this flood plain is non sawah ridge rice cultivation. In 2016, sawah system development is in progress at 20% of the flood plain. Sawah plots size in 2016 is 20-100m².

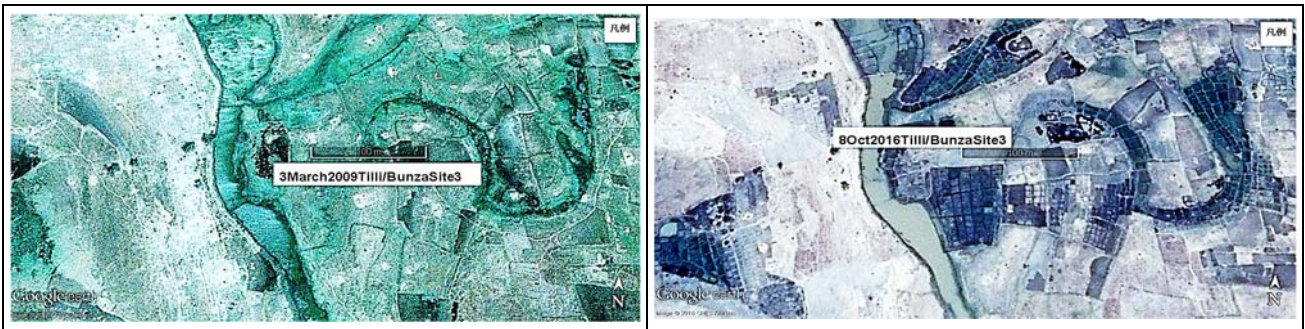


Figure 35. Progress of sawah platform improvement between 2009 (left) and 2016 (right) appeared in Google images near Site 3 of the Rima River floodplain from Tilli to Bunza shown in Figure 31. The total area shown is 10 ha. The length of the scale marker is 100 m. In 2009, 100% of flood plain in this area is non sawah rice cultivation. In 2016, sawah system development is in progress at 40% of the flood plain. Sawah plots size in 2016 is 20-130m².



Figure 36. Progress of sawah platform improvement between 2010 (left) and 2016 (right) appeared in Google images near Site 4 shown in Figure 31. The total area shown is 10 ha. The length of the scale marker is 100 m. In 2010, 100% of the flood plain is non sawah rice or ridge rice cultivation. In 2016, sawah system development is in progress at 30% of the flood plain. But still ridge rice palnting is common. Mean sawah plots size in 2016 is 50m².



Figure 37. Progress of sawah platform improvement between 2010 (left) and 2016 (right) appeared in Google images near Site 5 shown in Figure 31. The total area shown is 10 ha. The length of the scale marker is 100 m. In 2010, almost all flood plain in this area is non sawah rice or ridge rice cultivation. In 2016, relatively good sawah system development is in progress at 30% of the flood plain. Mean sawah plots size in 2016 is 80m².

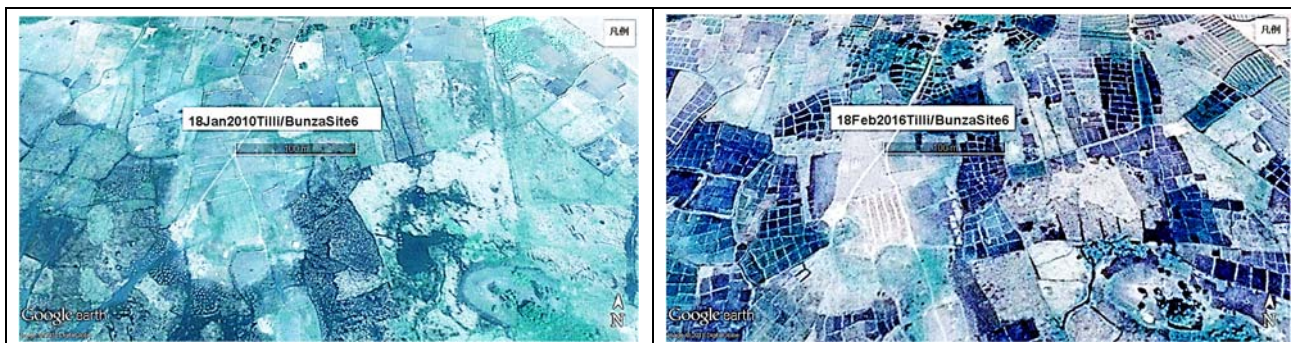


Figure 38. Progress of sawah platform improvement between 2010 (left) and 2016 (right) appeared in Google images near Site 6 shown in Figure 31. The total area shown is 10 ha. The length of the scale marker is 100 m. In 2010, almost all flood plain in this area is non sawah rice or ridge rice cultivation. In 2016, relatively good sawah system development is in progress at 80% of the flood plain. The Site 6 is adjacent to Sangelu where explosive sawah system development has progressed since 2011. Mean sawah plots size in 2016 is 150m².

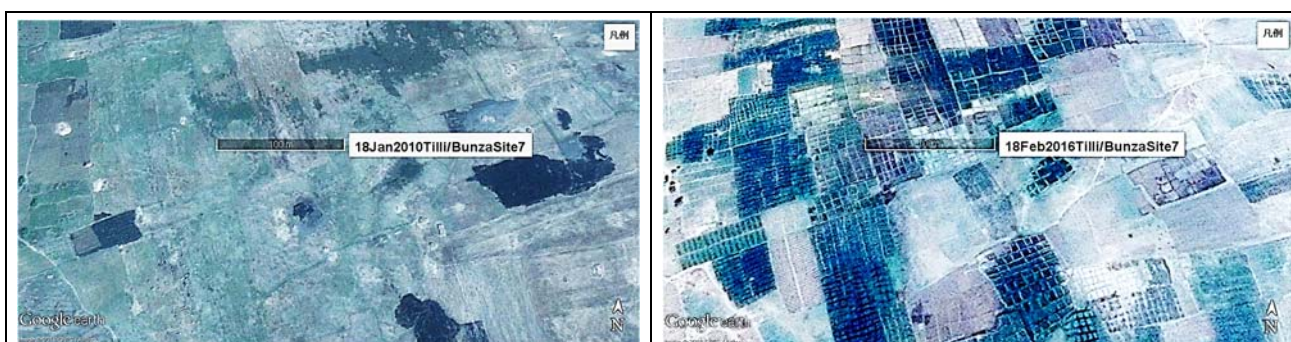


Figure 39. Progress of sawah platform improvement between 2010 (left) and 2016 (right) appeared in Google images near Site 7 shown in Figure 31. The total area shown is 10 ha. The length of the scale marker is 100 m. In 2010, almost all flood plain in this area is non sawah rice or ridge rice cultivation. In 2016, sawah system development is in progress at 60% of the flood plain. Although sawah plot size is 30-50m². Ridge rice planting is still operating. The Site 7 is adjacent to Sangelu where explosive sawah system development has progressed since 2011. Mean sawah plots size in 2016 is 50m². The Site 7 is located on the other side of Site 6 across the floodplain of the Rima river, about 5 km

6. The Zamfara River floodplain near Jega City: 20,000 ha

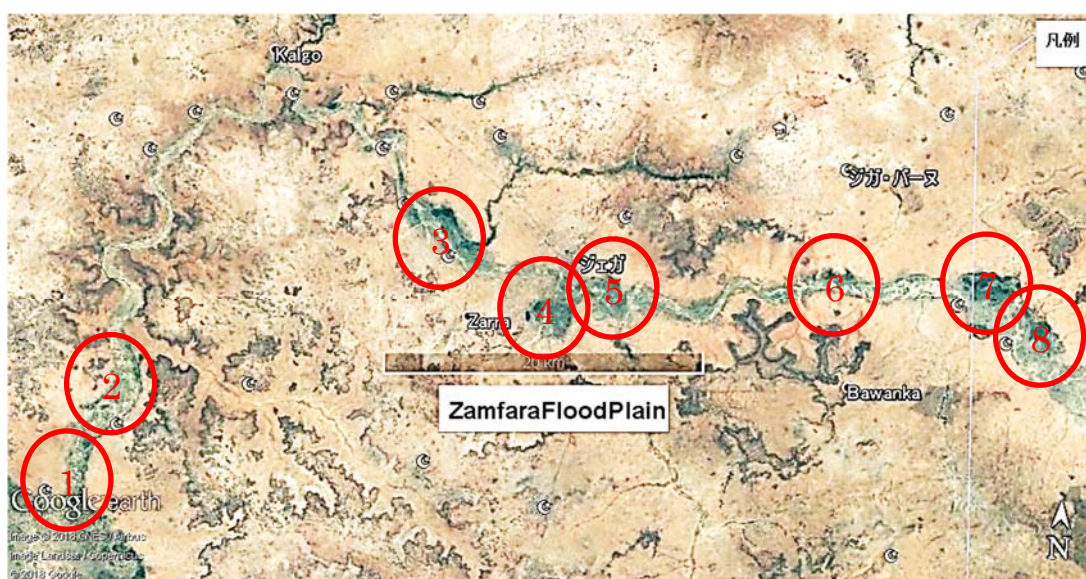


Figure 40. Google Earth image of the flood plains from ① just before the Zamfara river joins the Rima river. to the sites of ⑦ and ⑧ that entered Zamfara province beyond Kebbi province. ③-⑥ are near Jega city area. The scale marker length in the figure is 20 km. The area of the floodplain in this picture is about 20,000ha. The following Figure 41-48 shows progress of sawah system platform development between 2007/2009/2010/2013 and 2014/2016.

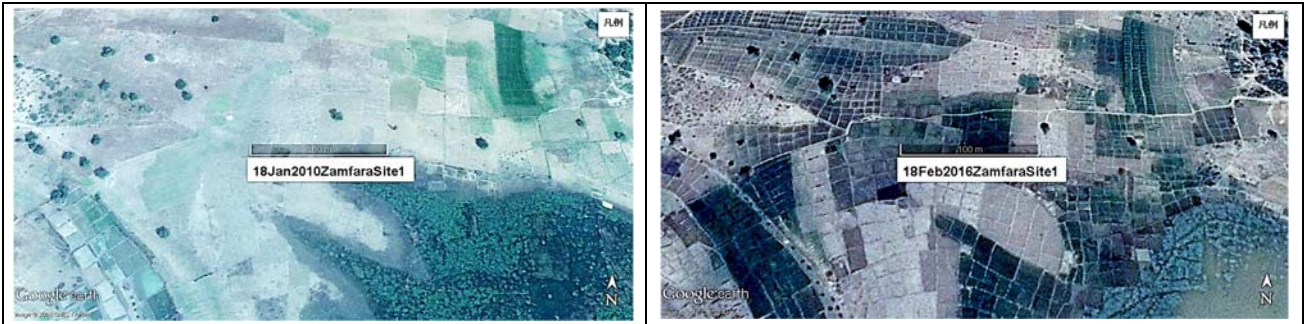


Figure 41. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 1 of the Zamfara River floodplain shown in Figure 40. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2010, about 80% area is non sawah, 10% is ridge rice cultivation and 10% is sawah plots. In 2016, more than 80% is sawah system (mean plots size is 150m^2) and 10% is ridge rice cultivation.



Figure 42. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 2 of the Zamfara River floodplain shown in Figure 40. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2010, about 90% area is non sawah and 10% is ridge rice cultivation. In 2016, 60% is sawah system (mean plots size is 80m^2) and 40% is ridge rice cultivation.

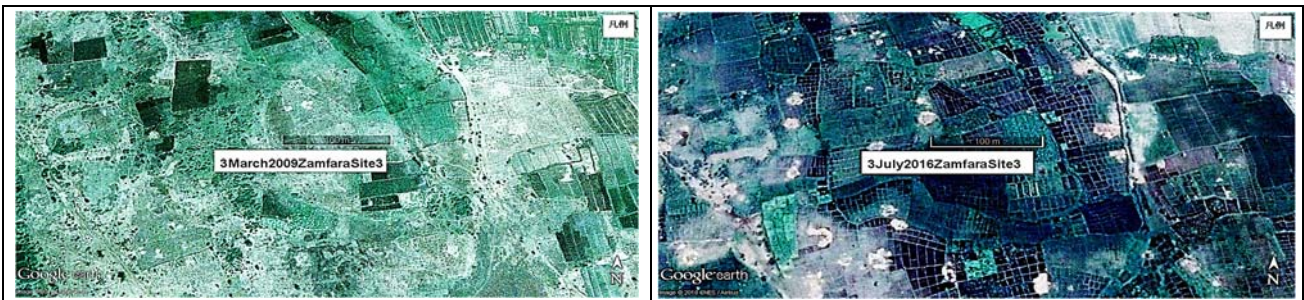


Figure 43. Progress of sawah platform improvement between 2009 (left) and 2016 (right) which appeared in Google image near Site 3 of the Zamfara River floodplain shown in Figure 40. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2009, about 80% area is non sawah and 20% is ridge rice cultivation. In 2016, 70% is sawah system (mean plots size is 50m^2) and 30% is ridge rice cultivation.



Figure 44. Progress of sawah platform improvement between 2007 (left) and 2016 (right) which appeared in Google image near Site 4 of the Zamfara River floodplain right south of Jega city shown in Figure 40. The area shown is about 10 ha. The scale marker is 100 m. In 2007, as described in the Sawah Technology (5) Kebbi Rice Revolution, 100% of land are covered with micro rudimentary sawah (plot size is $<30\text{m}^2$) and non sawah. In 2016, there are about 20% land is still covered with micro rudimentary sawah and ridge cultivation areas, but the progress of sawah platform improvement (mean plot size is 100m^2) is clearly recognized.

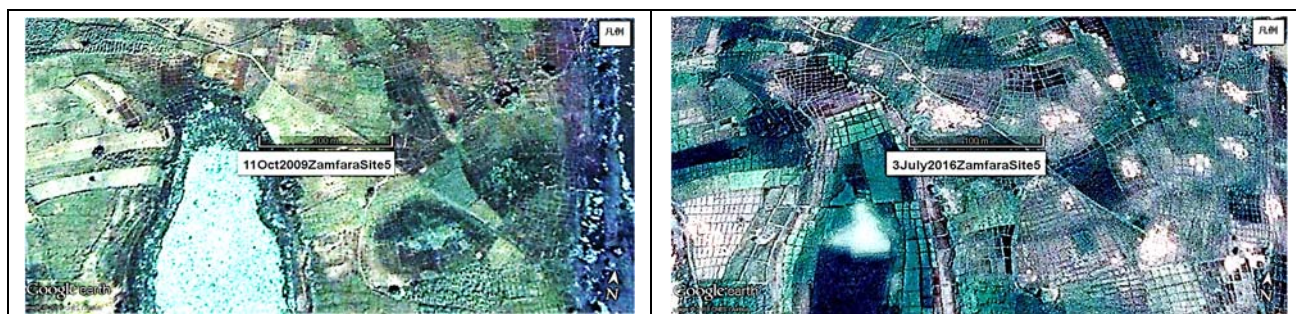


Figure 45. Progress of sawah platform improvement between 2009 (left) and 2016 (right) which appeared in Google image near Site 5 (adjacent to site 4) of the Zamfara River floodplain shown in Figure 40. The area shown is about 10 ha. The scale marker is 100 m. In 2009, 100% of land are covered with micro rudimentary sawah (plot size is $<30\text{m}^2$) and non sawah. In 2016, there are about 30-40% land is still covered with micro rudimentary sawah and ridge cultivation areas, but the progress of sawah platform improvement (mean plot size is 60m^2) is clearly recognized.



Figure 46. Progress of sawah platform improvement between 2009 (left) and 2016 (right) which appeared in Google image near Site 6 of the Zamfara River floodplain shown in Figure 40. The area shown is about 10 ha. The scale marker is 100 m. In 2009, 100% of land are covered with non sawah and ridge rice. In 2016, 60% land is covered with sawah system (mean plot size is 70m^2). Others are non sawah and ridge rice cultivation.



Figure 47. Google images of 2009 (left) and 2014 (right) of Site 7 of the Zamfara River floodplain shown in Figure 40. This site is Zamfara state adjacent to Kebbi state. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2009, the area presumed to be a sawah system, but it is unclear. In 2014, sawah system improvement is progressing all over the area (mean plot size is 100m^2)

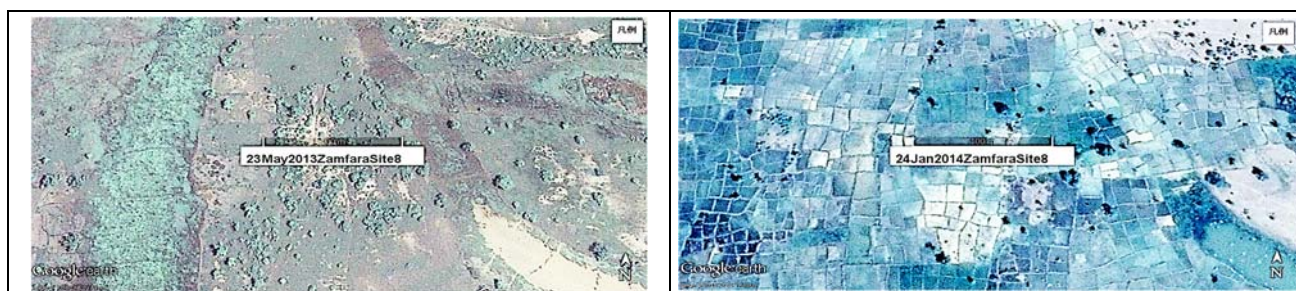


Figure 48. Google images of Site 8 of 2013 (left) and 2014 (right) of the Zamfara River floodplain shown in Figure 40. This site is Zamfara state adjacent to site 7. The total area shown is about 10 ha. The length of the scale marker is 100 m. Even in 2013 it is a completely non - sawah field. In 2014, sawah system developemnt is progressing all over the area (mean plot size is 140m^2).

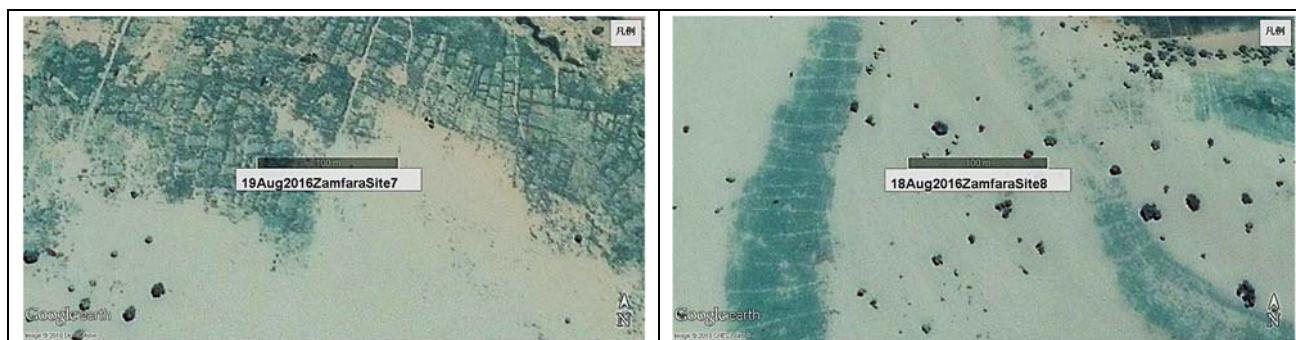


Figure 49. Google earth image on August 2016 showing the inundation of sawah systems of the Site 7 (Fig. 47) and Site 8 (Fig. 48). In these two sites, sawah system development progressed almost entirely by 2014. As shown in the figure 49, flood damage occurred in August 2016. Both sites are flooded over the entire area, but the bunding system of the sawah plots of relatively high specific height are clearly recognized. The average river slope is less than 1/1000, and in the usual floods of this degree, the sawah systems are not destroyed. It is considered that sustainable management of sawah systems developed by farmers' self-help efforts will not be so difficult.

7. The Rima River flood plain from the Zamfara River junction to the Niger River

7-1. Sangelu and Suru Region: flood plains where the impact of Sawah Technology is the most Prominent: 20,000 ha

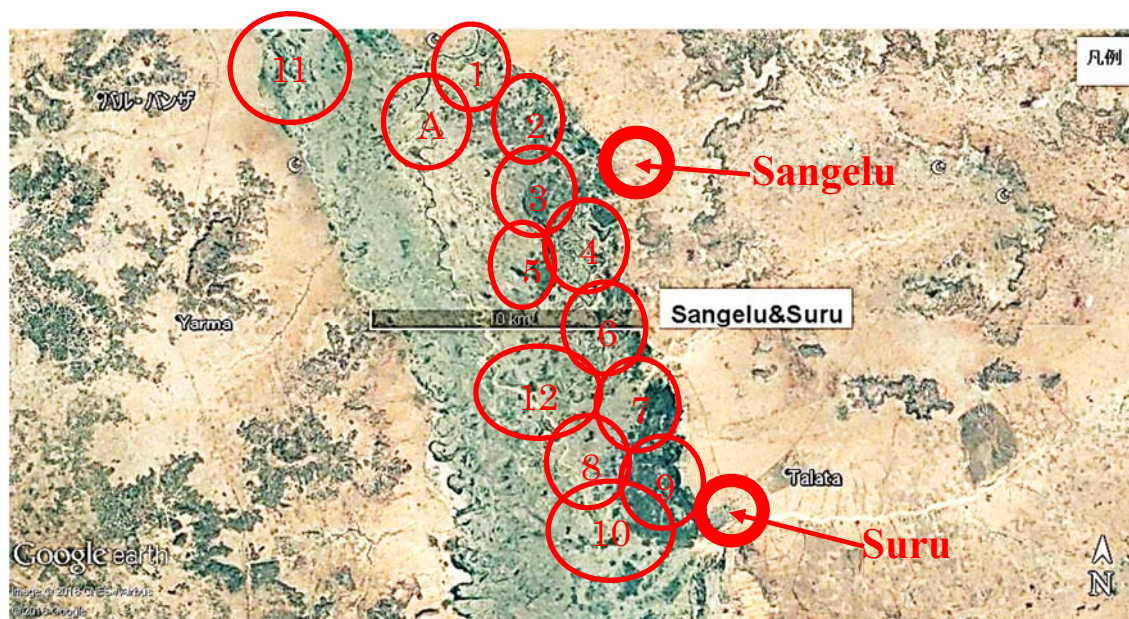


Figure 50. Flood plains of Sangelu and Suru region where the impact of Sawah Technology are the most prominent. This Google earth image shows the flood plains of the Rima river immediately after joining the Zamfara river from (A) and (11) as well as ①-⑤ near Sangelu town. The ⑥, ⑦ and (12) are in-between Sangelu and Suru. The ⑧-⑩ are in the vicinity of Suru town. The scale marker length in the figure is 10 km. The area of the floodplain in this picture is about 20,000 ha. The following Figure 50-63 show the explosive progress of the sawah system platform in this flood plains between 2010 and 2016.

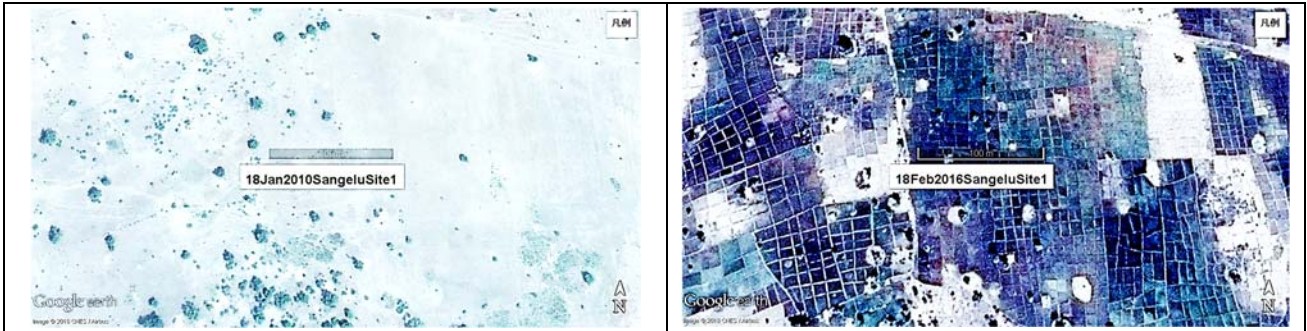


Figure 51. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 1 in the Sangelu area of the Rima River floodplain shown in Figure 50. The area shown is about 10 ha. The scale marker is 100 m. In 2009, almost 100% of land are covered with non sawah field. In 2016, more than 90% land is covered with sawah system (mean sawah plot size is 100m^2).



Figure 52. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site A in the Sangelu area of of the Rima River floodplain shown in Figure 50. The area shown is about 10 ha. The scale marker is 100 m. In 2009, almost 100% of land are covered with non sawah field. In 2016, more than 90% land is covered with sawah system (mean sawah plot size is 200m^2).

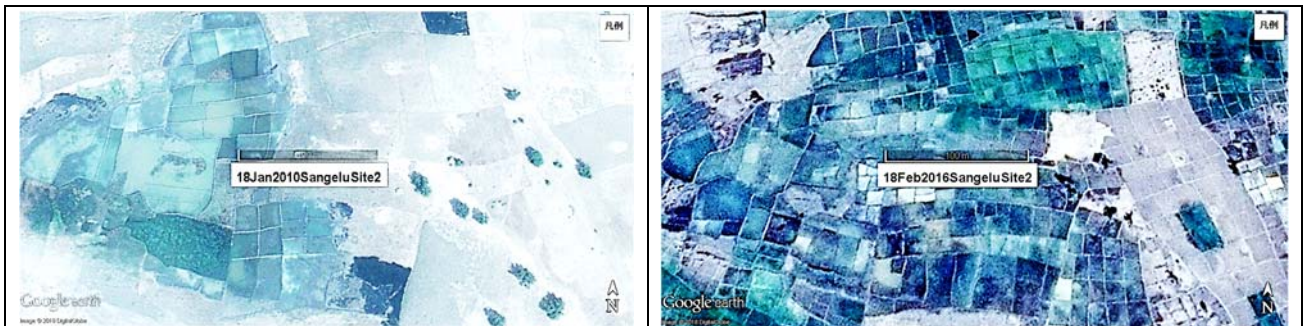


Figure 53. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 2 in the Sangelu area of of the Rima River floodplain shown in Figure 50. The area is about 10 ha. The scale marker is 100 m. In 2009, 10-20 % land have sawah plot like compartment in the depression. In 2016, more than 90% land is covered with sawah system (mean sawah plot size is 180m^2).

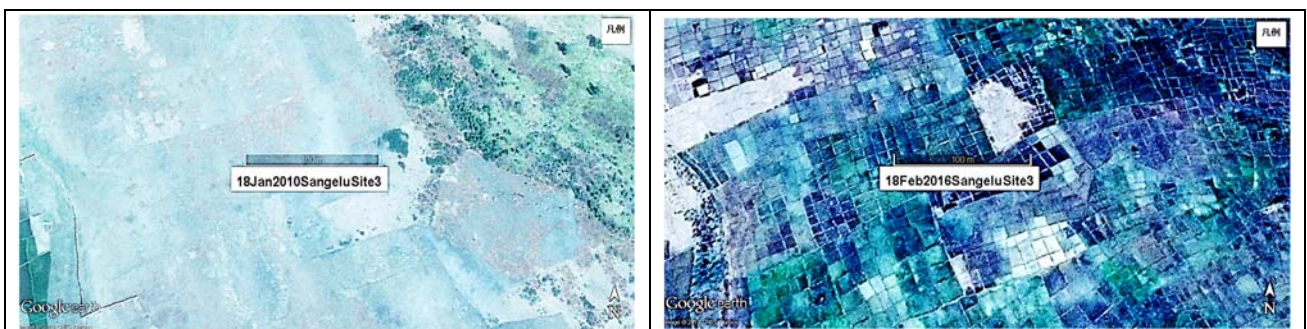


Figure 54. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 3 in the Sangelu area of of the Rima River floodplain shown in Figure 50. The area shown is about 10 ha. The scale marker is 100 m. In 2009, 100 % land have no sawah system. In 2016, 100% land is covered with sawah system (mean sawah plot size is 140m^2).



Figure 55. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 4 in the Sangelu area of of the Rima River floodplain shown in Figure 50. The area is about 10 ha. The scale marker is 100 m. In 2009, 90 % land have no sawah system and 10 % land have sawah plot like compartment. In 2016, more than 90% land is covered with sawah system (mean sawah plot size is 200m²).

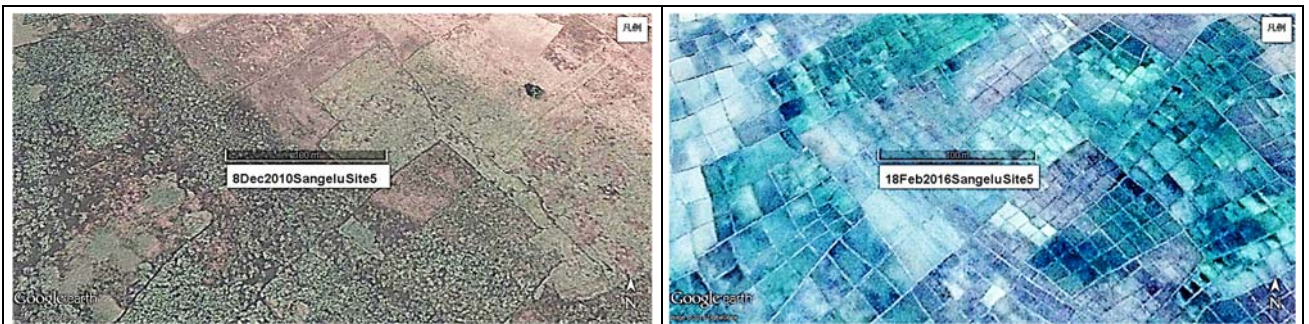


Figure 56. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 5 in the Sangelu area of of the Rima River floodplain shown in Figure 50. The area is about 10 ha. The scale marker is 100 m. In 2009, 100 % land have no sawah system. In 2016, 100% land is covered with sawah system (mean sawah plot size is 300m²).

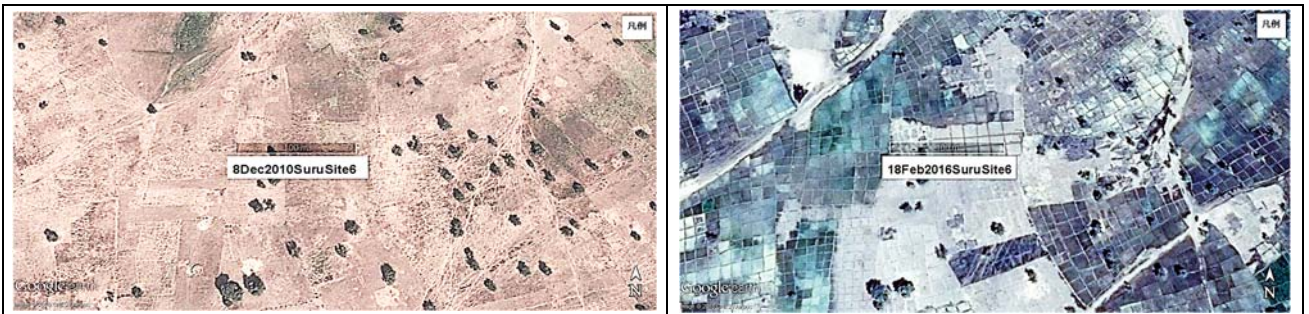


Figure 57. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 6 in-between Sangelu and Suru area of of the Rima River floodplain shown in Figure 50. The area is about 10 ha. The scale marker is 100 m. In 2009, 100 % land have no sawah system. In 2016, 90% land is covered with sawah system (mean sawah plot size is 120m²).

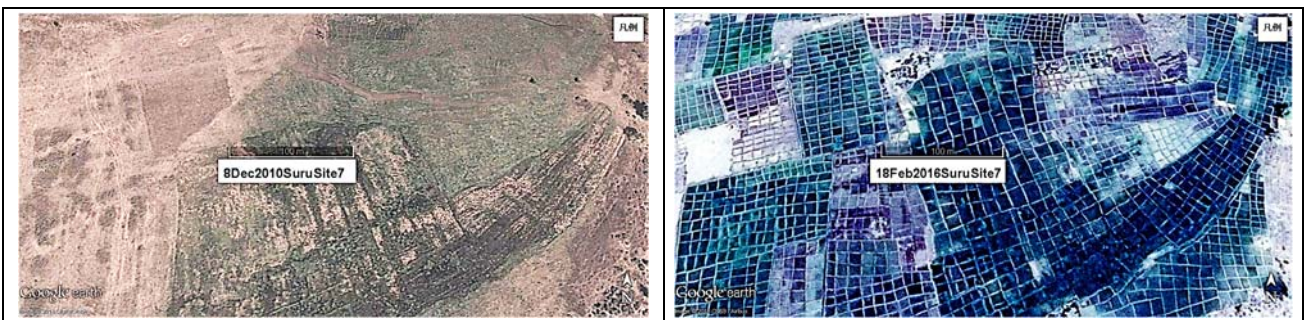


Figure 58. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 7 in Suru area of of the Rima River floodplain shown in Figure 50. The area is about 10 ha. The scale marker is 100 m. In 2009, 100 % land have no sawah system. In 2016, 100% land is covered with sawah system (mean sawah plot size is 110m²).



Figure 59. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 8 in Suru area of of the Rima River floodplain shown in Figure 50. The area is about 10 ha. The scale marker is 100 m. In 2009, 90 % land have no sawah system and 10% rudimentary sawah system. In 2016, 100% land is covered with sawah system (mean sawah plot size is 100m²).

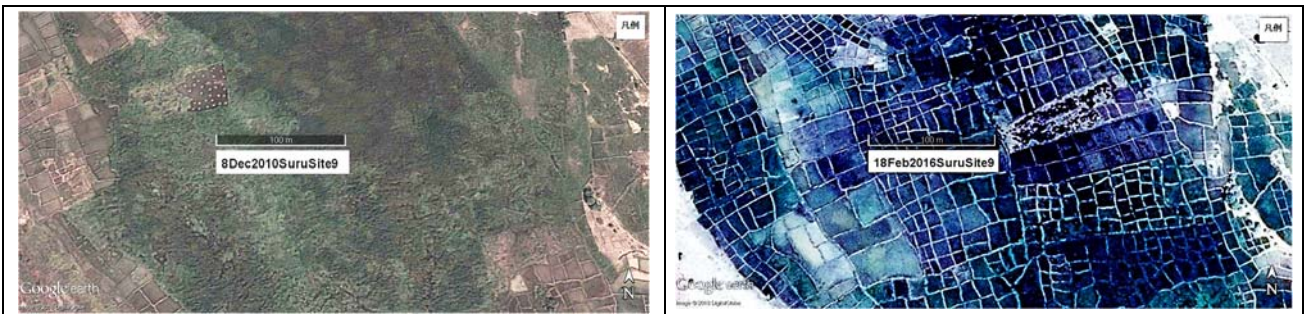


Figure 60. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 9 in Suru area of of the Rima River floodplain shown in Figure 50. The area is about 10 ha. The scale marker is 100 m. In 2009, 90 % land have no sawah system and 10% rudimentary sawah system. In 2016, 90% land is covered with sawah system (mean sawah plot size is 250m²).

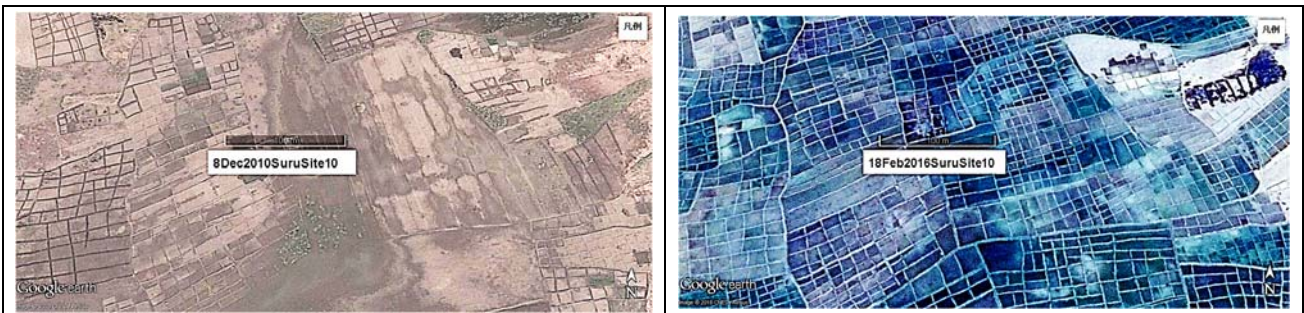


Figure 61. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 10 in Suru area of of the Rima River floodplain shown in Figure 50. The area is about 10 ha. The scale marker is 100 m. In 2009, 90 % land have no sawah system and 10% rudimentary sawah system. In 2016, 90% land is covered with sawah system (mean sawah plot size is 180m²).

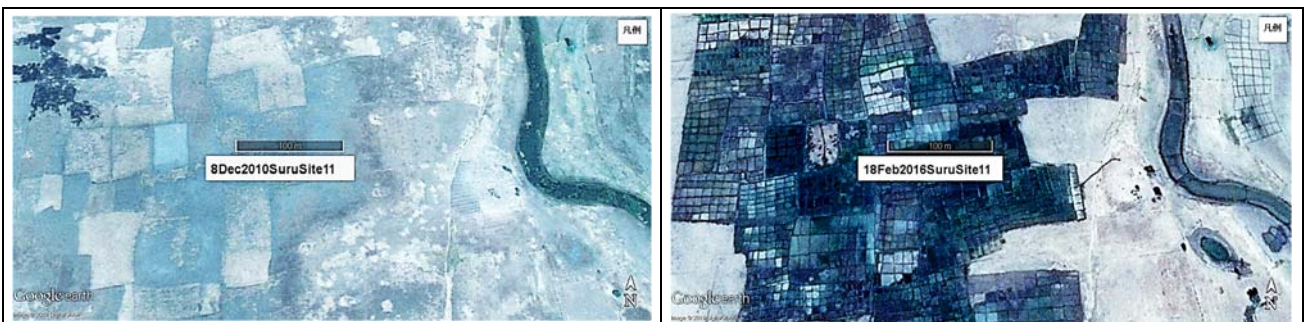


Figure 62. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 11. As shown in Figure 50, this site is located on the west bank opposite the Sangelu which is the eastern bank of the Rima River floodplain. The area is about 10 ha. The scale marker is 100 m. In 2009, 100 % land have no sawah system. In 2016, 60% land is covered with sawah system (mean sawah plot size is 80m²).



Figure 63. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 12 in Suru area of of the Rima River floodplain shown in Figure 50. The area is about 10 ha. The scale marker is 100 m. In 2009, 95 % land have no sawah system and 5% rudimentary sawah system. In 2016, 80% land is covered with sawah system (mean sawah plot size is 150m^2).

7-2. The Rima River flood plain from the downstream of Suru to the confluence of the Niger River: 20,000 ha

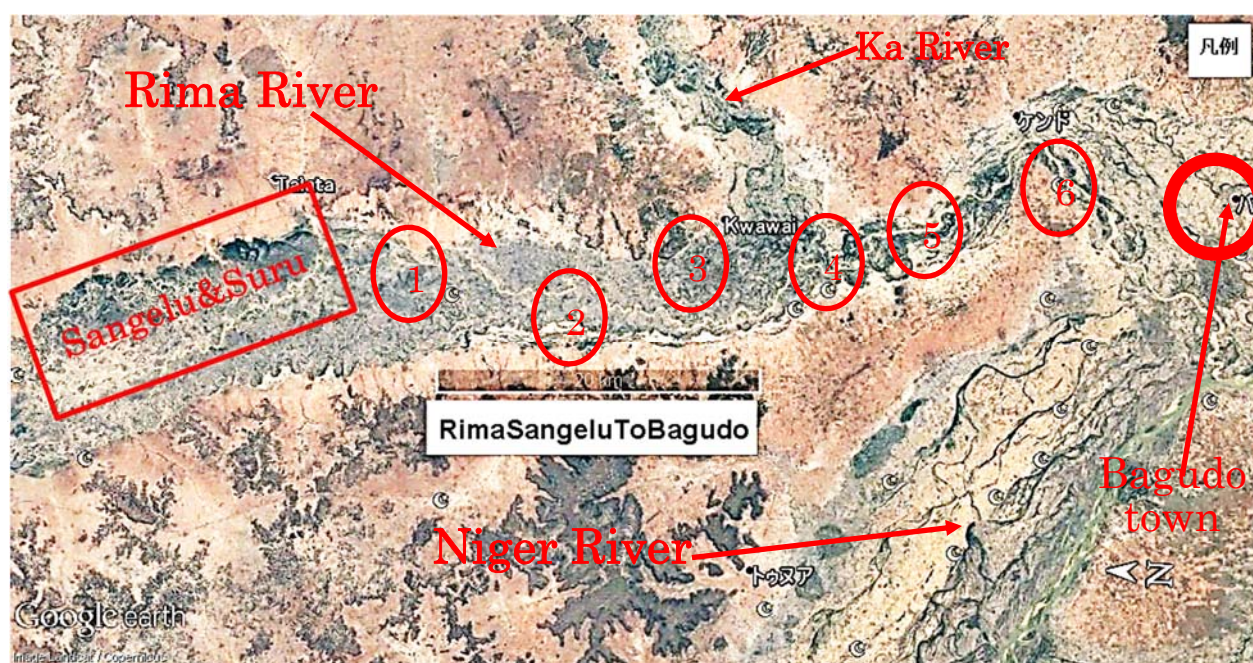


Figure 64. Rima river floodplain from Sangelu and Suru to the Bagudo junction of the Niger River. The scale marker length in the figure is 20 km. The area of the Rima River flood plain in this picture is about 35,000 ha excluding the vicinity of Sangelu and Suru area which are enclosed by a square. The area of 35,000ha is also excluding the area of the flood plains of both Ka river and the Niger river. The following Figure 65-70 shows progress of sawah system platform development and improvement between 2010/2011/2012 and 2016.



Figure 65. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google image near Site 1, which is just south of Suru town, downstream of the Rima River floodplain shown in Figure 64. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2010, 100% flood plain has no sawah

system. In 2016, 60% land is covered with sawah system (mean sawah plot size is 150m²)



Figure 66. Progress of sawah platform improvement between 2012 (left) and 2016 (right) which appeared in Google image near Site 2 of the Rima River floodplain shown in Figure 64. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2012, 90% flood plain has no sawah system and 10% rudimentary sawah system. In 2016, 50% land is covered with sawah system (mean sawah plot size is 150m²). Ridge rice cultivation and micro rudimentary sawah can be seen at the red circle are. Remaining is non sawah.

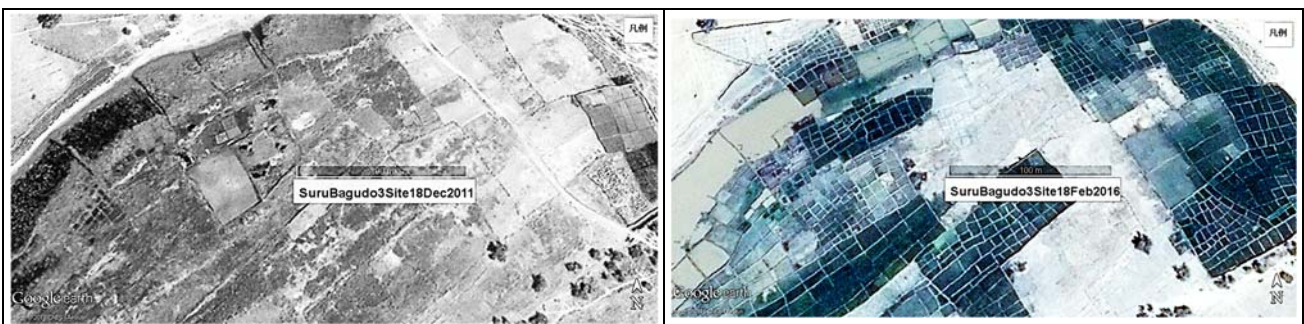


Figure 67. Progress of sawah platform improvement between 2011 (left) and 2016 (right) which appeared in Google image near Site 3 of the Rima River floodplain shown in Figure 64. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2011, 100% flood plain has no sawah system. In 2016, 70% land is covered with sawah system (mean sawah plot size is 70m²).



Figure 68. Progress of sawah platform improvement between 2011 (left) and 2016 (right) which appeared in Google image near Site 4 of the Rima River floodplain shown in Figure 64. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2011, 100% flood plain has no sawah system. In 2016, 30% land is covered with sawah system (mean sawah plot size is 80m²).

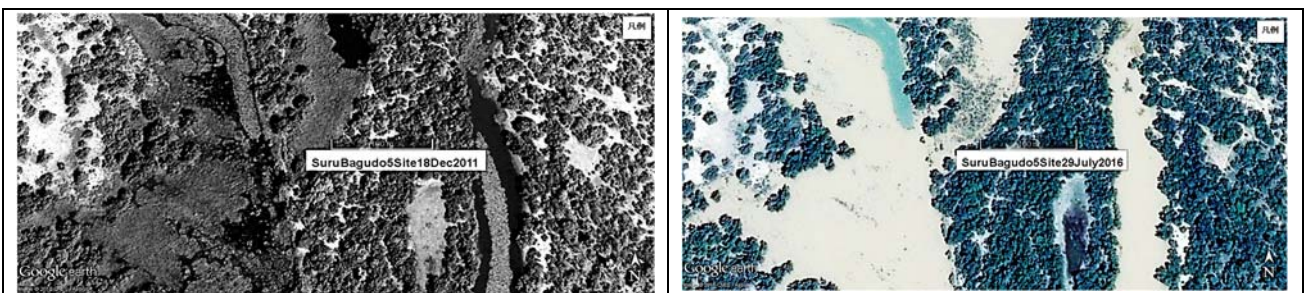


Figure 69. Progress of sawah platform improvement between 2011 (left) and 2016 (right) which appeared in Google image near Site 5 of the Rima River floodplain shown in Figure 64. The total area shown is about 10 ha. The length of the scale marker is 100 m. Both in 2011 and 2016, 100% flood plain has no sawah system. This is the plateaus

covered with forest left in the floodplain. Thus the site is inappropriate for wetland rice cultivation.



Figure 70. Progress of sawah platform improvement between 2012 (left) and 2014 (right) which appeared in Google image near Site 6 of the Rima River floodplain shown in Figure 64. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2012, 20% flood plain has covered with micro rudimentary sawah system (mean sawah plot size is 30m²). In 2016, 40% land is covered with sawah system (sawah plot size range is 20-70m²).

7-3. The Ka River flood plains within the Kebbi state: 10,000 ha

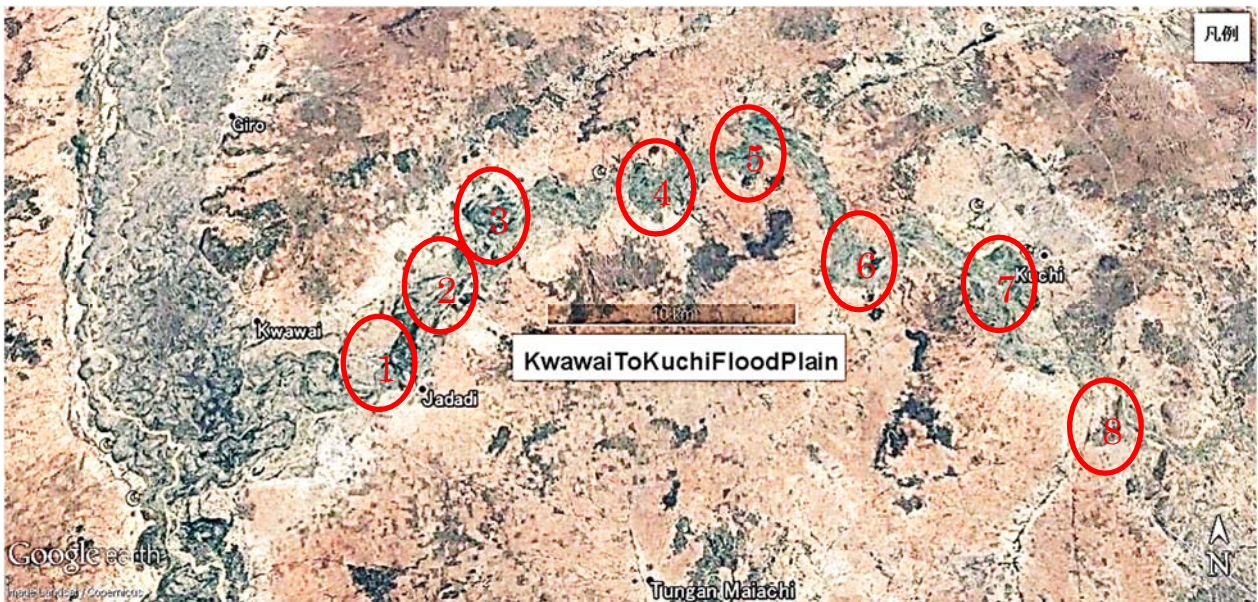


Figure 71. Eight sites ①—⑧ examined the progress of the sawah system platform during 2011/2012 and 2016 on the Ka river flood plains within the Kebbi state from the Rima River junction near Kwawai town to Kuchi town near the border of the Zamfara state. The scale marker length in the figure is 10 km. The area of the Ka River floodplain in this picture is 10,000 ha. The progress is shown in Figure 72-79 below.

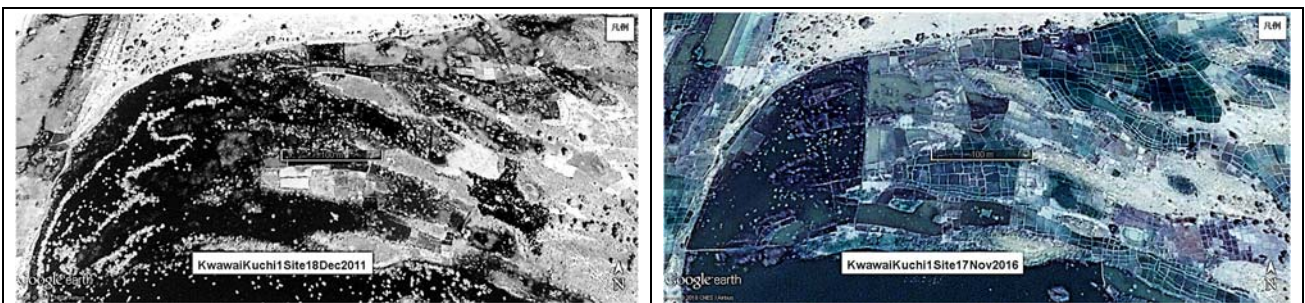


Figure 72. Progress of sawah platform improvement between 2011 (left) and 2016 (right) which appeared in Google image near Site 1 of the Ka River floodplain shown in Figure 71. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2011, 100% flood plain has no sawah system. In 2016, 40% land is covered with sawah system (mean sawah plot size is 80m²).

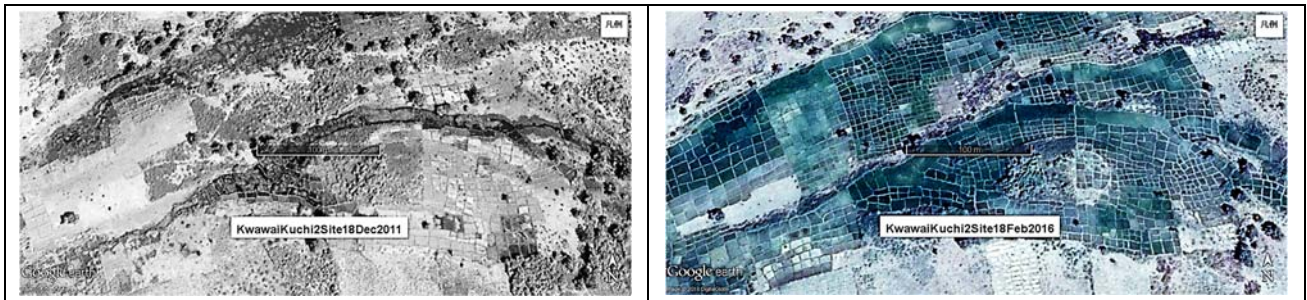


Figure 73. Progress of sawah platform improvement between 2011 (left) and 2016 (right) which appeared in Google image near Site 2 of the Ka River floodplain shown in Figure 71. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2011, 90% flood plain has no sawah system and 10% rudimentary sawah system. In 2016, 60% land is covered with sawah system (mean sawah plot size is 70m^2).



Figure 74. Progress of sawah platform improvement between 2011 (left) and 2016 (right) which appeared in Google image near Site 3 of the Ka River floodplain shown in Figure 70. The total area shown is about 10 ha. The length of the scale marker is 100 m. In December 2011, sawah system development is proceeding in 10% area, the others are ridge rice cultivation and non-sawah, in 2016 although still rudimentary level, sawah system is expanding to 20-30 % area (mean plot size is 50m^2). Remaining 80-70 % is ridge rice cultivation.

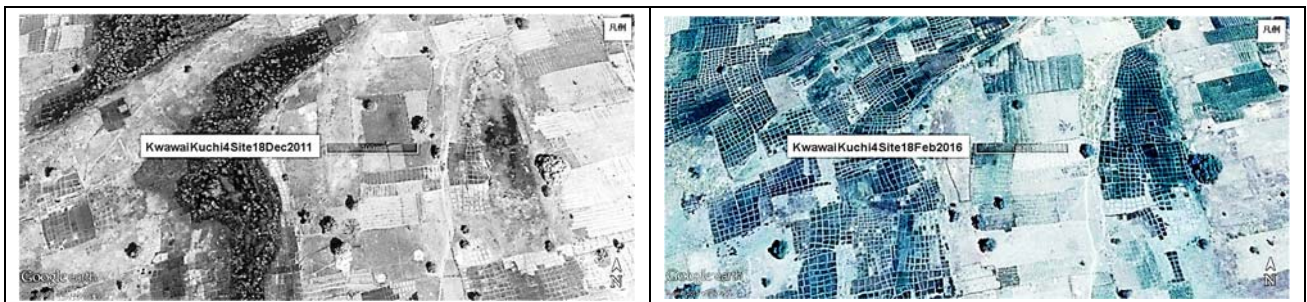


Figure 75. Progress of sawah platform improvement between 2011 (left) and 2016 (right) which appeared in Google image near Site 4 of the Ka River floodplain shown in Figure 70. The total area shown is about 10 ha. The length of the scale marker is 100 m. In December 2011, sawah system development is proceeding in 10% area, the others are ridge rice cultivation and non-sawah, in 2016 although still rudimentary level, sawah system is expanding to 60 % area (mean plot size is 50m^2). Remaining 40 % is ridge rice and non sawah rice cultivation.



Figure 76. Progress of sawah platform improvement between 2012 (left) and 2016 (right) which appeared in Google image near Site 5 of the Ka River floodplain shown in Figure 70. The total area shown is about 10 ha. The length of the scale marker is 100 m. In January 2012, sawah system development is proceeding in 10% area, the others are ridge rice cultivation and non-sawah, in 2016 although still rudimentary level, sawah system is expanding to 30 % area (mean plot size is 30m^2). Remaining 70 % is ridge rice and non sawah rice cultivation.

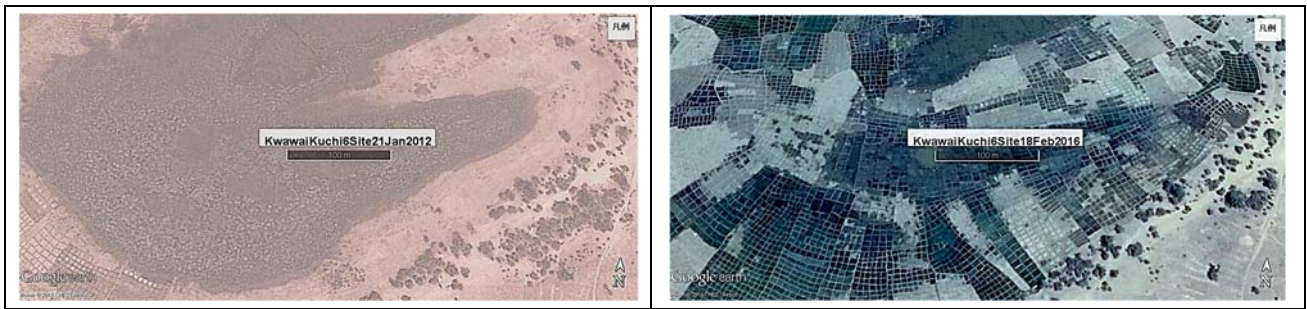


Figure 77. Progress of sawah platform improvement between 2012 (left) and 2016 (right) which appeared in Google image near Site 6 of the Ka River floodplain shown in Figure 70. The total area shown is about 10 ha. The length of the scale marker is 100 m. In January 2012, sawah system development is proceeding in 5% area, the others is non-sawah, in 2016 although still rudimentary level, sawah system is expanding to 70 % area (mean plot size is 50m^2).



Figure 78. Progress of sawah platform improvement between 2012 (left) and 2016 (right) which appeared in Google earth image near Site 7 of the Ka River floodplain shown in Figure 70. The total area shown is about 10 ha. The length of the scale marker is 100 m. In January 2012, sawah system development is proceeding in 5% area, the others is non-sawah, in 2016, sawah system is expanding to 70 % area (mean plot size is 80m^2).



Figure 79. Progress of sawah platform improvement between 2012 (left) and 2016 (right) which appeared in Google earth image near Site 8 of the Ka River floodplain in Figure 70. The total area shown is about 10 ha. Length of the scale marker is 100 m. In January 2012, 100% area are non-sawah and ridge rice cultivation. In 2016, although still rudimentary, sawah system is expanding to 40 % area (mean plot size is 40m^2). Remaining is ridge rice cultivation.

8. The Niger River flood plain from Benin border to Bagudo junction of the Rima river: 150,000 ha



Figure 80. Ten sites of (A)-(B) and ①-⑧ examined the progress of the sawah system platform during 2007/2010 and 2012/2016/2017 on the Niger river flood plains within the Kebbi state from the Niger/Benin border to Bagudo (BGD) area. The scale marker length in the figure is 30 km. The area of the flood plains shown in this picture is about 150,000 ha. The following Figure 81-90 show the progress of sawah system development. The BGD area was described in Fig. 39-48 of Sawah Technology (5) Kebbi Rice Revolution, Nigeria.



Figure 81. Progress of sawah platform improvement between 2012 (left) and 2016 (right) which appeared in Google earth image near Site A of Kamba town area in Figure 80. The site is a part of Niger river flood plain, just close to the border of Niger. The total area shown is about 10 ha. Length of the scale marker is 100 m. In 2011, 10% area is rudimentary sawah and remaining is non-sawah rice cultivation. In 2017, sawah system is expanding to 80 % area (mean sawah plot size is 170m²).

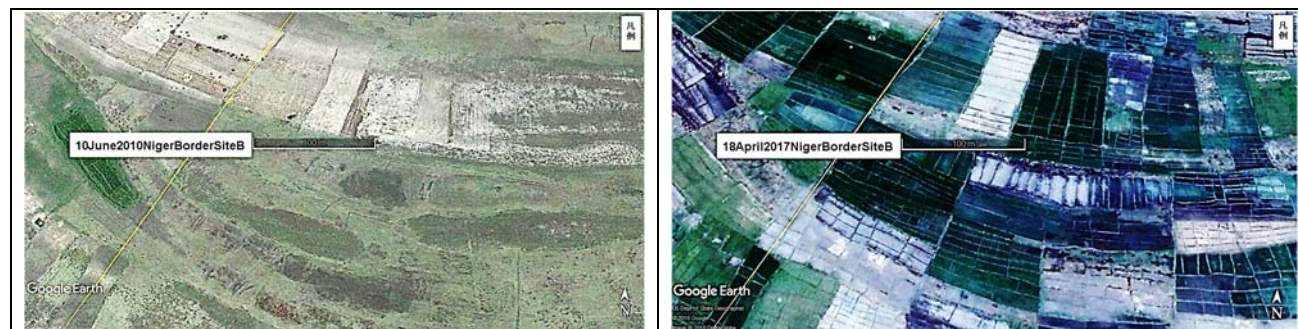


Figure 82. Progress of sawah platform improvement between 2010 (left) and 2017 (right) which appeared in Google

earth image near Site B in Figure 80. The site is a part of Niger river flood plain, just close to the border of Niger and Benin. The total area shown is about 10 ha. Length of the scale marker is 100 m. In 2010, almost 100% area is non-sawah rice cultivation. In 2017, sawah system is expanding to 90 % area (mean sawah plot size is 150m²).



Figure 83. Progress of sawah platform improvement between 2010 (left) and 2017 (right) which appeared in Google earth image near Site 1 in Figure 80. The site is a part of Niger river flood plain, just close to Tungun Rogo town. The total area shown is about 10 ha. Length of the scale marker is 100 m. In 2010, 10% area is being on development of sawah system. In 2017, although still rudimentary, sawah system is expanding to 80 % area (mean sawah plot size is 50m²).



Figure 84. Progress of sawah platform improvement between 2010 (left) and 2017 (right) which appeared in Google earth image near Site 2 in Figure 80. The site is a part of Niger river flood plain. The total area shown is about 10 ha. Length of the scale marker is 100 m. In 2010, 10% area near the village (red circle) is being on development of sawah system. In 2017, although still rudimentary, sawah system is expanding to 60 % area (mean sawah plot size is 70m²).



Figure 85. Progress of sawah platform improvement between 2010 (left) and 2017 (right) which appeared in Google earth image near Site 3 in Figure 80. The site is near Tungun Rafi town, which is a part of Niger river flood plain. Total area shown is about 10 ha. Scale marker length is 100 m. In 2010, 100% area has no sawah system. In 2017, sawah system is expanding to 60 % area (Red circled sawah system is the best, which mean sawah plot size is 130m²).



Figure 86. Progress of sawah platform improvement between 2010 (left) and 2017 (right) which appeared in Google earth image near Site 4 in Figure 80. The site is a part of Niger river flood plain. Total area shown is about 10 ha. Scale marker length is 100 m. In 2010, 100% area has no sawah system. In 2017, sawah system is expanding to 50 % area

(mean sawah plot size is 100m²).



Figure 87. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google earth image near Site 5 in Figure 80. The site is a part of Niger rive flood plain. Total area shown is about 10 ha. Scale marker length is 100 m. In 2010, 100% area has no sawah system. In 2016, although still rudimentary, sawah system is expanding to 50 % area (mean sawah plot size is 40m²).



Figure 88. Progress of sawah platform improvement between 2010 (left) and 2016 (right) which appeared in Google earth image near Site 6 in Figure 80. The site is a part of Niger rive flood plain. Total area shown is about 10 ha. Scale marker length is 100 m. In 2010, 100% area has no sawah system. In 2016, sawah system is expanding to 50 % area (mean sawah plot size is 70m²).

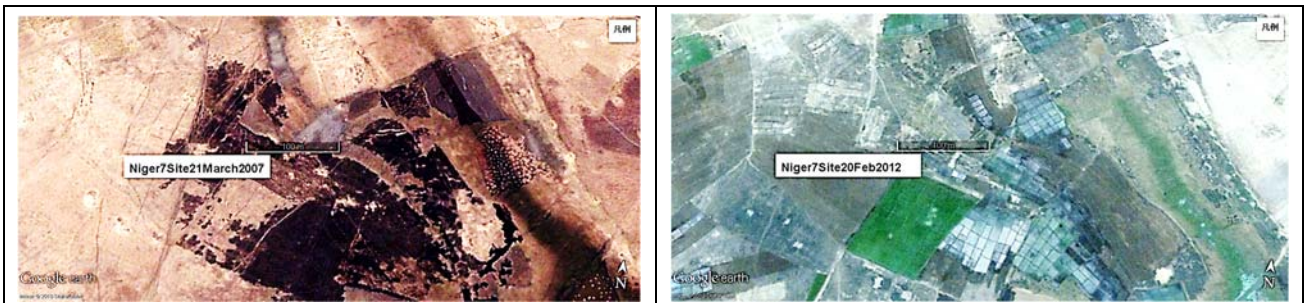


Figure 89. Progress of sawah platform improvement between 2007 (left) and 2012 (right) which appeared in Google earth image near Site 7 in Figure 80. The site is a part of Niger rive flood plain. Total area shown is about 10 ha. Scale marker length is 100 m. In 2010, 100% area has no sawah system. In 2016, sawah system is covering 20 % area (mean sawah plot size is 140m²). Please note the most recent available Google image was 2012.

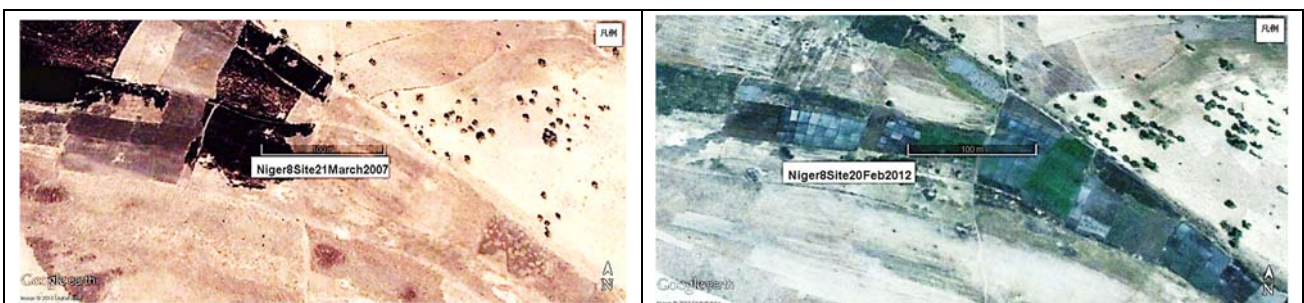


Figure 90. Progress of sawah platform improvement between 2007 (left) and 2012 (right) which appeared in Google earth image near Site 8 in Figure 80. The site is a part of Niger rive flood plain. Total area shown is about 10 ha. Scale marker length is 100 m. In 2010, 100% area has no sawah system. In 2016, sawah system is covering 20 % area (mean sawah plot size is 70m²). Please note the most recent available Google image was 2012.

9. The Niger River floodplain from the Bagudo junction to the lake Kainji dam: 60,000 ha

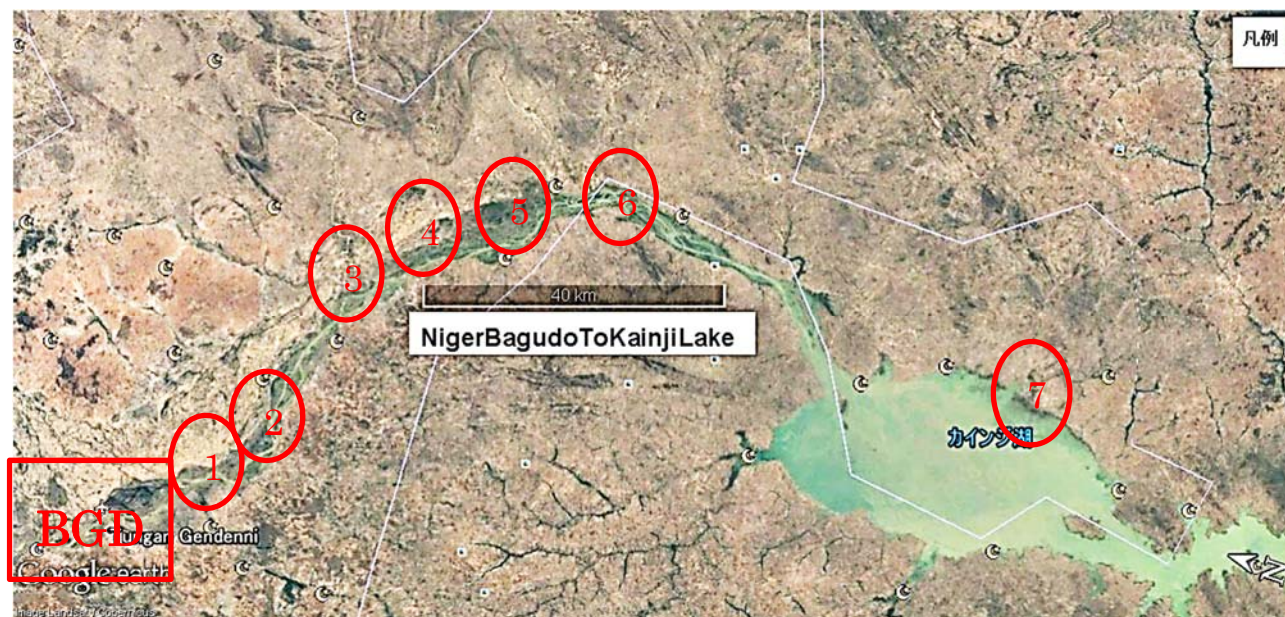


Figure 91. The Niger river flood plains from Bagudo (BGD) area to the Kainji dam lake. The scale marker length in the figure is 40 km. The area of the floodplain in this picture is about 60,000 ha. The following Figure 92-97 shows the progress of sawah system development and improvement by farmers' own efforts during 2011/2012/2013 and 2014/2016. The ⑥ site is Yelwa town. There are few suitable sites for sawah based rice cultivation in the downstream part of Yelwa. ⑦ is an incomplete government irrigated rice land.



Figure 92. Progress of sawah platform improvement between 2011 (left) and 2014 (right) which appeared in Google earth image near Site 1 in Figure 91. The site is a part of Niger river flood plain. Total area shown is about 10 ha. Scale marker length is 100 m. In 2011, 10% area has started sawah system development. In 2014, although still rudimentary, sawah system is expanding to almost 100 % area (mean sawah plot size is 50m²).

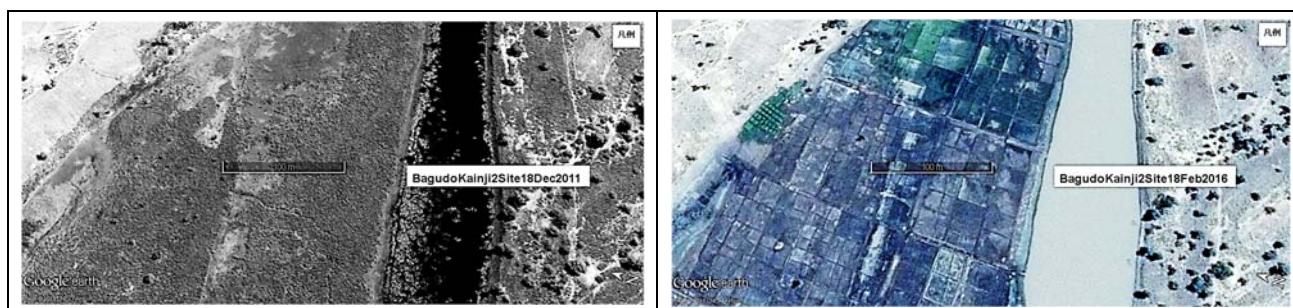


Figure 93. Progress of sawah platform improvement between 2011 (left) and 2016 (right) which appeared in Google earth image near Site 2 in Figure 91. The site is a part of Niger river flood plain. Total area shown is about 10 ha. Scale marker length is 100 m. In 2011, 100% area has no sawah system. In 2016, sawah system is expanding to 60 % area (mean sawah plot size is 180m²).

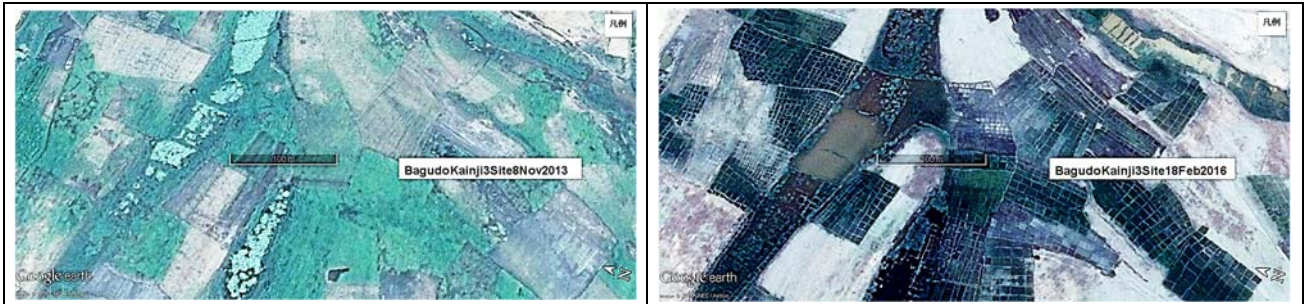


Figure 94. Progress of sawah platform improvement between 2013 (left) and 2016 (right) which appeared in Google earth image near Site 3 in Figure 91. The site is a part of Niger river flood plain. Total area shown is about 10 ha. Scale marker length is 100 m. In 2013, 10-20% area has started sawah system development. In 2016, sawah system reached to 70-80 % area (mean sawah plot size is 70m^2).

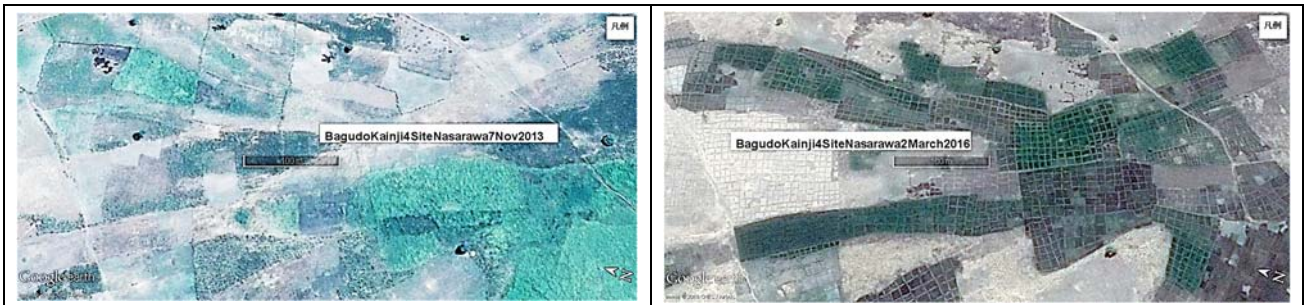


Figure 95. Progress of sawah platform improvement between 2013 (left) and 2016 (right) which appeared in Google earth image near Site 4 in Figure 91. The site is near to Nasarawa town and a part of Niger river flood plain. Total area shown is about 10 ha. Scale marker length is 100 m. In 2013, 100% area has no sawah system. In 2016, sawah system reached to 70-80 % area (mean sawah plot size is 100m^2).

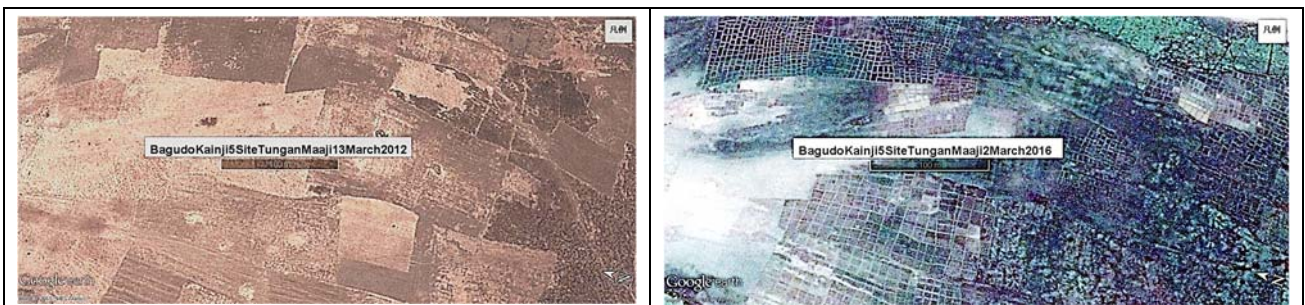


Figure 96. Progress of sawah platform improvement between 2012 (left) and 2016 (right) which appeared in Google earth image near Site 5 in Figure 91. The site is near to Tungan Maaji town and a part of Niger river flood plain. Total area shown is about 10 ha. Scale marker length is 100 m. In 2012, 100% area has no sawah system. In 2016, sawah system reached to 80 % area (sawah plot size range is $20\text{-}100\text{m}^2$).



Figure 97. Google image in January 2011 near Yelwa. This picture shows the Site 6 of the Figure 91 near Yelwa town and the site is a part of Nigeri river flood plain. The time series of Google satellite pictures could not be obtained. The total area shown is about 10 ha. The length of the scale marker is 100 m. In 2011, 100 % agricultural land are ridge rice and others' cultivation.



Figure 98. Google earth image in 2002 near Site 7 on the left bank of Kainji Dam Lake shown in Figure 91. The total area shown is about 1400 ha. The length of the scale marker is 1 km. The time series of Google satellite pictures could not be obtained. This site was planned to operate irrigated rice production by pumping water of Kainji dam lake, but the situation as of 2018 is unknown. However, this type of government irrigation system in Kebbi state did not contribute much to rice development promotion in Kebbi state during 2010-2017, compared with sawah technology, which is irrigated sawah system development and sawah based rice farming by farmers' self-help efforts. (African paddy farming method, Sawah Technology).

10. References

- Abdullahi SA, Muhammad MM, Adeogun BK and Mohammed IU. 2014. Assesment of Water Availability in the Sokoto Rima River Basin, Resources and Environment 2014, 4(5): 220-233, DOI: 10.5923/j.re.20140405.03
- Dakingari ASU, 2013. Growing Agriculture in Kebbi state, paper presented by the executive governor of Kebbi state at the 19th National Economic summit, Group(NESG) held in Abuja on the 4th September, 2013 (https://ifdc.org/wp-content/uploads/2015/03/report_of_the_19th_nigerian_economic_summit.pdf)