Fig. 32C. December 2011, immediately after the sawah technology training Photographs of Fig.15②&⑤, Fig.17A-F, Fig.18G, Fig.19①, Fig31a①and Fig31b③&④were taken from the site 1. Photographs of Fig.15①, ③ & ④, Fig.18G, Fig.20 ④, Fig.31a③, Fig.31b① &②were taken from the site 2. Some part of the site1 damaged by the flooding on July 2011.

Fig. 32D. Google Earth on January 2014. We can see the progress of sawah plots improvement throughout the flood plain. However, it is difficult to distinguish between standards sawah plots and rudimentary sawah plots by the Google earth images alone. Ground Truth confirmation is necessary

Fig. 32E. July 2016 Google earth shows the flooding, which occurred in depressions of the floodplain. It can be seen that the progress of sawah platform improvement are ongoing. With this extent of flooding the bunds of sawah system were not completely destroyed. Thus the restoration will not be so difficult.

Fig. 32A-D show the chronological improvement of the sawah system plat form on the Zamfara river flood plains in the vicinity of Jega City (see also Fig 16), which appeared on the Google earth images during 2003-2016. Fig. 32A and B show the Google Earth image of the Zamfara River floodplain south of Jega City before the sawah technology training and demonstration. The two demonstration plots, the site 1 and site 2 were established during March to December 2011, which can be seen on the Fig.32C-D. Before sawah technology training, the rudimentary sawah plots were common as seen in the photographs of Fig.15①-⑤, and Fig.18 G. Through the on-the-job training we established standard sawah system plots and standard sawah based rice farming as shown in the Fig.18H, Fig. 19① and Fig. 20①. However, it is difficult to distinguish between standards sawah plots and rudimentary sawah plots by the Google earth images alone. Ground Truth confirmation to compare the rudimentary sawah photographs of Fig.15①-⑤, and Fig.18 G as well as standards sawah photographs of Fig18H, Fig. 19① and Fig. 20① is necessary.

As shown in the Fig. 31b③ and Fig. 32E, some parts of the demonstration site 1 was damaged by flooding on July 2011(see also Fig.17E and F). Fig. 32D shows the state of flooding in July 2016. Flooding occurred in the depression of the former crescent parts of the floodplain. With this extent of flooding the bunds of sawah system were not completely destroyed. Thus the restoration will not be so difficult. It can be seen that the progress of the improvement of sawah system platform is ongoing as a whole.

7. Training and demonstration in the Birinin Kebbi area

Birinin Kebbi is the capital city. See Fig. 3 for the position. Fig. 33 of Google earth picture of 2018 shows irrigated rice fields of about 70 hectares which was developed by the Kebbi state government on the Rima River floodplain adjacent to the north of Birnin Kebbi city. The length of the scale marker on the Fig. 33 is 500 m. At the two sites of (1) and (2), Nigeria sawah team under Kinki university/NCAM project conducted on-the-job training to establish the demonstration plots, total 3.5ha, which was in collaboration with the World Bank-supported Fadama III/ADP staffs and rice farmers' association, during March-December 2011. The yield data are shown in the Table 4.1.

Fig. 33. Google earth picture on November 2016. Government old Irrigation site on the Rima River flood plain, just the north of the Birinin kebbi town. Length of scale maker is 500m. Total area is aboutb70 ha.
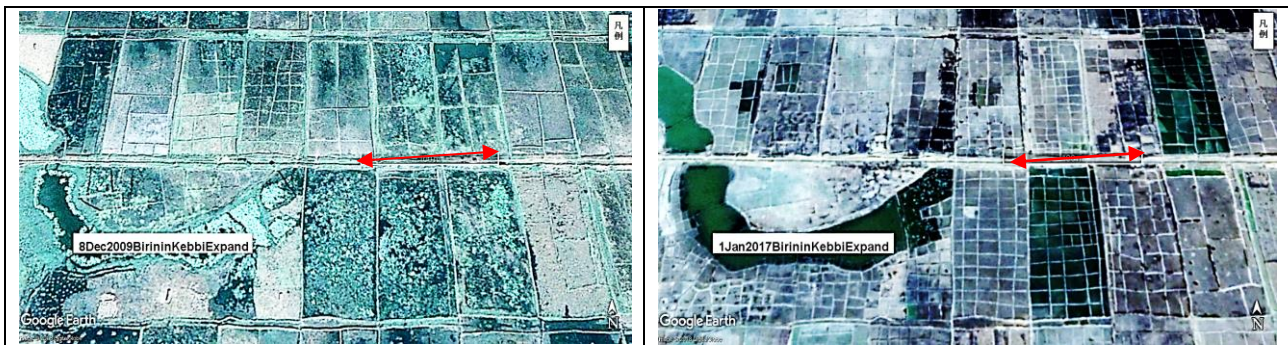

Fig. 34A. Sawah plots improvement during 2011-2017. These two are expanded the area of A on the Fig.33. Maker scale is 100m. The left picture was taken on 2009 and the right on 2017.
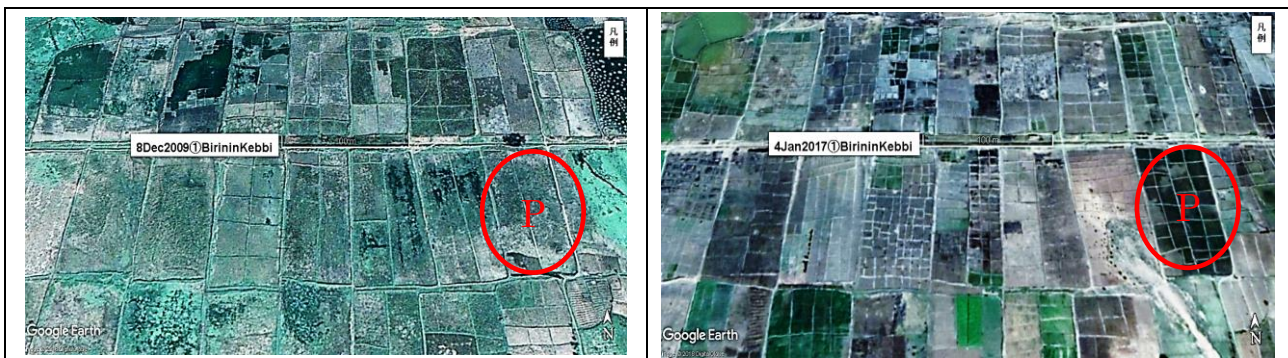

Fig. 34(1). Sawah plots improvement during 2011-2017. These two are expansion of ① area on Fig.33. Maker is 100m. The left picture was taken on 2009 and the right on 2017. The location was the (P) point

Fig. 34(1). Two photographs taken on May 2011. Yield data are shown in the Table 4. 1, which was 6.6t/ha.

Fig. 34(2). Sawah plots improvement during 2011-2017. These two are expanded the area of ② on the Fig.33. Maker scale is 100m. The left picture was taken on 2009 and the right on 2017.

Fig. 34(2). Photographs on May 2011. Location is the (P) position of Fig.34(2), showing weedy rudimentary sawah and standard rice on demonstration plots

Fig. 34(2). Photograph (left). Location is the (P) of Fig.33②, i.e., Fig 34②

Fig. 34B. Broken irrigation intake point. Photographed location is the (B) of Fig.33.

As shown in various pictures in Fig. 34A, B, (1) and (2), before sawah technology training almost all the irrigated fields were non sawah or rudimentary sawah plots even though they have demarcation of 0.5 ha size which were created by bulldozer. However from the first, plots were not sawah plots and thus no management had been conducted as sawah plots so far. Therefore there were many plots where farmers abandoned rice cultivation because original irrigation pump was broken, the height difference was over 50cm within a plot, water management was impossible, thus poor yield. The World Bank-supported Fadama III and the NCAM Sawah team conducted sawah technology training and demonstration of 3.5 ha in two location (1) and (2) as shown in Fig. 33 during March- December 2011. The agronomic results are shown in Table 4.1.

Fig. 34A and B as well as Fig. 34(1) and (2) are the magnified images corresponding the positions of Google earth pictures on the Fig.33. Also photographs taken during evaluation trips on May 2011 are shown as Fig. 34 (1) photographs, Fig. 34(2) photographs and Fig. 34B photographs, respectively. The length of the marker of expanded images is 100 m. As seen of Google earth images in Fig. 34A, 34(1) and (2), which were just before sawah technology training, bunds for water management are not clear. Even if it was recognized within the compartment of 0.5 ha, it was rudimentary and poor. In the Google earth images of 2016 below, which are 5years after sawah technology training, almost all over the irrigation area have standard sawah plots with reinforced bunds and leveling for water management improvement. However, understanding of farmers' sawah system seems to remain at an elementary stage. Even in such irrigated land of government development, the Arugungu floodplain, which are described in former section 5, appears to be more advanced as the evolutionary stage of sawah based rice cultivation.

Red circle (1) and (2) in Fig. 33 are the demonstration sites. The photographs during the evaluation trips on May 2011 are shown in the Fig. 34(1) and (2) respectively. It is very clear contrast the good performance of sawah based rice cultivation in the sawah plots and the very weedy non- sawah plot. The Fig. 34 B shows the original concrete structure of the inflow point of pump irrigation water in this irrigated land, which was created by the government. But at that time on 2011 till now it has been no more functioning. The small pump and hose in front of the concrete structure are managed by farmers for irrigation to the right side rice fields.
Fig. 34(1) and (2) shows the demonstration sites board (point (1) and (2) in Fig. 33, respectively) and the monitoring team taken in May 2011. Yield data at this point is shown in Table 4. The board states "Kebbi State Fadama III Sawah Rice Production Technology, Plot 1, Variety Faro 44, Transplant Date and Time May 14, 2011". Although high yield of 6.5 t/ha or more has been achieved using Faro 44 of high yielding variety, contamination of other varieties was recognized during the evaluation trip on May 2011.

8. Penetration of Sawah Technology at Sangelu and Suru area of the Rima river flood pains during 2011-2014

As shown in Fig.35, the on-the-job training and demonstration were done near the ① site at Snagelu and ② site at Suru. Agronomic results at Suru were shown in the Table 4. Field observation photographs at the Sangelu site on November 2012 are shown in Fig. 36.

Fig. 35. Sawah technology training and demonstration sites at ①Sangelu and ②Suru during 2011-2014.

As shown in Fig. 3, Sangelu town is located on the east bank of the Rima River floodplain just below the point where the Zamfara River joins the Rima River. Fig. 35 is a Google satellite image showing the Rima river floodplain from Sangelu town to the Suru/Talata town area. The scale marker length in the figure is 8 km. The area of the floodplain in this picture is about 20,000 ha.

Fig. 36A. Google earth image on January 2010 at the site ① on the Rima river flood plain near Sangelu town. Scale maker length is 100m and total area of this photograph is about 16ha. Since this is before sawah technology training, there are no sawah system.
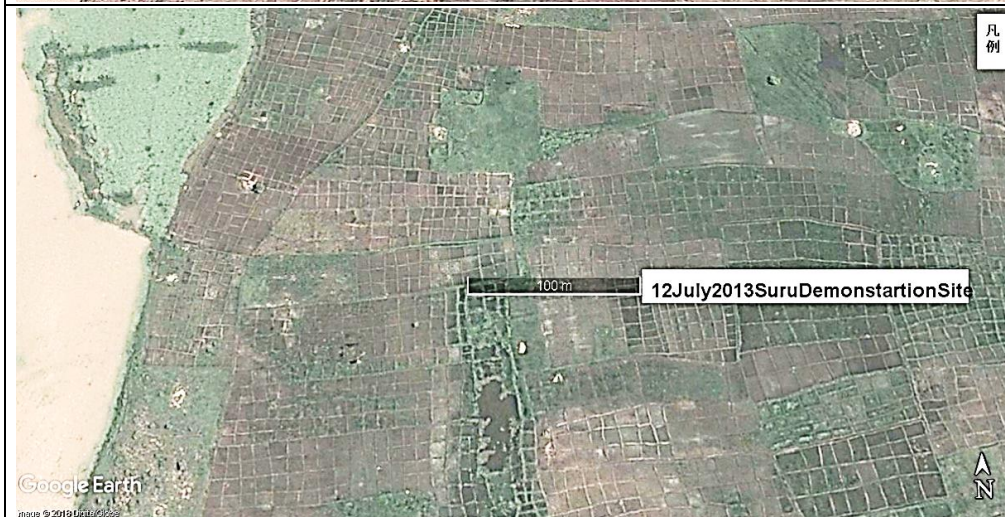

Fig. 36B. Google earth image on July 2013 at the same site of Fig. 36A above. This Google image was taken shortly after the sawah tech. training during Mar. 2011-Dec. 2012. About 40 % of this flood plain has sawah system. Evaluation photographs on Nov. 2012 are shown in Fig. 37.

Fig. 36C. Google earth image on Feb. 2016 at the same site of Fig.36A and B above. This Google image was taken 5 years after sawah technology training during Mar. 2011-Dec. 2012. About 80 % of this flood plain has covered with the standard sawah system. Size range of sawah plots are 70-160m², mean 115m².

Fig. 37. Demonstration Sawah plots at Sangelu. Photographs were taken on Nov 2012 by J. Aliyu (who is one of the authors of this report) during Supervision trip as team leader at Kebbi sawah project.

Fig. 38A. Google earth image on December 2010 at the site ② on the Rima river flood plain near Suru town. Scale maker length is 100m and total area of this photograph is about 16ha. Since this is before sawah technology training, there are no sawah system except for rudimentary trial on the corner of the east side of the river of this floodplain.

Fig. 38B. Google earth image on July 2013 at the same site of Fig.38A above. This Google image was taken shortly after the sawah tech. training during Mar. 2011-Dec. 2012. About 80 % of this flood plain has sawah system. Paddy yield data during 2012-14 are shown in the Table 4

Fig. 38C. Google earth image on Feb. 2016 at the same site of Fig.38A and B above. This Google image was taken 5 years after the sawah technology training during Mar. 2011-Dec. 2012. Almost 100 % of this flood plain has covered with standard sawah system. Size range of sawah plots are 70-160m², mean 115m².

9. Penetration of Sawah Technology at Bagudo area of the Niger River flood plain by 2014

Fig. 39 shows the Google earth picture of the Niger River floodplain near Bagudo area on 30 March 2014. The length of the scale marker is 3 km. The flood plain width of this picture is up to 8 km. The selected sites of A, B, C, D, D2 and E are enlarged and shown in the following figures. We could not get a time series of Google earth photos except for B and D2 sites. The P position is the bridge, which photograph is in Fig. 42. In the box D2 areas we obtained time series Google Earth pictures of 2012 and 2014, which are shown in Fig. 43 and 44.

Fig. 40 shows the Google Earth pictures of the A location in the Fig. 39. The image was taken on 30 March 2014. The length of the scale marker is 300 m above and 100 m below. The sawah plot size range of this A site is 10 - 60 m² (average 35 m²). Fig. 41 shows Google Earth pictures of the B location in the Fig. 39, of which left was taken on 1 February 2012 and right was on 30 March 2014. The length of the scale marker is 100 m. The sawah plots of this B site are 10 - 60 m² (average 35 m²) similar to the A site. During the two years, 2012-2014, sawah evaluation was not observed at the A and B sites. These are typical micro rudimentary sawah plots. Fig. 42 shows a picture of these micro rudimentary sawah near Bagudo (source downloaded though internet but source is unknown). Fig. 43 shows NCAM/Kinki university Sawah team on the Bagudo bridge. The team was guided by Fadama III and ADP staffs and Mr. Alf. Bello Baidu (ABB) who was in charge of the demonstration with members of the rice farmers' association.
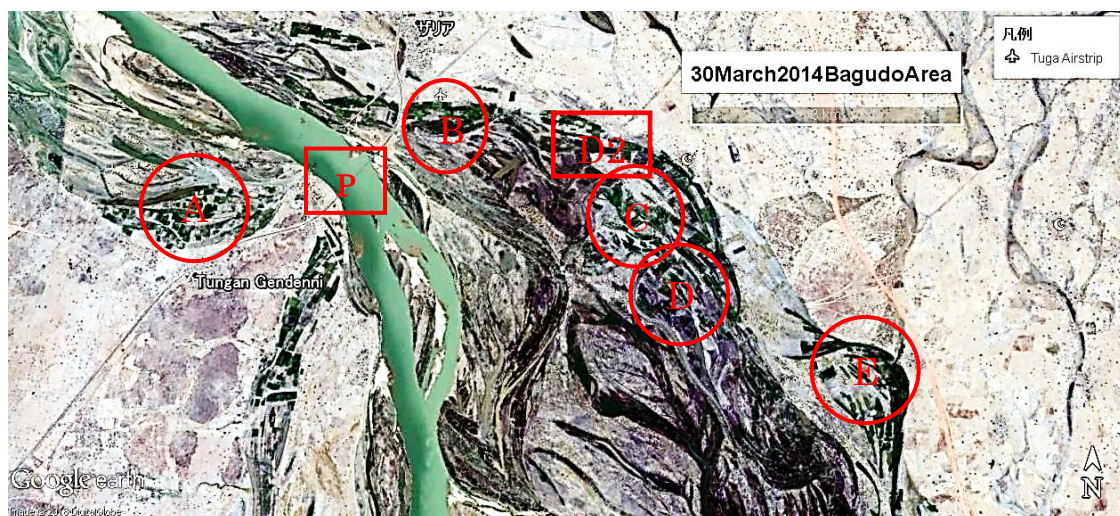

Fig. 39. Google earth picture of the Niger river floodplain near Bagudo area, 30ᵗʰ of March 2014. Scale marker is 3 km. The flood plain width of this picture is 3-8 km. The enlarged Google earth of A-E and of time series of 2012 and 2014 are shown in the following figures. The P shows bridge crossing the Niger river.

Fig. 40. Google Earth pictures of the A location in the Fig. 39. The image was taken on 30 March 2014. The length of the scale marker is 300 m above and 100 m below. The sawah plot size range of this A site is 10 - 60 m² (average 35 m²).
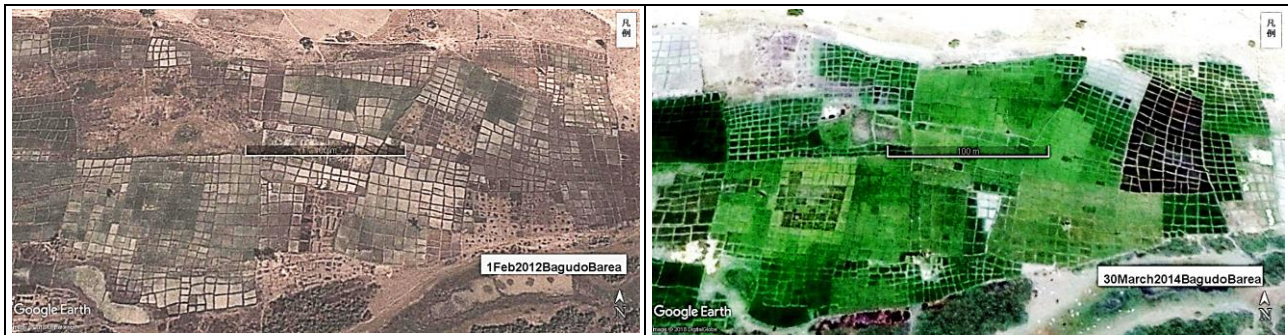

Fig. 41. Google Earth pictures of the B location in the Fig. 39, of which left was on 1 February 2012 and right was on 30 March 2014. The length of the scale marker is 100 m.

Fig. 42. The micro rudimentary sawah at Bagudo Area (downloaded through internet)

Fig. 43. Bagudo bridge of the P position in Fig. 39

Fig. 46①-③ were photographed of June 2014 at the ABB(Mr. Alh. Bello Baidu) farm. As shown in Table 4, ABB purchased five Chinese Dong Feng tillers, opened 50 hectares of sawah system and got paddy yield 7t/ha near D site in Fig.39. We could access from the Bagudo bridge to the D site by motorcycle as shown in Fig.46 ④. Mr. ABB said that he tried to use a laser leveler tractor, but in this kind of busy and swampy flood plain, the best option was the powertillers that could be disassembled and transported to the farms by ship or motorcycle.

Fig. 44. Google Earth picture of the C location in Fig. 39. The length of the scale marker is 100 m. This C site has both micro rudimentary sawah and the standard sawah plots by lead farmer of Mr. ABB.
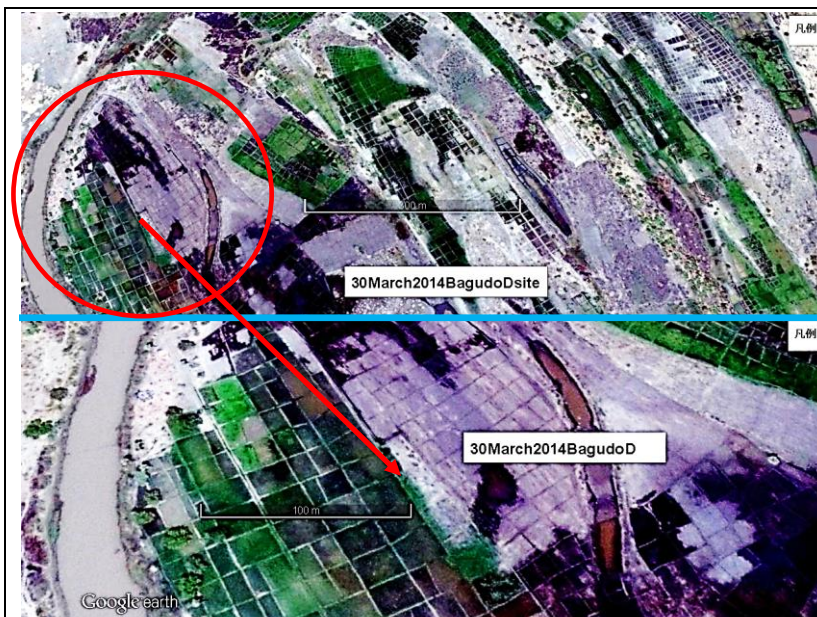

Fig. 45. Google Earth pictures at the D area in Fig. 39. The length of the scale marker is 300 m at the top and 100 m at the bottom. This D site is Mr. ABB's improved standard sawah plots development. The size range of sawah plots is 200-400 m². As shown in the Table 4, paddy yield was 7 t/ha. The pictures shown in Fig. 46 were taken on June 2014. This Google Earth photo was taken on March 2014. On the left side of the photo is the crescent moon lake of the flood plain and access is necessary on foot, bike or boat, even in the dry season.

Fig. 46. ①-③ are photographs of ABB farm (D site) shown in Fig.45. ④ motorcycle access to the D site from the bridge (P) shown in Fig.39.

Fig. 47 shows Google Earth pictures at the E area of Fig.39. The length of the scale marker is 300 m at the top and 100 m at the bottom. The quality of the sawah plots of this E site is at the middle level between the micro rudimentary sawah and the standard sawah plots. The picture was March 2014, and it is unknown how it is expanding or evolving after 2014.

Fig. 47. Google Earth pictures near Bagudo, E region in Fig. 39. The length of the scale marker is 300 m at the top and 100 m at the bottom.

Fig. 48 shows some progress of sawah system development through the comparison of Google Earth photograph taken in February 2012 and the end of March 2014 at the D2 site in the Fig.39. The length of the center marker is 100 m. Pump irrigated sawah plots both standard and rudimentary quality have developed about 7ha in 2014 photograph but there are almost no sawah plots not in 2012 photograph.

Fig. 48. Google earth at the D2 location on 2012 (left) and 2014(right). Scale is 100m.

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