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DIRECT METHOD OF RICE DAMAGE ESTIMATION BY RED-BILLED QUELEA (*QUELEA QUELEA*) IN HADEJIA-NGURU WETLANDS OF NORTH-EAST NIGERIA USING GIS AND GEOSTATISTICAL TOOLS

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Abstract

In Nigeria rice production is facing a lot of challenges notably pest and diseases, lack of capital, climatic problems etc. The major problem that curtailed rice production is the incidence of vertebrate pest, the Red-billed quelea which accounted for rice damage amounting to over 50 US Dollars annually according to FAO reports. This research is an attempt to estimate damage caused by the Quelea in order to justify efforts by government and relevant authorities to control the bird species. A novel rice damage assessment method as proposed by Allan 1997 was adopted and sample of damage and undamaged panicles were collected from predefined rice fields. The samples were weighted to obtain the percentage damage to rice by Red-billed quelea. Calculation of the percentage damage was done using Microsoft excel and the result was [redacted] imported into ArcGIS 10.4.1 software. IDW and kriging interpolation methods was used to show the percentage damage spatially for farm A and farm B plots. In conclusion results of the damage estimation have showed Red-billed quelea have done a significant damage to rice crop in the

Keywords:
Wetlands, Hadejia-Nguru, Rice Damage, Red-Billed Quelea, Geostatistical Tools

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study area and this is attributed to the presence of large vegetation of Typha which serve as a breeding and roosting ground for the bird species. Efforts must be made to clear the Typha to serve as habitat destruction for the bird species in order to significantly reduce the damage by the birds by reducing their population to the bearest minimum.

Introduction

In many African countries rice is considered a staple food and it is considered a major part of their diets in many others (Oteng and Anna, 1999). There is considerable increase in rice production during the last three decades because of increase demand as a result of increasing human population. By providing food for more than half of the global population, rice is regarded as the most important crop worldwide. It accounted for a good source of livelihood for several billions of people in rural areas(Chen et al., 2015). Many African countries including Nigeria like their counterparts in other regions of the world have incorporated rice production as part of their food security planning policies(Oteng and Anna, 1999). According to report by (FAO,1996) a total of 11.6 million tons of milled rice was consumed per year, out of this total about 3.3 million tones (33.6 %) is imported. About 21 to 39 African countries that produce rice import between 50 to 99% of their basic rice needs. 50% of world's population depend on rice as their staple food particularly china and India in Asia and a number of African countries including Nigeria. over 4.8 billion people in 176 countries depend on rice for their food. It is the most important food crop to over 2.89 billion people in Asia, another 40 million in Africa, 150.3 people in America and more than 120 million Nigerians(H.R.Suleiman1 et al., 2014). Despite the countries high output in rice production towards the end of the 20th century and rapid rise in the number of farmlands devoted to rice farming. the production does not meet the rising demand which led to massive importation of rice to bridge the deficit(Merem et al., 2017). Red-billed quelea has been identified as the main predator of rice. They are regarded by farmers as the major constraints in agricultural production. studies revealed that 75% of rice production in South East Nigeria are consumed by birds(Agossou et al., 2022).

In Africa Red-billed Quelea has been an agricultural pest for centuries, images of farmers cracking whips to scare off Quelea have been recorded within the tombs of Pharaohs as reported by De Groot (1990). Expansion of total area of cereal grain crops in Africa has been followed by a dramatic increase in Red-billed Quelea

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population. In Hadejia-Nguru wetlands of North-eastern Nigeria bird species that were regarded as pest was a greater concern to farmers than to fishermen(Oduntan et.al., 2010). The feathered locusts as it is popularly known are probably the most abundant and most destructive bird in the world, with Agricultural losses estimated at US$ 50 to 70 million per annum as reported by FAO, (2011). In an effort to increase production of rice to become self-sufficient and stop the importation resulting in huge bill to the government has made it a prominent policy on rice production. Some of the efforts put y government to increase rice production includes use of improved seed varieties to increase the national average yield of 2 tons/ha. many studies were conducted globally to assess crop yield losses(Chen et al., 2015). findings indicated that pests including birds and insects accounts for 15 to 37% of pre harvest losses in rice production(Saliu A. Tiamiyu, Bashir Mohammed, 2019).

It was suggested that loss estimates should be collected directly from the farmers through sample survey for a reliable extrapolation in similar geographical settings (Kannan, 2014). According to Kannan, 2014, farmers' estimates are likely to be subjective and need to be validated with expert estimates of the agricultural research stations(Saliu A. Tiamiyu, Bashir Mohammed, 2019). This paper is out to study the application of geospatial and geostatistical analysis on the previously collected damage sample to spatially show the damage extent on map using kriging interpolation method. Wildlife damage to crop can vary substantially across space and time. Owing to distributional changes of wildlife populations across the country , crop damage can also vary across time(Mckee et al., 2021).

In Mali systematic sampling of rice fields showed that losses varied from as little as 0.65% to as much as 13.34% at varying times(Treca, 1992). The spatial distribution of paddy fields , thorough observation of crop development and growth, and the early yield prediction of crop area is of great significance for planners and policy makers and for the management of food security and water resources(Siyal & Becker-reshef, 2015). Depredation caused by avian pests and rodents can be severe, diverse and vary across time and space. Using monte Carlo method on multiple crops and multiple pests damage estimation was done in California USA(Gebhardt et al., 2011). There are so many reports of estimated losses related to birds on major cereal crops in the wetland, because of the painful and horrific experience farmers are undergoing as a result of the activities of avian pests, many of the farmers rejected the idea of wildlife conservation(Akinsola et al., 2010). In the Senegal river valley, annual bird damage is found to average around 13.2% of

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the potential rice production during the wet seasons of 2003 -2007, which translates into an average annual economic loss of 4.7 billion FCFA (€ 7.1 million(De Mey et al., 2012)).

Materials and Method

Methodology

Rice Damage estimation was done by collecting damage and undamaged panicles of rice from 11 predefined rice farms of 50m by 20m size which was divided into 20 plots. Samples were collected from ten randomly selected plots out of the 20 and panicles were collected systematically after every two steps (Allan, 1997). Samples were collected using polythene bag labelled "damaged panicles" and "the other one "undamaged panicles" the procedure was repeated for another 11 plots to serve as a replicate sample, the samples were weighted using an analytical balance to find the percentage damage. The percentage damage was calculated using the formula below:

- $100\,\{(1 - (\frac{\text{number of damage seeds}}{\text{total number headS sampled}})\}\frac{\text{Av wtg damaged heads}}{\text{Av wtg undamaged heads}})$

This method of rice damage estimation was adopted from Allan, (1997). Cluster sampling technique was used to select two farming lands from each of the selected 11 communities in the study area. 22 Rice farms were set up with 2 farms each from Madachi, Gubusum, Kuradige, Abir, Dabar Alhaji Giwa. Marma, Likori, Adiani, Garbi, Gayin, and Mattafari. All land preparatory exercises were done until ready for planting. A high yielding early growing variety Faro 44(SIPI) was planted and nursed until harvesting time. Each farmland is divided into 20 plots. Out of the 20 plots 10 were selected at random along a line of transect. Samples were collected using systematic sampling technique after every two steps. Damaged and undamaged panicles of rice were picked using sickle. The researcher together with assistants carrying bags labelled damaged panicles and another one undamaged panicle went around and picked the panicles as described until we finished the randomly selected 10 plots. The damaged pannicles were put inside the bag labelled damaged panicles and the undamaged panicles into the bag labelled undamaged pannicles. This procedure was done until all the selected 10 plots were picked . The percentage damage was calculated in Microsoft excel and the result was imported into ARGIS using the formula below:

The resulting percentage damage was interpolated using IDW (Inverse distance weighing) to spatially show the damage on map (percentage damage in farm A

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and percentage damage in farm B). The average percentage damage between farm A and farm B was calculated using cell statistics on ARGIS. Finally, the density of the damage was shown on ArcGIS using Kernel density tool.

Study Area

The study area is in the heart of Hadejia-Nguru wetlands area. It is located between latitude 10° 5' N and 10° 38' N, longitude 12° 20' E and 12° 55'E, covering an approximate area of 99369.5 hectares which is equivalent to 940.034 square kilometres (Fig 1). The area lies between two northern Nigerian states of Jigawa and Yobe. The area falls within four local government areas, two local governments from Jigawa state (Guri and Kirikasamma) and two local government areas from Yobe state (Nguru and Karasuwa local government areas). The climate is seasonally arid with mean annual rainfall ranging from 250mm and 550mm and mean day temperature varying from 38°C to 42°C during the hottest months of March, April and May in Nguru. Temperature also varies from 17°C to 22°C during the coldest months of December and January. Most rainfall occurs between May and October. August is normally the wettest period.

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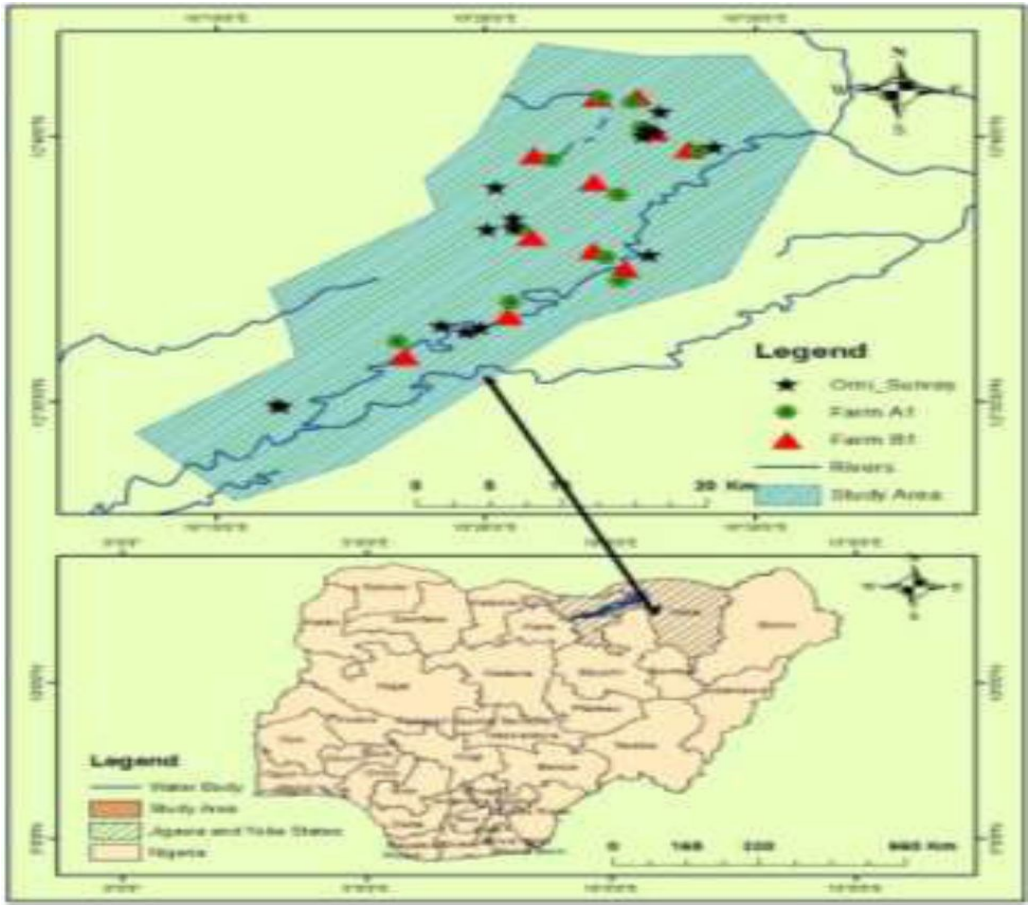

Figure 1. Map showing Nigeria, Yobe and Jigawa states and the study area in the Heart of Hadejia-Nguru wetlands area.

Problem statement

Pests are the major biotic component that largely determines the effectiveness of providing mankind with food. Mammalian pests notably Quelea which form a flock of over 30 million individuals which eats grains. A colony consisting of 2 million individuals can consume up to 50 tonnes of grains per day(Govorushko, 2014). weeds and grain feeding birds are the two main biotic causes of yield losses in irrigated rice in Africa. Bird damage to cereal crops has been a persistent problem to African farmers. Different traditional methods of crop protection were evaluated by (Ruelle & Bruggers, 1982) The reduced level of control remains somewhat controversial. This necessitates the introduction of satellite monitoring programme capable of providing timely information on the spatial and temporal distribution of potential breeding habitat which can play an important role in objectively evaluating the potential impact of the Red-billed Quelea on cereal

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production both locally and at the national level. Red-billed Quelea has a very serious economic impact on local farmers as a result of crop damage throughout sub-Saharan Africa. It is the World's most abundant bird species numbering up to 1500 million birds in Sub-Saharan Africa(Sychra et al., 2010). Ainsley and Kosoy,(2015). Suggest that a yield estimation formula should be created for each of different rice varieties. They also suggest that a key in agricultural insurance is the damage assessment which is required to be as accurate, fast, measurable and cheap as possible. It is a threat to both small-scale and large-scale farmers. Because of its role in serious crop damage, the species is officially declared a pest species by IUCN (Markula et al., 2009) As a result of the crop damage by *Quelea,* the importation of food aid, such as the 5,081 tonnes imported into Tanzania in 1942. It also leads to famine such as witnessed in Ugogo-land, Dodoma, Tanzania in 1881. A single bird can consume and/or destroy up to about 10g of grain in a day. Thus, a flock of one million birds can destroy up to 10 tonnes of crop daily. In the event of major invasions, crop damage can be as high as 50% of potential crop harvest and at times entire crops may be wiped out. Millions of US Dollars' were spent by African countries in buying chemicals and hiring aircrafts in order to control the bird species. The economic value of Red-billed Quelea has not been adequately evaluated. Mullié, (2000) estimated that trappers in Chad were selling up to 10,000,000 birds, valued at the US $75,000 at 1994 prices. Birds caught at Kondoa, Tanzania, were sold for the equivalent of 0.75 – 2 GB pounds per 100 birds in 2009.

According to report by FAO (2007) The damage attributable to Quelea was in excess of $50 million annually. According to (Oduntan, 2015) Based on the level of damage they cause to the grain farmers, the conflict between human and the Red-billed Quelea have led to the following problems: - (1). A serious reduction in farm output in the affected communities and the whole country at large. (2). unavailability of food for human population. (3). Malnutrition, hunger and famine in extremecases.4. It encouraged object poverty leading to rural hardship.

Literature review

The Black-faced Dioch as it is also called is the most populous avian species in the world, and obviously a migrating species, it is problematic to local African farmers and the species is common to the African continent. (Grazio, 1978; Hongo, *et al*., 2015;)

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The Red-billed Quelea has been described as the most destructive and most numerous pest bird in the world, potentially affecting cereal production in at least 25 African countries(Types, 2011). In many African countries 90% of farmers report crop loss to wildlife, particularly bird crop raids which usually required farmers to watch and scare birds from their farmlands for long hours(Ainsley and Kosoy, 2015). In norther Nigeria, bird pests have been identified as a major drawback on rice production. Birds are reported to have eaten up to 75% of total output from entire production areas(Bright and Ellliot, 2007). They are regarded as the most destructive bird pest in Africa (Berry, et al, 2004;). Birds can become serious pests when large flocks migrate seasonally in large populations which is a typical characteristics of the Quelea(Mey and Demont, 2013). presently granivorous birds act as a hurdle on the development of cereal production in many African region. The best known of the avian pests of the grain crop in Africa is the Quelea quelea(Jackson, 1973). Under favourable conditions birds breeds in vast colonies which forms ideal target for control operations(Cheke et al., 2007). In Southern Africa The persistence of migrant pests such as locust, quelea birds and army worms accounts for the major challenges facing agriculture (R.A. Cheke, 1999;). A case of itinerant breeding have been observed in Red-billed quelea where a single individual relies on different food supplies from different areas in a single season(Rohwer, et al, 2009;). According to Ozolua in (Yusuf, 2004), granivorous birds generally prefer wild grass seeds and tend to go for man's cultivated crops when the former is in short supply(Ward et al., 1979) One of the major constrains to rice production in Africa is the issue of pest of which the Red-billed Quelea is the major pest. Jackson, (1974) noted the connectivity between weather, plant growth, food abundance, and migrations of Quelea and other granivorous birds are paramount to predicting crop depredation. Quantitative assessment of bird damage to lowland Sorghum (Sorghum bicolor) was conducted in the Awash river basin of Ethiopia. Result of the assessment indicated that the Red-billed Quelea (Quelea quelea) is the major threat in the total cereal production in the region(Jaeger and Erickson, 1980). In Southern Africa most of the damage cause by Quelea mostly affects rain-fed sorghum and millet at the milking stage just before harvesting. The damage is mostly caused by juveniles from nearby breeding colonies within a vicinity of 10-30 km radius(Jones et al., 2000). Quelea swarms have often been compared to locusts and sometimes mistaken for them (Disney and Haylock, 2016). Using two rice cultivars Sahel 202 and Sahel 108. It was found that in two seasons, much lower yield loss was observed in short-cycle

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cultivar Sahel 108, where as in one season the medium cycle cultivar Sahel 202 was much less damaged. It was concluded that damaged is incurred more in weedy rice as compared with weed free rice(Rodenburg, et al, 2014). Damage by bird pests to Sunflower (Helianthus annuus L.) is a global economic issue. Presently many methods were developed and tested in the prairie pothole region of the USA. Because of the concentration of sunflower production and severe incidence of blackbird (Icteridae) depredation in the region an intensive research programme was conducted in the region(Linz et al., 2011)..

Result and Discussion

The result of the rice damage estimation showed that the Red-billed Quelea had done a significant amount of damage in the selected study area. There are different degrees of damage in the different parts of the study area. Since the area comprises of both flooded rice and upland rice together. There appears that presence of thick vegetation of Typha that is invasive and well spread in the area contributed to the intensity of the damage. This is because Typha vegetation provides breeding and roosting ground for the principal pest, the Red-billed Quelea. Even though there is no any correlation between distance and damage since a flock of Quelea can travel to a distance of up to 30 kilometres to feed on food of their preference. The choice of food by Quelea influence the damage to a crop more than the influence of distance from the farmlands to the roosting and breeding site as indicated by studies
(Avery, 1979). The stage of crop growth is also another determinant of damage time, because birds prefer the rice at the milking stage more than when they are ripe. When the rice crop is ripe, they are dry and difficult to break, but in the milk stage they can break and suck the liquid in the grain. There is no any feeding relationship existing between Typha and the Red-billed Quelea. They prefer Typha vegetation because the vegetation is aquatic growing inside water and is serving as cover for wildlife including the Quelea. They prefer it more than other vegetation cover because it grows very tall and thick, they are densely packed. Birds easily build their nests as the plants are closely packed and tall enough (1.5 to 1.7 metres tall) to keep them away from predators during breeding. In other studies, carried out by(Rodenburg et al., 2014) in lower Senegal lowlands presence of weeds in a rice farm attract more damage by birds compared to a rice farm that is free of weeds. The study shows that presence of weeds attracts birds and thereby contribute to increase in bird damage. Therefore, in Hadejia-Nguru

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wetlands, the higher damage is experienced n farmlands that are closer to Typha vegetation or farmlands that are not free of weeds. In view of this most of the areas neighbouring Typha vegetation are likely experiencing more damage

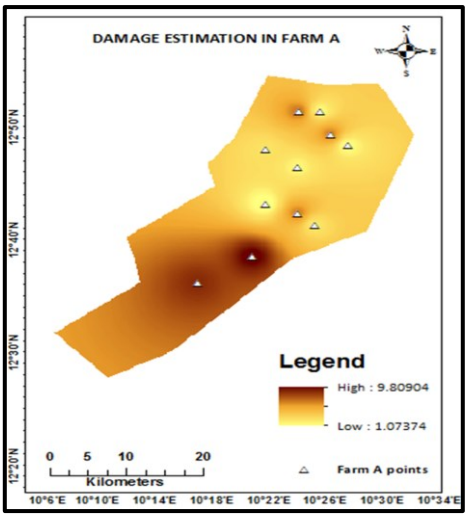

Figure 2. map showing the spatial distribution of damage in percentage in Farm A points

S/NO	Village	Y	X	Avg weighted undmgd head	Avg weighted dmg head	No of dmg heads	Total no of heads sampled	Estimated damage in %
1	Adiani	13.0417	10.5152	136.73	101.3	106	436	6.3%
2	Marma	12.7936	10.5194	126.17	90.1	94	426	6.31%
3	Gubusum	12.7981	10.5005	109.99	95.6	82	429	2.5%
4	Likori	12.6614	10.3841	118.09	80.0	97	319	9.81%
5	Madachi	12.8719	10.3713	121.22	75.3	85	380	8.47%
6	Mattafari	12.8253	10.4261	121.73	101.2	78	472	2.79%
7	Gayin	12.8617	10.4880	104.18	97.8	67	385	1.07%
8	Garbi	12.9425	10.6108	125.77	112.3	92	526	1.87%
9	Dabar Mgn	12.9608	10.4161	109.26	76.2	70	320	6.62%
10	Karigidi	12.8719	10.3713	131.95	110	69	568	2.02%
11	Kirikasamma	12.8431	10.2747	138.44	115.6	51	546	1.54%

Table 1. showing the list of villages, X and Y coordinates of points and percentage damage in Farm A

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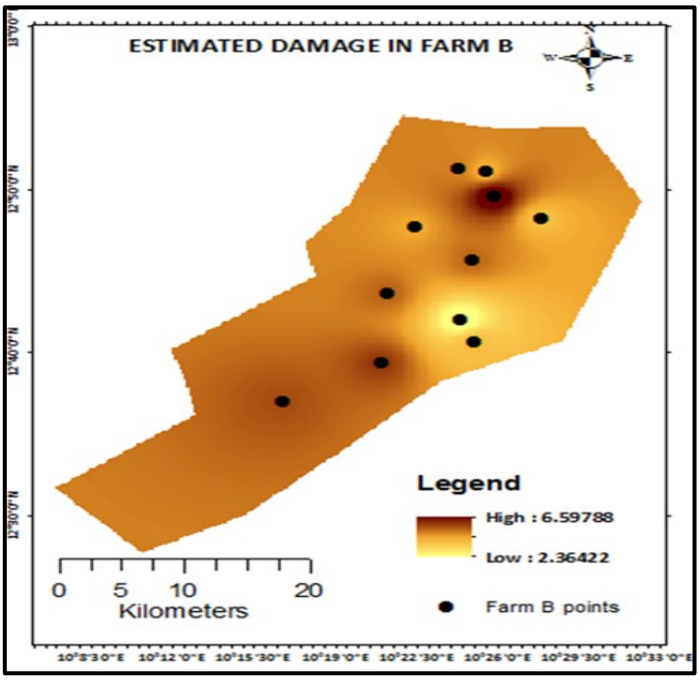

Figure 3. Map showing the spatial distribution of damage in farm B points.

S/NO	Village	Y	X	Avg weighed undmgd head	Avg weighted dmg head	No of dmg heads	Total no of heads sampled	Estimated damage in %
1	Adiani	12.8611	10.5666	130.23	85	99	521	6.6%
2	Marma	12.7491	10.4461	122.57	89.7	35	398	2.36%
3	Gubusum	12.8347	10.4713	110.14	78	95.6	451	4.08%
4	Likori	12.6725	10.3441	123.71	76	80.0	503	5.44%
5	Madachi	12.7933	10.4516	145.67	101.3	75.3	520	5.21%
6	Mattafari	13.0247	10.3827	125.37	60	101.2	562	4.36%
7	Gayin	12.8321	10.3888	106.42	59.5	97.8	493	5.01%
8	Garbi	12.9738	10.6051	124.83	87	112.3	436	4.1%
9	Dabar Mgn	12.9319	10.4461	122.88	73.5	76.2	303	4.47%
10	Kuradige	12.8072	10.4808	151.53	87.9	110	347	4.96%
11	Abir	12.7722	10.4011	121.54	85.3	115.6	360	3.89%

Table 2. showing names of villages, X and Y coordinates of points and percentage damage in Farm B.

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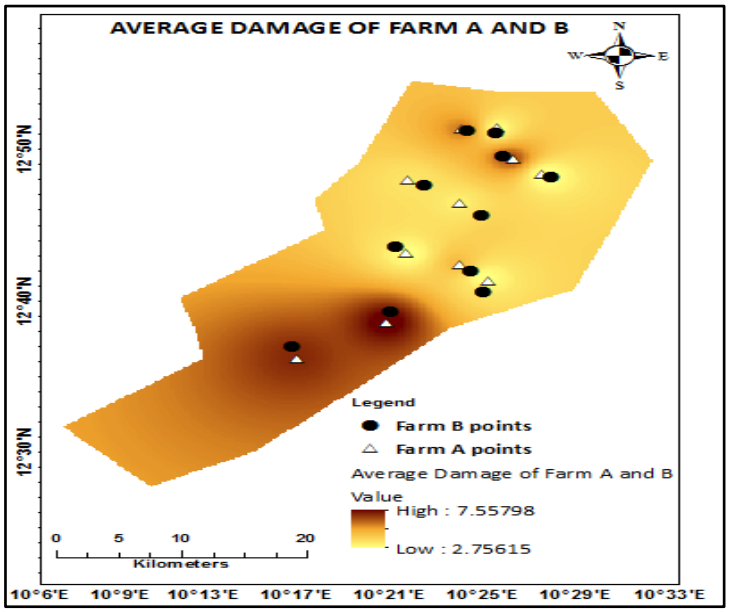

Figure 4. Map showing the average spatial damages in Farm A and B in percentage.

Village	*Estimated damage of Farm A in %*	*Estimated damage of Farm B in %*	*Average % damage of Farm A and B*
Adiani	*6.3%*	*6.6%*	*6.45%*
Marma	*6.31%*	*2.36%*	*4.33%*
Gubusum	*2.5%*	*4.08%*	*3.29%*
Likori	*9.81 %*	*5.44%*	*7.63%*
Madachi	*8.47%*	*5.21%*	*6.84%*
Mattafari	*2.79%*	*4.36%*	*3.57%*
Gayin	*1.07%*	*5.01%*	*3.04%*
Garbi	*1.87%*	*4.1%*	*2.99%*
Dabar Magini	*6.62%*	*4.77%*	*5.7%*
Kuradige	*2.02%*	*4.96%*	*3.49%*
Abir	*1.54%*	*3.89%*	*2.72%*

Table 3. showing percentage damages in Farm A, Farm B and average damage of Farm A and B.

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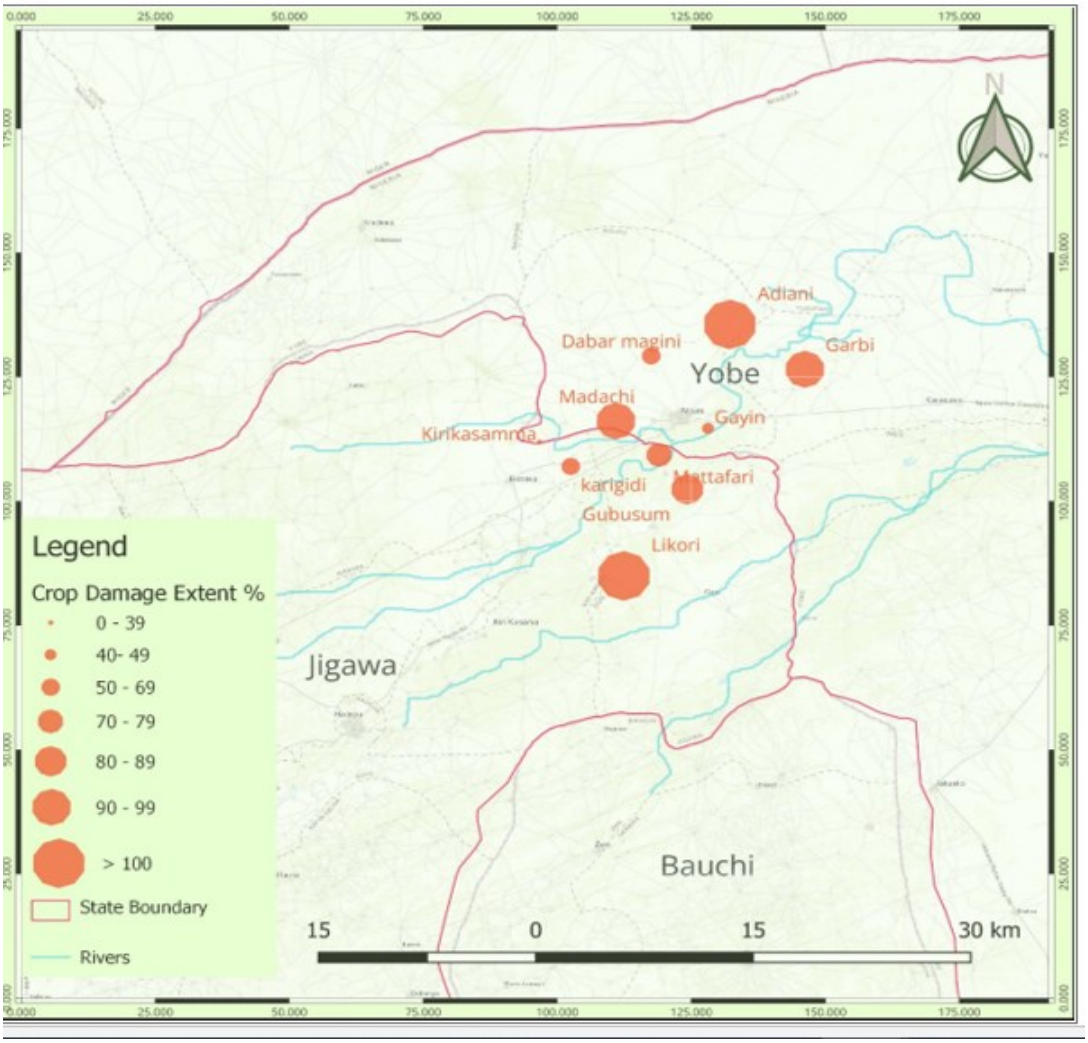

The percentage damage and the final IDW and kriging map shows that rice damage was spread variably in different locations with different intensity. The highest percentage damage in farm A was obtained in Likori village with 9.81% damage and the lowest percentage damage in farm A was obtained in Gayin village with 1.07% damage. The highest percentage in farm B was found in Adiani village with 6.6% damage and the lowest percentage damage was found in Marma village with 2.36% damage. The highest average damage was found in Likori with 7.63% and the lowest average damage was found in Abir Village with 2.72 % damage. The final kriging map shows that the highest percentage damage was found around Likori village and the lowest percentage damage was found around Abir village. This could be attributed to many factors like distance of farms, bird's habitat, distance away from water, food preference of the birds, feeding habit of

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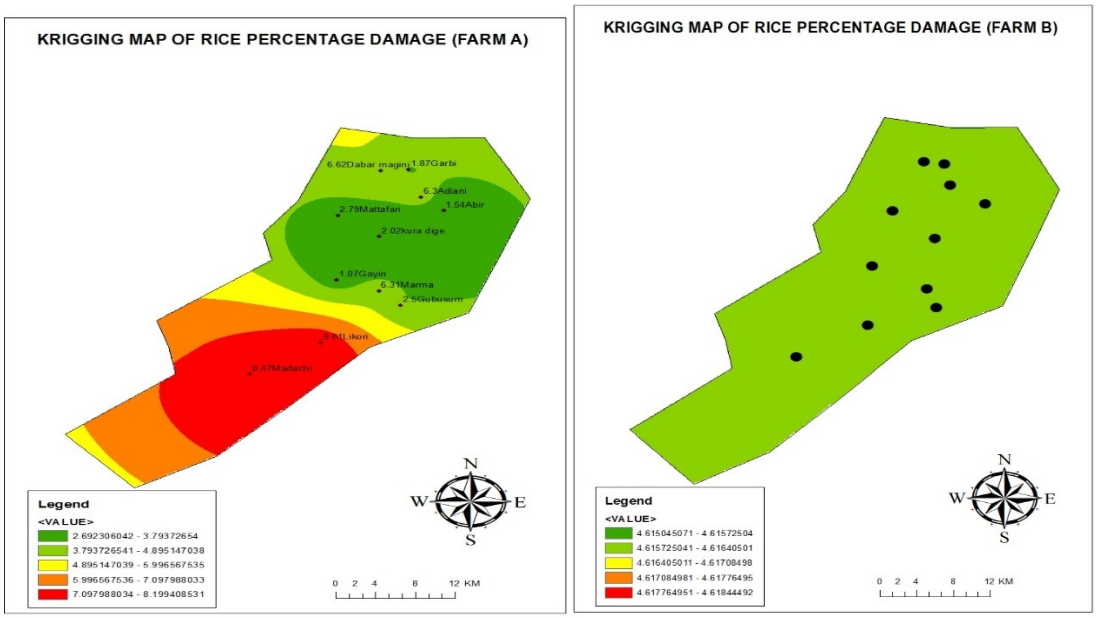
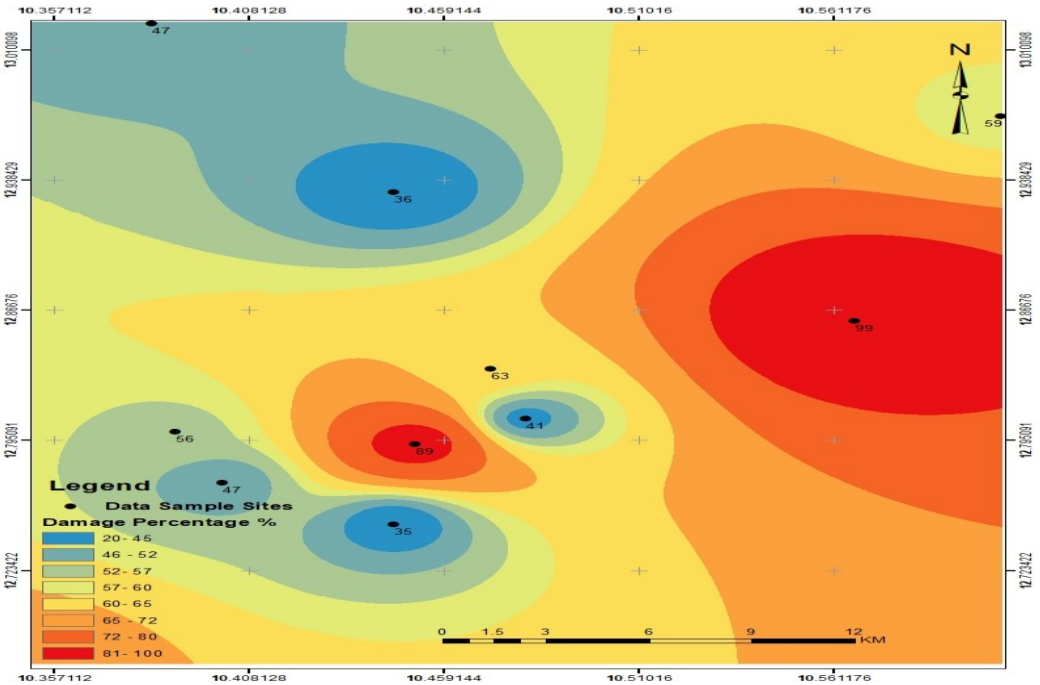
the birds and varieties of rice grown. This result will further lead to other researches like habitat suitability of the birds, impacts of the birds on the livelihood of farmers and impact of climate on the distribution of the birds





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Discussion and Conclusion

In conclusion damage by red-billed quelea to rice farms is one of the constraints affecting rice production in Nigeria particularly Hadejia –Nguru wetlands area. This study was conducted to assess the extent of damage by this African bird species. A method of damage assessment adopted by Allan (1997) and integration of GIS and geostatistics was applied. The result was displayed on percentage damage on map spatially using IDW and Kriging interpolation methods. There is significant variability on the damage at different locations. This shows that there are certain factors that determine the rate of damage intensity and spread of the damage in geographical space. This opens a room for further research particularly relations between, distance of farm to bird habitat availability of water, habitat and food preference for the bird species.

References.

A, H. D. O., & A, L. G. U. (2008). Primary moult of adult Red-billed Queleas (Quelea quelea) in southern Africa in relation to patterns of movement. *Emu*, *108*, 331–339.

Agossou, H., Assede, E. P. S., & Dossou, P. J. (2022). Effect of bird scaring methods on crop productivity and avian diversity conservation in agroecosystems of Benin. *Int. J. Biol. Chem. Sci.*, *16*(2), 527–542.

Ainsley, M., & Kosoy, N. (2015). The tragedy of bird scaring. *Ecological Economics*, *116*, 122–131. https://doi.org/10.1016/j.ecolecon.2015.04.021

Akinsola, O. A., Ezealor, A. U., Polet, G., Akinsola, O. A., Ezealor, A. U., Polet, G., Akinsola, O. A., Ezealorz, A. U., & Polelj, G. (2010). Conservation of waterbirds in the Hadejia-Nguru Wetlands , Nigeria : current efforts and problems efforts and problems. *Ostrich Journal of African Ornithology*, *71*(1 & 2), 118–121. https://doi.org/10.1080/00306525.2000.9639885

Avery, M. L. (1979). Food Preferences and Damage Levels of Some Avian Rice Field Pests in Malaysia. *Bird Control Seminars Proceedings*, *November*, Paper 22. http://digitalcommons.unl.edu/icwdmbirdcontrol/22

Berry, H. H., Kyle, R., & Kyle, D. (2004). Mass breeding and diet of Red-billed Quelea in the Etosha National Park , Namibia , in 1978. *Ostrich Journal of African Ornithology*, *75*(1–2), 66–74. https://doi.org/10.2989/00306520409485414

Bright, E., & Ellliot, C. (2007). *PrOpCom REVIEW OF THE BIRD PEST PROBLEM AND BIRD SCARING IN SOUTH WEST NIGERIA* (Issue February).

Cheke, R. A., Venn, J. F., & Jones, P. J. (2007). Forecasting suitable breeding conditions for the red-billed quelea Quelea quelea in southern Africa. *Journal of Applied Ecology*, *44*(3), 523–533. https://doi.org/10.1111/j.1365-2664.2007.01295.x

Chen, C., Son, N., Chen, C., & Chiang, S. (2015). Assessing rice crop damage and restoration using remote sensing in tsunami-affected areas , Japan. *Journal of Applied Remote Sensing*, *9*(1–20). https://doi.org/10.1117/1.JRS.9.096002

De Grazio, J. W. (1978). World bird damage problems. *Proceedings of the 8th Vertebrate Pest Conference*, 8–24. http://digitalcommons.unl.edu/vpc8/13/

De Mey, Y., Demont, M., & Diagne, M. (2012). Estimating Bird Damage to Rice in Africa: Evidence from the Senegal River Valley. *Journal of Agricultural Economics*, *63*(1), 175–200. https://doi.org/10.1111/j.1477-9552.2011.00323.x

Disney, H. J. D. S., & Haylock, J. W. (2016). The Distribution and Breeding Behaviour of the Sudan Dioch (Quelea Q . Aethiopica) in Tanganyika THE DISTRIBUTION AND BREEDING BEHAVIOUR OF. *The East African Agricultural Journal*, *21*(3), 141–147. https://doi.org/10.1080/03670074.1956.11665025

Elliott, C. C. H., Mtobesya, B. N., & Cheke, R. A. (2014). Alternative approaches to Red-billed Quelea Quelea quelea management : mass-capture for food. *Ostrich Journal of African Ornithology*, *85*(1), 30–37. https://doi.org/10.2989/00306525.2014.900827

Gebhardt, K., Anderson, A. M., Kirkpatrick, K. N., & Shwiff, S. A. (2011). A review and synthesis of bird and rodent damage estimates to select California crops. *Crop Protection*, *30*(9), 1109–1116. https://doi.org/10.1016/j.cropro.2011.05.015

Govorushko, S. M. (2014). Mammals and birds as agricultural pests: A global situation. *Sel'skokhozyaistvennaya Biologiya*, *4836*(6), 15–25. https://doi.org/10.15389/agrobiology.2014.6.15rus

H.R.Suleiman1, ; H.Ibrahim2, ; O.M.Isa, 3, & and O.K.Ishiaku. (2014). Labour-Use Differential among Mechanized and non Mechanized \nrice Farmers in Nasarawa State, Nigeria.\n. *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)* , *7*(9), 35–44. http://www.iosrjournals.org/iosr-javs/papers/vol7-issue9/Version-2/F07923544.pdf

Hongo, C., Tsuzawa, T., Tokui, K., & Tamura, E. (2015). *Development of Damage Assessment Method of Rice Crop for*

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Agricultural Insurance Using Satellite Data. *7*(12), 59–71. https://doi.org/10.5539/jas.v7n12p59
Jackson, J. J. (1973). FAO QUELEA RESEARCH IN AFRICA. *Bird Control Seminars Proceedings*, 1–14.
Jackson, J. J. (1974). *THE RELATIONSHIP OF QUELEA MIGRATIONS TO CEREAL CROP DAMAGE IN THE LAKE CHAD BASIN*. 3–5.
Jaegar, M. M., & Erickson, W. A. (1980). Levels of Bird Damage To Sorghum in the Awash Basin Ofethiopia and the Effects of the Control of Quelea Nesting Colonies. *Levels of Bird Damage to Sorghum in the Awash Basin of Ethiopia and the Effects of the Control of Quelea Nesting Colonies*, 3–4.
Jones, P. J., Cheke, R. A., Mundy, P. J., Dallimer, M., & Venn, J. F. (2000). *15 Quelea Populations and Forecasting in Southern Africa* (Issue March 1999).
Linz, G. M., Homan, H. J., Werner, S. J., Hagy, H. M., Bleier, W. J., Linz, G. M., Homan, H. J., Werner, S. J., Hagy, H. M., & Bleier, W. J. (2011). Assessment of Bird-management Strategies to Protect Sunflowers. *BioOne*, *61*(12), 960–970. https://doi.org/10.1525/bio.2011.61.12.6
Markula, A., Hannan-jones, M., & Csurhes, S. (2009). *Pest animal risk assessment Red billed quelea* (Issue June).
Mckee, S., Shwiff, S. A., Anderson, A. M., & Mckee, S. C. (2021). Estimation of wildlife damage from federal crop insurance data. *Pest Management Science*, *77*, 406–416. https://doi.org/10.1002/ps.6031
Merem, E. C., Twumasi, Y., Wesley, J. M., & Shenge, M. N. (2017). Analyzing Rice Production Issues in the Niger State Area of Nigeria ' s Middle Belt. *Food and Public Health*, *7*(1), 7–22. https://doi.org/10.5923/j.fph.20170701.02
Mey, Y. De, & Demont, M. (2013). *Bird Damage to Rice in Africa : Evidence and Control in Realizing Africa's rice promise*.
Mofokeng, M. A., & Shargie, N. G. (2016). *Available online at www.ijaaer.com BIRD DAMAGE AND CONTROL STRATEGIES IN GRAIN SORGHUM PRODUCTION*. *2*, 264–269.
Mulliè, W. C. (2000). Traditional capture of Red-billed Quelea Quelea quelea in the Lake Chad Basin and its possible role in reducing damage levels in cereals and its possible role in reducing damage levels in cereals. *ostrich Journal of African Ornithology*, *71*(1–2), 15–20. https://doi.org/10.1080/00306525.2000.9639856
O.O. Oduntan A.F. Akinyemi and I.A. Ayodele. (2010). Asssesment of bird friendly farming and fishing in Hadejia-Nguru wetlands, Nigeria.pdf. *Agricultural Journal*, *5*(5), 286–291.
Oduntan, O. O. (2015). Human-wildlife Conflict: A View on Red-Billed Quelea (*Quelea quelea*). *International Journal of Molecular Evolution and Biodiversity*, *5*(2), 1–4. https://doi.org/10.5376/ijmeb.2015.05.0002
Oschadleus, H. D. (2015). First Red-billed Quelea breeding record in the winter rainfall region of South Africa. *Ostrich*, *86*(3), 295–296. https://doi.org/10.2989/00306525.2015.1069413
Oteng, J. W., & Anna, R. S. (1999). Rice production in Africa : current situation and issues. *International Rice Commission Newsletter*, *48*(Figure 1), 1–14.
R.A. Cheke, L. J. R. and M. E. K. (1999). Workshop on Research Priorities for Migrant Pests of Agriculture in Southern Africa. *Workshop on Research Priorities for Migrant Pests of Agriculture in Southern Africa*, 219.
Rodenburg, J., Demont, M., Sow, A., & Dieng, I. (2014). Bird, weed and interaction effects on yield of irrigated lowland rice. *Crop Protection*, *66*, 46–52. https://doi.org/10.1016/j.cropro.2014.08.015
Rohwer, S., Hobson, K. A., & Rohwer, V. G. (2009). *Migratory double breeding in Neotropical migrant birds*.
Ruelle, P., & Bruggers, R. L. (1982). Traditional approaches for protecting cereal crops from birds in Africa. *Proceedings of the Thirteenth Vertebrate Pest Conference*, Paper 37 (pp 80-86).
S.D. Yusuf, Y. Y. and B. N. M. (2004). The food of Quelea birds (Quelea quelea) during dry season in Borno State..pdf. *Pakistan Journal of Biological Sciences*, *7*(4), 620–622.
Saliu A. Tiamiyu, Bashir Mohammed, V. O. A. and G. M. (2019). Assessment of pest damage and its effects on rice income in southern guinea savanna zone of Nigeria. *Invited Paper Presented at the 6th African Conference of Agricultural Economists, September 23-26, 2019, Abuja, Nigeria*, 1–15.
Siyal, A. A., & Becker-reshef, I. (2015). Rice yield estimation using Landsat ETM ǂ Data. *Journal of Applied Remote Sensing*, *9*, 1–16. https://doi.org/10.1117/1.JRS.9.095986
Sychra, A. O., Barlev, E., Literák, I., Č, M., Koubek, P., & Procházka, P. (2010). The Chewing Lice (Phthiraptera) of Red-Billed Quelea (Quelea quelea) in Senegal , with a Description of a New Species. *Bio One*, *18*(1), 17–22.
Treca, B. (1992). Water Birds and rice cultivation. *Proceedings VII Pan -African Ornithological Congress .297-301*, 297–301.
Types, A. (2011). Journal of Ecology and the Natural Environment. In *Methods* (Vol. 7, Issue 7).
Ward, P. (1965). DISTRIBUTION , SYSTEMATICS , AND POLYMORPHISM OF THE AFRICAN WEAVER-BIRD QUELEA QUELEA. *IBIS 108*, 34–40.
Ward, P. (1971). THE MIGRATION PATTERNS OF QUELEA QUELEA IN AFRICA. *THE IBIS*, *113*(3), 1–23.
Ward, P., Pant, N. C., Roy, J., Dorow, E., Betts, E., & Whellan, J. A. (1979). Rational Strategies for the Control of Queleas and Other Migrant Bird Pests in Africa [and Discussion]. *Philosophical Transactions of the Royal Society of London. B, Biological Sciences*, *287*(1022), 289–300. https://doi.org/10.1098/rstb.1979.0062

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