Sustainability of paddy rice farming in the conservation of birds in Uganda amidst a growing expansion of the rice farming industry

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List of Abbreviations

IUCN: International Union for Conservation of Nature

IRRI: International Rice Research Institute

CIAT: International Centre for Tropical Agriculture

SDG: Sustainable Development Goal

NDPIII: National Development Programme III

NRDS: National Rice Development Strategy

MAAIF: Ministry of Agriculture, Animal Industry and Fisheries

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Abstract

Rice has become a cash crop in Uganda, making the rice agro-ecosystems a common feature in ecological landscapes. In this research, waterbird species diversity at three paddy rice growing schemes namely: Doho, Kibimba and Lukaya is collected and compared. A rapid cross-sectional survey was conducted at these 3 sites over a period of 3 months in which both quantitative and qualitative data were collected. This study was guided by the anthropogenic impacts hypothesis which proposes that humans have modified the 'natural' biodiversity patterns such that diversity is generally depressed in areas with long history of human occupation or intensive activities. Results of One-way ANOVA show significant variations in species diversity ($P = 0.022$) and abundance ($P=0.04$) across the sites. There was generally a low diversity at the sites. However, Doho rice scheme had the highest waterbird diversity (1.05 ± 0.99), followed by Kibimba (0.09 ± 0.05) while Lukaya had the least (0.07 ± 0.02), and the reverse was true for waterbird abundance. Birds of international significance such as the Grey crowned Crane (*Balearica regulorum)* were more abundant at Lukaya Rice scheme than the other two. Kibimba and Doho rice rich schemes have been under rice cultivation for almost 5 decades while Lukaya rice fields are hardly a decade old. The findings are contrary to the hypothesis; most probably because rice fields are artificial habitats that are attractive to water birds only when there are farming activities going on. Out of the 150 farmers we interacted with, 120 (80%) mentioned that the Grey crowned Crane (*Balearica regulorum)* numbers had declined, mainly because of conversion of the natural wetland into rice paddies, moreover the birds on the paddies are also threatened by extensive use of pesticides and herbicides, including hunting by the local community members. There is need to introduce alternative income-generating activities and continuous sensitization of stakeholders on wise use of rice farms.

<u>Note:</u>

This abstract has been considered for presentation during the forthcoming Pan African Ornithological Congress 15 (PAOC 15), to be held at Victoria falls, Zimbabwe, from 21st-25th November 2022.

CHAPTER ONE: INTRODCUTION

1.1. Background to the study

Loss of biological diversity is one of the most important problems of the world and a threat to our civilization. Biodiversity loss has occurred worldwide at an unprecedented scale and agricultural intensification has been a major driver of this global change (Matson et al., 1997). The dramatic land use changes include the conversion of complex natural ecosystems to simplified ecosystems and the intensification of resource use, including application of more agrochemicals. This land use change has arisen due to increasing demand for food, rural incomes and improving food and nutrition security (Foley et al., 2011). These anthropogenic changes in land use have resulted into natural habitat loss, degradation, and fragmentation, thereby threatening the diversity of life on our planet (Bellard et al., 2012), and are implicated in the loss of between 13% and 75% of the world's species (Haddad et al., 2015). The combined effect of climate and habitat changes are drastically altering the distribution and health of many ecosystems, including lakes and wetlands (Anderson et al., 2017), along with the way human populations interact with them (Kronik & Verner, 2010; Bellio & Kingsford, 2013). Uncertainty about how such changes influence biodiversity constrains our ability to develop adequate conservation strategies, especially for current globally endangered and vulnerable ecosystems (IUCN, 2019).

Agriculture, more especially rice farming, has been ranked as one of the anthropogenic activities that are threatening the existence of many organisms especially birds (IUCN, 2019). Rice is a staple food of more than a half of the world's population; more than 3.5 billion inhabitants depend on rice to obtain 20% of their daily calorie intake (IRRI, Africa Rice & CIAT, 2010). In Uganda, rice growing is considered strategic as it has the potential to contribute to increasing rural incomes and improving food and nutrition security, thus contributing to United Nations Sustainable Development Goal (SDG) 2. Based on this notion, the Government of Uganda has expanded its paddy rice-growing areas from the original districts of eastern Uganda, to central Uganda. Rice production in Uganda started in 1942 mainly to feed the World War II soldiers; however due to a number of constraints, production remained minimal until 1974 when Doho and Kibimba Rice Irrigation Schemes, eastern Uganda, were established with the help of the

Chinese government. However due to increasing demand for rice on the local market, the government of Uganda in 2015, established Lukaya rice scheme, a commercial paddy rice farm in Lwera wetland located along the Kampala-Masaka highway, also supported by the Chinese government.

This study was guided by the anthropogenic impacts hypothesis**:** This hypothesis proposes that humans have modified the 'natural' biodiversity patterns such that diversity is generally depressed in areas with long history of human occupation or intensive activities (Nogués Bravo et al., 2008). Kibimba and Doho rice-rich schemes have been under rice cultivation for almost 5 decades while the Lwera rice fields are hardly a decade old. This provided a very good scenario for testing the hypothesis.

1.2. Statement of the problem

The industrialization of agriculture has caused, directly and indirectly, a dramatic reduction in the diversity of the fauna and flora compared to the situation a century ago (Storkey et al., 2012). This has been compounded as human populations expand (Aari et al., 2014). The three main species of plants such as rice, maize, and wheat provide about 60% of the energy consumed by humanity. However, paddy rice, being an aquatic plant, grows and produces well when grown in flooded soil than when grown in dry soil (Nachuha & Quinn, 2012). This creates a big threat to wetlands, not only in Uganda, but world over. It is therefore imperative to explore the interaction between wildlife such as birds and the rice agro-ecosystems.

1.3. Objectives of the study

1.3.1. General objective

The overall objective of the study was to assess the diversity of birds on rice farms, with the view to establishing whether these farms can act as refugia for birds, enabling persistence and continuation of evolutionary processes given that their natural habitats are being altered.

1.3.2. Specifically, the study:

i) Determined avifaunal species richness and diversity at these three rice-growing areas;

ii) Assessed the human-bird interactions at these 3 study sites; and

iii) Determined the social-economic effects of the rice farms on the local communities.

1.3.3. Study hypothesis

We hypothesized that bird diversity, richness and abundance would be higher at Lwera rice farm, than the other two rice farms given that humans had been at Lwera for about 5 years only, and at Doho and Kibimba for close to 5 decades.

1.4. Justification

Studying the interaction between wildlife specifically birds on rice agro ecosystems was essential not only to guide agro-ecological strategies aimed at maximizing food productivity and improved rural livelihoods, but also for exploring opportunities for ensuring that these systems are not a sink for birds. Results of this study would contribute to United Nations Sustainable Development Goal 2 which focuses on increasing rural incomes and improving food and nutrition security, The study was also in line with NDPIII programme on the environment and climate change, and Uganda‘s National Rice Development Strategy (NRDS) that aims at promoting rice production, increasing household food security and reducing household poverty primarily by increasing the production of high-quality rice. Considering that some studies, for example, Nachuha (2009) noted that rice paddies favour birds that are generalist and threatens the specialist feeders, and cannot be used as breeding grounds for many birds given the short rotation cycle of the rice plant, information from this study would guide policy on how rice fields should be managed to enable a balance between human needs and bird conservation.

CHAPTER TWO: LITERATURE REVIEW

2.1. Estimating Avifaunal richness and diversity

Rice-growing is a fast-growing human activity world over, including Uganda (Nachuha & Quinn 2012). Unlike other crops, paddy rice suffers from water stress; thus adequate water availability is very important for good growth and high yields of rice. Based on this, natural wetlands have been encroached on to grow rice: for example, the Ministry of Water and Environment figures in Uganda show that the country's wetland coverage has reduced to 8 per cent from 13 per cent of the country's land surface since 1990 to date. The reduction is attributed to the population pressure where people are now resorting to wetland reclamation to grow rice, among other crops.

Considering that wetlands are known to be the most productive systems in the world, with high species diversity (Gardner et al., 2015), then the threat from rice-growing cannot be over-emphasized. In addition, the aquatic nature of rice fields provides suitable foraging grounds for most waterbirds (Nachuha & Quinn 2012), amidst the current weather fluctuations. There is therefore a need to collect data on the status of avian populations in these rice fields. The most fundamental description of an ecological community is provided by a measure of its diversity, which is based on species equitability (or heterogeneity), i.e. the number of species of organisms or species richness, and their abundance (Kerkof, 2010). Species richness and abundance are usually closely related, and have been used to calculate diversity indices that are considered one of the most important attributes when assessing the wildlife conservation value of a site (Volvenko, 2012). In most studies, for example Ntongani and Andrew (2013), Nachuha and Quinn (2012), and including this one, count data was used as an estimate of species diversity.

2.2. Human-bird interactions in agro- ecosystems ecosystem

Agro-ecosystems have increasingly become important habitats for biodiversity in ttheight of the current human population trends that is heavily impacting on the environment. For example, rice paddies provide foraging and dispersal space for waterbirds (Nachuha & Quinn, 2012). Commercial rice-growing involves the use of pesticides and herbicides that have an effect on water quality. As birds seek these alternative feeding grounds, they are faced with a number of threats among which include: direct and indirect poisoning by use of chemicals. On the contrary, birds have been found to boost agricultural yields through pollination, seed dispersal, and even aid in improving plant genetic diversity (Whelan et al., 2008). Many waterbirds such as Storks, Ibises, Egrets and Gulls forage extensively in both aquatic and terrestrial habitats. These birds also produce guano that enhances nutrient cycling and are likely to be important as control agents of agricultural pests reducing crop loss (Thiollay, 1995). In Uganda, rice agriculture has been an integral part of the economy since the 1940s when the government began to cultivate it at Doho and Kibimba swamps. Studies in these habitats have been limited to assessing habitat use without documenting possible conflicts between birds and humans. This study, therefore intended to fill this gap.

3. Social-economic benefits of the rice agro-ecosystems to the local communities

Rice agro-ecosystems are both providers and consumers of ecosystem services. Humans value these systems chiefly for their provisioning services, and these highly managed ecosystems are designed to provide food, forage, fibre, bioenergy and pharmaceuticals. Approximately 20 million farmers in sub-Saharan Africa grow rice while about 100 million people depend on it for their livelihood (FAO, 2019). For the past 5 decades, the Government has directly intervened to promote the cultivation of rice as a strategy to achieve the following objectives: (a) to reduce household poverty, and (b), to reduce rice imports in a country that is currently experiencing an upsurge in rice consumption, which lags behind production (MAAIF, 2009). Ntundhu (2018), observes that if rice production in Uganda grew at 6% per annum, poverty levels would fall from 31.1%in 2005 to 17.9% by 2015 in areas where commercial rice production is a major economic activity. A good harvest ensured food security, enabled famers to sell some to get money to meet basic needs and service their loans, and provided employment as well. Lwera rice farm is only a few years old; there is need therefore to assess if the benefits mentioned above are being realized by the local communities.

CHAPTER THREE: METHODS AND MATERIALS

3.1. Study sites

The study was conducted at Doho, Kibimba and Lukaya rice schemes. Doho rice scheme is located in Nampologoma, Butaleja district and covers an area of about 3,200 ha; Kibimba rice scheme is located in Kibimba, Bugiri district, and covers an area of 3900 ha; and located in Kalungu district, Lukaya rice scheme currently covers an area of 1,214 ha, with capacity to expand to 2,400 ha (see other details in table 1).

Table 3.1. Characteristic features of the study site

Site	**Doho Scheme**	**Kibimba Scheme**	**Lukaya Scheme**
Year of establishment	1976	1972	2014
Number Middle managers	7	8	6
Number Casual workers:	37	1200	58
Yield/Acre (Kg)	1,200	2,500	30,000
Gross Income (Shs)	2,760,000	3,250,000	3,800,000
Production costs (Shs)	725,000	1,300,000	1,800,000
Net Income (Shs)	204,000	1,950,000	2,500,000

3.2. Study design

The study adopted a cross-sectional survey design in data collection. This design facilitated collection of both quantitative and qualitative data on bird number, human-bird interaction, and social-economic effects of rice fields on local communities from the 3 sites at almost the same time.

3.3. Sampling design

Rice fields are divided into blocks for water management purposes and have motorable farm roads to faciliate movement. To achieve objective 1, strategic farm roads located in the centre of the rice farms were identified at each of the 3 sites and a total distance of 5 km was walked, with occasional stopping to record all birds seen and flying over. For the purpose of objective 2 and 3, the district agricultural oficers and managers of the rice farms were selected purposively, while the casual labourers were stratified into female and male and then random selection applied. The sample size for the labourers was determined from the list of labourers working at each farm that was obtained from management. Water quality measurements was done at the point of water entry into the farm and exit. Additional measurements were taken at 50 randomly selected points within the farms. We ensured that these points were far apart to minimise spatial effects in the sample.

3.4. Methods of data collection

3.4.1. Avifaunal species richness and diversity at Doho, Kibimba and Lukaya rice farms

Bird surveys at each study site were conducted over a period of 3 months in which a total count of all bird species using the rice fields at the time of the survey were recorded. Surveys were conducted along a 5km line transect (farm roads) running across the rice paddy fields. Bird species observation was aided by use of binculars and telescope while identification was guided by use of a bird identification field guide book (Stevenson & Fanshaw, 2002). These surveys were done between 0600-1000 hrs and again between 1500-1700 hrs when the birds were expected to be most active.

Plate 1: Bird observation using a telescope

3.4.2. The possible conflicts present arising from the human-bird interaction at Doho Kibimba and Lukaya rice farms

Documents from the District Agricultural Officers of the respective districts were reviewed for information on different threats posed by rice fields to the birds and vice versa. Interviews were held with the same district agricultural officers and the managers of each of the rice farms, including the casual labourers who worked on the farms. Information on what the farmers considered as pests in the rice scheme, how they managedd these pests, and the bird species they considered helpful in controlling some of the pests to the rice crop were sought from each respondent and recorded.

In order to determine threats/ possible conflicts from the agricultural practice, we assessed the quality of the habitat by measuring the physical parameters of water in-situ. These included water pH, temperature and turbidity. We made effort to document through observation any other posisble threats to birds and the birds to the rice farm industry.

3.4.3. The social-economic effect of the rice farms on the local communities at Doho, Kibimba and Lukaya rice farms

Communities are foundations for long-term sustainable conservation and, most often, the frontline beneficiaries of agricultural projects. They are also the chief architects of ecosystems destruction. A structured questionnaire was administered to the employees (including the casual labourers) of the rice farms. In addition, we reviewed documents from the District Agricultural Officers of the respective districts to obtain information on production levels for different years. In addition, interviews were held with the district agricultural officers of the 3 districts and the managers of each of the rice farms to obtain data on the income from the rice farm, possible conflicts between the farm and the environment, especially birds, and the mitigation measures to employ to minimize losses caused by birds, if any.

3.5. Methods of Data analysis

Avifauna has been classified into families and species and threat categories based on the IUCN REDLIST (IUCN, 2019) categories. The Shannon–Weaver (H') diversity index and the abundance of all the species has been calculated.

The Shannon-weaver diversity index, H', was calculated for each count as:

H' = - (Total of bird species)/ (Total birds) ×
(ln (Total of bird species)/ (Total birds))

The mean diversity and abundance of birds was calculated for each site and Analysis of Variance (ANOVA) was conducted to compare avifauna diversity and abundance, and water quality variables across the 3 sites.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. Avifaunal species richness and diversity at Doho, Kibimba and Lukaya rice farms

Table 4.1. Bird Species abundance and Diversity at Kibimba Rice Scheme

BRIT NO	Species Name	*Species Name*	August	December	22-Jan
32	Cattle Egret	*Bubulcus ibis*	500	300	500
38	Yellow-billed Egret	*Egretta intermedia*	900	1200	600
43	African Open-billed Stork	*Anastomus almelligerus*	350	300	400
27	Black-headed Heron	*Ardea melanocephala*	200	150	200
36	Little Egret	*Egretta garzetta*	150	230	150
30	Squacco Heron	*Ardeola ralloides*	50	40	25
25	Grey Heron	*Ardea cinerea*	30	25	20
50	Yellow-billed Stork	*Mysteria ibis*	30	45	50
55	African Spoonbill	*Plattalea alba*	60	72	80
53	Glossy Ibis	*Plegadis falcinellus*	200	230	300
249	Spur-winged Plover	*Vanellus spinosus*	10	3	6
50	Long-toed Plover	*Vanellus crassirostris*	175	100	70
51	Hadada Ibis	*Bostrychia olivacea*	300	240	300
194	Grey-crowned Crane	*Balearica pavonina*	75	100	240
201	Black Crake	*Limnocorax flavirostra*	50	30	20
28	Purple Heron	*Ardea purpurea*	2	5	12
60	White-faced whistling Duck	*Dendrocygna viduata*	15	20	55
79	Spur-winged Geese	*Plectropterus gambensis*	3	5	10
54	Sacred Ibis	*Threskiornis aethiopica*	70	120	210
257	Green Shank	*Tringa nebularia*	12	6	23
282	Black-winged Stilt	*Himantopus himanntopus*	15	10	4
80	Knob-billed Duck	*Sarkidornis melanotos*	5	12	15
318	White-winged Black Tern	*Chlidonias leucopterus*	25	34	54
225	African Jacana	*Actophilornis africanus*	20	24	20
17	Long-tailed Cormorant	*Phalacrocorax carbo*	400	320	150
306	Grey-headed Gull	*Larus cirrocephalus*	3	0	3
278	Black-tailed Godwit	*Limosa limosa*	5	2	12
34	Great-white Egret	*Egretta alba*	15	34	38
42	Hammerkop	*Scopus umbreta*	9	15	4
48	Saddle-billed Stork	*Ephippiorhnchus senegalesis*	0	1	2
59	Fulvous-whistlng Duck	*Dendrocygna bicolor*	25	12	3
33	Green-backed Heron	*Butorides striatus*	13	2	24

466	Malachite kingfisher	*Alcedo cristata*	2	12	20
262	Common Snipe	*Gallinago gallinago*	25	33	34
66	Red-billed Teal	*Anas erythroorhynchos*	7	2	4
44	Abdmin's Stork	*Ciconia ciconia*	2	1	2
206	Stripped Crake	*Porzana marginalis*	2	1	0
46	Woolly-necked Stork	*Ciconia episcopus*	2	1	6
320	Gull-billed Tern	*Gelochelidon nilotica*	0	2	3
202	Allen's Gallinule	*Porphyrio alleni*	3	1	0
23	Little Bittern	*Ixobrynchus minutus*	3	1	3
248	Wattled Plover	*Vanellus sengallus*	2	5	10
199	Common Moorhen	*Gallinula chloropus*	1	2	3
15	Pied Kindgfisher	*Ceryle rudis*	3	5	20
		Species Abundance	**3769**	**3753**	**3705**
		Species diversity	**-0.0232266**	**-0.19393**	**-0.05568**

Table 4.2: Bird Species abundance and Diversity at Doho Rice Scheme

BRIT NO	Species Name	Scientific Name	August	December	22-Jan
32	Cattle Egret	*Bubulcus ibis*	50	90	240
38	Yellow-billed Egret	*Egretta intermedia*	40	55	70
43	African Open-billed Stork	*Anastomus almelligerus*	60	102	100
27	Black-headed Heron	*Ardea melanocephala*	15	66	78
36	Little Egret	*Egretta garzetta*	50	35	50
30	Squacco Heron	*Ardeola ralloides*	20	30	25
25	Grey Heron	*Ardea cinerea*	12	15	25
50	Yellow-billed Stork	*Mysteria ibis*	15	35	70
55	African Spoonbill	*Plattalea alba*	41	55	89
53	Glossy Ibis	*Plegadis falcinellus*	20	50	57
249	Spur-winged Plover	*Vanellus spinosus*	3	24	32
245	Long-toed Plover	*Vanellus crassirostris*	0	15	6
51	Hadada Ibis	*Bostrychia olivacea*	45	55	77
194	Grey-crowned Crane	*Balearica pavonina*	0	2	12
201	Black Crake	*Limnocorax flavirostra*	5	12	34
28	Purple Heron	*Ardea purpurea*	6	10	22
60	White-faced whistling Duck	*Dendrocygna viduata*	0	0	3
79	Spur-winged Geese	*Plectropterus gambensis*	0	0	2
54	Sacred Ibis	*Threskiornis aethiopica*	1	15	24
257	Green Shank	*Tringa nebularia*	0	0	1
282	Black-winged Stilt	*Himantopus himanntopus*	2	2	2
80	Knob-billed Duck	*Sarkidornis melanotos*	0	2	2
318	White-winged Black Tern	*Chlidonias leucopterus*	14	13	24
225	African Jacana	*Actophilornis africanus*	12	12	22
17	Long-tailed Cormorant	*Phalacrocorax carbo*	70	80	120
306	Grey-headed Gull	*Larus cirrocephalus*	0	0	2
278	Black-tailed Godwit	*Limosa limosa*	0	0	1
34	Great-white Egret	*Egretta alba*	0	0	21
42	Hammerkop	*Scopus umbreta*	1	3	12
48	Saddle-billed Stork	*Ephippiorhnchus senegalesis*	0	0	1
59	Fulvous-whistlng Duck	*Dendrocygna bicolor*	30	21	10
33	Green-backed Heron	*Butorides striatus*	3	0	1
466	Malachite kingfisher	*Alcedo cristata*	2	15	21
262	Common Snipe	*Gallinago gallinago*	30	44	23
66	Red-billed Teal	*Anas erythroorhynchos*	0	0	1
44	Abdmin's Stork	*Ciconia ciconia*	0	0	1
206	Spotted Crake	*Porzana marginalis*	0	0	1

46	Woolly-necked Stork	*Ciconia episcopus*	0	0	1
320	Gull-billed Tern	*Gelochelidon nilotica*	0	0	1
202	Allen's Gallinule	*Porphyrio alleni*	0	0	1
23	Little Bittern	*Ixobrynchus minutus*	1	0	1
248	Wattled Plover	*Vanellus sengallus*	2	10	15
199	Common Moorhen	*Gallinula chloropus*	0	0	1
	Marabou stork		1	2	21
	Great-white Egret		8	4	20
		Species Abundance	**559**	**874**	**1343**
		Species diversity	**-0.072093**	**-0.03857**	**-3.03884**

Table 4.3: Bird Species abundance and Diversity at Lukaya Rice Scheme

BRIT NO	Species Name	Scientific Name	August	December	22-Jan
32	Cattle Egret	*Bubulcus ibis*	350	400	500
38	Yellow-billed Egret	*Egretta intermedia*	24	15	32
43	African Open-billed Stork	*Anastomus almelligerus*	1000	2000	1500
27	Black-headed Heron	*Ardea melanocephala*	56	70	92
36	Little Egret	*Egretta garzetta*	202	455	600
30	Squacco Heron	*Ardeola ralloides*	4	34	28
25	Grey Heron	*Ardea cinerea*	3	8	21
50	Yellow-billed Stork	*Mysteria ibis*	34	45	67
55	African Spoonbill	*Plattalea alba*	12	23	22
53	Glossy Ibis	*Plegadis falcinellus*	304	430	400
249	Spur-winged Plover	*Vanellus spinosus*	3	5	9
245	Long-toed Plover	*Vanellus crassirostris*	3	4	12
51	Hadada Ibis	*Bostrychia olivacea*	80	120	150
194	Grey-crowned Crane	*Balearica pavonina*	300	400	600
201	Black Crake	*Limnocorax flavirostra*	23	21	18
28	Purple Heron	*Ardea purpurea*	4	7	12
60	White-faced whistling Duck	*Dendrocygna viduata*	100	200	120
79	Spur-winged Geese	*Plectropterus gambensis*	50	42	67
54	Sacred Ibis	*Threskiornis aethiopica*	45	23	26
257	Green Shank	*Tringa nebularia*	2	4	6
282	Black-winged Stilt	*Himantopus himanntopus*	3	5	13
80	Knob-billed Duck	*Sarkidornis melanotos*	42	43	55
318	White-winged Black Tern	*Chlidonias leucopterus*	23	32	38
225	African Jacana	*Actophilornis africanus*	20	23	25
17	Long-tailed Cormorant	*Phalacrocorax carbo*	45	60	55
306	Grey-headed Gull	*Larus cirrocephalus*	4	5	7
278	Black-tailed Godwit	*Limosa limosa*	1	2	2

34	Great-white Egret	*Egretta alba*	24	20	15
42	Hammerkop	*Scopus umbreta*	2	7	12
48	Saddle-billed Stork	*Ephippiorhnchus senegalesis*	0	1	3
59	Fulvous-whistling Duck	*Dendrocygna bicolor*	58	67	120
33	Green-backed Heron	*Butorides striatus*	1	3	0
466	Malachite kingfisher	*Alcedo cristata*	8	12	15
262	Common Snipe	*Gallinago gallinago*	23	20	15
66	Red-billed Teal	*Anas erythroorhynchos*	0	1	0
44	Abdmin's Stork	*Ciconia ciconia*	4	2	4
206	Spotted Crake	*Porzana marginalis*	2	0	2
46	Woolly-necked Stork	*Ciconia episcopus*	3	4	0
320	Gull-billed Tern	*Gelochelidon nilotica*	2	2	0
202	Allen's Gallinule	*Porphyrio alleni*	0	1	1
23	Little Bittern	*Ixobrynchus minutus*	5	3	8
248	Wattled Plover	*Vanellus sengallus*	27	32	23
199	Common Moorhen	*Gallinula chloropus*	2	52	0
		Species Abundance	2898	4703	4695
		Species diversity	- 0.05956498	-0.09957	-0.03872

Table 4.4: Single factor ANOVA for variation in bird species diversity across the 3 sites

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	8.656164	1	8.656164	13.16841	0.022183	7.708647
Within Groups	2.629372	4	0.657343			
Total	11.28554	5				

Table 4.5: Single factor ANOVA for variation in Bird Abundance across the 3 sites

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	12792520	1	12792520	8.464489	0.043705	7.708647
Within Groups	6045265	4	1511316			
Total	18837785	5				

4.2. Study Hypothesis

We hypothesized that bird diversity, richness and abundance would be higher at Lukaya rice farm than the other two rice farms, given that humans had been at Lukaya for about 5 years only, and at Doho and Kibimba for close to 5 decades.

Results of One-way ANOVA show significant variations in species diversity ($P = 0.022$) and abundance ($P=0.04$) across the sites. However, Doho rice scheme had the highest bird diversity, while Lukaya had the highest bird abundance (see Tables 5-7). Birds used these fields for feeding (Plates 2, 3, and 4),

Table 4.6: Mean ± SE of Bird species diversity, richness and Abundance at the 3 study sites

#	Site	Species diversity (Mean ± SE)	Species Richness	Species Abundance (Mean ± SE)
1	Kibimba RS	0.09±0.05	44	3743±18.6
2	Doho RS	1.05±0.99	45	925.3±227.8
3	Lukaya RS	0.07±0.02	43	4098.6±600.3

Plate 2: A flock of Grey crowned cranes at Kibimba Rice Scheme

Plate 3: A flock of Yellow-billed Storks at Doho Rice Scheme

Plate 4: Mixed Species composition of birds at Lukaya Rice Scheme. Circled individuals were seen swallowing prey

4.3. Water quality

Results of One-way ANOVA show no significant variations in Water pH, Turbidity (JU), Phosphates (ppm), and Nitrates (ppm) (P .0.05) within the rice fields and across the sites (Table 8). The quality of the water was almost uniform across the 3 sites, with no variations within the rice fields.

Table 4.7: Mean ± SD of the water quality variables

		Kibimba Rice Scheme		
#	**Variable**	**Point of entry**	**Within the rice scheme**	**Point of exit**
1	Water pH	7.3 ± 0.1	7.52 ± 0.06	7.3 ± 0.07
2	Turbidity (JU)	0.61 ± 0.15	2.94 ± 1.12	0
3	Phosphates (ppm)	0.02 ± 0.01	0.01 ± 0.01	0.03 ± 0.01
4	Nitrates (ppm)	0.30 ± 0.37	0.54 ± 0.05	0.21 ± 0.04
		Doho Rice Scheme		
#	**Variable**	**Point of entry**	**Within the rice scheme**	**Point of exit**
1	Water pH	7.31 ± 0.1	7.32 ± 0.04	7.1 ± 0.08
2	Turbidity (JU)	0.63 ± 0.25	2.88 ± 1.10	0
3	Phosphates (ppm)	0.03 ± 0.01	0.01 ± 0.01	0.04 ± 0.01
4	Nitrates (ppm)	0.31 ± 0.37	0.44 ± 0.03	0.22 ± 0.06

Lukaya Rice Scheme				
#	**Variable**	**Point of entry**	**Within the rice scheme**	**Point of exit**
1	Water pH	7.2 ± 0.1	7.32 ± 0.06	7.4 ± 0.08
2	Turbidity (JU)	0.61 ± 0.25	2.64 ± 1.11	0
3	Phosphates (ppm)	0.03 ± 0.01	0.01 ± 0.01	0.04 ± 0.02
4	Nitrates (ppm)	0.32 ± 0.37	0.52 ± 0.05	0.22 ± 0.06

4.4. Human-bird interactions at these 3 study sites

4.4.1 Demographic Composition of Respondents

Table 4.8: Demographic Composition of Respondents at Kibimba Rice scheme

1) Parish of Respondents		**2) Time spent at the rice scheme**	
Buduma	3 (5.9%)	< 5years	13 (25.5%)
Bugayi	3 (5.9%)	> 5years	38(74.5%)
Bulesa	4 (7.8%)	All are cauals workers (100%)	
Buluguyi	1 (2%)	**3) Age of Respondents**	
Butema	10 (19.6%)	15-20	03(5.9%)
Butundula	1(2%)	21-35	32(62.7%)
Buwuni	9 (17.6%)	>36	16 (31.4%)
Igogo	4 (7.8%)	**4) Gender of Respondents**	
Kayango	4 (7.8%)	Male	34(66.7%)
Kusebere	1(2%)	Female	17(33.3%)
Mahoma	4 (7.8%)		
Mulendere	1(2%)	**5) Education level of respondents**	
Muwayo	4 (7.8%)	Primary School level	21(41.2%)
Nainala	2 (3.9%)	Secondary School level	29(58.9%)
		Post-secondary	01(2%)
		6) Income per day	
		4,500 ug x	
Total	**51(100%)**		

Source: Field data (2022)

Table 4.9. Demographic Composition of Respondents at Lukaya Rice scheme

1) Parish of Respondents		**2) Time spent at the rice scheme**	
Bukoli	1(5.9%)	< 5years	14 (82.4%)
Bunagana	1(5.9%)	> 5years	3 (17.6%)
Buwani	2 (11.8%)	All are casual workers (100%)	
Byimana	1(5.9%)		
Fortportal	1(5.9%)	**3) Age of Respondents**	
Gisagara	2 (11.8%)	15-20	01(5.9%)
Gisozi	3 (17.6%)	21-35	11(64.7%)
Kakigani	1(5.9%)	>36	05 (29.4%)
Kamira	1(5.9%)	**4) Gender of Respondents**	
Mutamba	2 (11.8%)	Male	13(76.5%)
Nyanamo	1(5.9%)	Female	4 (23.5%)
Rutaka	1(5.9%)		
		5) Education level of respondents	
		Primary School level	08(47.1%)
		Secondary School level	08 `(47.1%)
		Post-secondary	01(5.9%)
		6) Income per day	
		20,000 ug x	
Total	**17(100%)**		

Source: Field data (2022)

Table 4.10: Demographic Composition of Respondents at Doho Rice scheme

1) Parish of Respondents		**2) Time spent at the rice scheme**	
Bubalya	1(2.04%)	< 5years	12 (24.5%)
Buhabeba	1(2.04%)	> 5years	37 (75.5%)
Butalesa	1(2.04%)	Casuals workers	05 (10.2%)
Doho	6 (12.2%)	Farmers	44 (89.8%)
Kapisa	2 (4.08%)	**3) Age of Respondents**	
Lubembe	4 (8.16%)	15-20	0(0%)
Mazimasa	3 (6.12%)	21-35	19(38.8%)
Muyaga	6 (12.2%)	>36	30 (61.2%)
Namehere	3(6.12%)	**4) Gender of Respondents**	
Nampologoma	7 (14.3%)	Male	30 (61.2%)
Namunasa	6 (12.2%)	Female	19 (38.8%)
Namuseru	2 (4.08%)		
Sihiro	4 (8.16%)	**5) Education level of respondents**	
Tindi	3(6.12%)	Primary School level	20(40.8%)
		Secondary School level	19(38.8%)
		Post-secondary	10(20.4%)
		6) Income per day	
		00	
Total	**49 (100%)**		

Source: Field data (2022)

4.5. Social-economic effects of the rice farms on the local communities

4.5.1. Interaction of community members with the rice farms

In order to determine threats/ possible conflicts from the agricultural practice, we made effort to document through observation how community members interact with the rice farms. The interaction is a possible sorce of conflict between the bird biodiversity and humans.

Table 4.11: Interaction of community members with the rice farms

Site	**Kibimba**	**Doho**	**Lukaya**
Rice varieties grown	Wita 9, Basimat, Kayiso, with majority opting for Wita 9	Wita 9, Basimat, Kayiso, with majority opting for Wita 9	Wita 9, Basimat, Kayiso, with majority opting for Wita 9
Reason	Resistant to pests, Matures early and has very good yields	Resistant to pests, Matures early and has very good yields	Resistant to pests, Matures early
Pests of rice	Birds such as Quelae and ducks, Rodents, Paddy stem bearer	Paddy stem bearer , Gall midge, Rodents, Ants, Birds such as Quelae, Monkeys	Birds such as Quelae, Rodents, Paddy stem bearer
Control of pests	Chemical spraying, Scare crows, Humans chasing the birds	Spraying, timely planting, noise machines, effective monitoring, scare crows, Humans chasing the birds	Chemical spraying, Scare crows, Humans chasing the birds
Employed elsewhere	39 mentioned No, while 12 said Yes	All farmers	None of them is employed elsewhere
Form of employment	Boda-Boda rider, Tailor, Growing maize, Market vendor, Art and crafts, fishing, Poultry	Boda boda, fishing	Not applicable
Why no other employment?	Lack of skills, No jobs available, Low level of education, company does not allow, Lack of land and lack of materials to use.	No jobs, lack of skills, low level of education	Lack of skills, No jobs available, Low level of education, company does not allow, Lack of land ad lack of materials to use

Results in Table 11 indicate that Wita 9, Basimat, Kayiso, were the rice varieties grown, with the majority opting for Wita 9, and birds such as Quelae and ducks were the common rice pests together with rodents, Paddy stem bearer and Gall midge, and the bird pests were scared off using scare crows (Plate 5). The majority of the local farmers/labourers depended on the rice scheme for a living, with very few engaging in additional activities such as Boda-Boda riding, Tailoring, Growing maize, Market vending, Fishing, and Poultry. This was mainly due to lack of skills, non-availability of other jobs, low level of education, company policy that prohibits them from working elsewhere, and lack of land among others.

Plate 5: Scare crows at Lukaya Rice Scheme

Table 4.12: Birds and rice growing

Site	Kibimba	Doho	Lukaya
Birds present	Cranes, Egrets, weaverbirds, Quealea, Ibises, Storks, Ducks, Geese and Spoonbills	Purple heron, Cranes, Egrets, Weaverbirds, Quealea, Ibises, Storks, Ducks, Geese and Spoonbills	Cranes, Egrets, Weaverbirds, Quealea, Ibises, Storks, Ducks, Geese and Spoonbills
Importance of birds	Tourism, Controlling Pests, Add manure, No importance, Removes snakes	Eat snails, pollinate, add nutrients in the silo, feed on snakes and rats, Ducks and quealea destroy rice	Pollinators, Fertilise the soil, removes pest
Effects of rice growing on birds	Birds migrate, Habitat destruction, Poisoned by chemicals in the field, Hunted and Killed by workers	The wetland has been destroyed so we have no cranes anymore, Farmers hunt them seriously	Habitat destruction, Poisoned by chemicals in the field, Hunted and Killed by workers
Birds that have declined and why?	The Grey crowned Crane, African Spoon bill, Crowned Cranes and Marabou Stokes due to habitat destruction	The Grey crowned Crane as a result of clearing the wetland for rice farming, watermelon and other crops given that there is no more water in the wetland	None
Birds that have increased and why?	Quelea, Open-billed storks and Egrets because of plenty of food	Queala, A lot of rice	Very many ducks, geese and cranes
How do we protect birds?	Restoration of their habitats, Reduction of agro chemicals, sensitization and protection of birds	Introduce other income generating activities like fish farming	I don’t know

Plate 6: Poisoned Fulvous whistling Ducks at Kibimba Rice Scheme

Birds were threatened by human practices such as poisoning (Plate 6), hunting and wetland destruction through expansion of the rice schemes. As a result, birds such as the Grey crowned Crane and African Spoon bill, have reduced in number, with no sighting of these birds at these sites for the past 3 years.

Table 4.13: Importance of rice farming to the local community

Site	Kibimba	Doho	Lukaya
Benefits of the rice scheme to the community	Employment opportunity, infrastructure improvement	Improve on food security, increased income, Improved education, controlled floods more, improved business in the area.	Provide food in short time, Provide employment opportunity, Turned useless land into useful.
Challenges from the community	Insecurity in form of theft of rice, poor policy, soil exhaustion, lack of modern rice skills	Monoculture is a problem. Pests and diseases, lack of modern skills to use in practice, poor communities, weeds.	Land disputes between the scheme and communities around it. Floods, pests and diseases.
Mitigations	Strengthen rice research, using modernized agriculture and using irrigation.	Sensitization, growing more up land crops, improving on education levels of people around the scheme and encouraging co-operative farming.	

The rice schemes have provided employment opportunities, food security, controlled flooding, improved livelihoods among the local communities. However, the practice has been done for many years and now the soils are no longer fertile to give the required yield. Effort needs to be made by the concerned government agencies to mitigate these situations by encouraging the local communities to grow upland crops including rice.

5.1. Discussion of findings, conclusion and recommendations

5.1.1. Avifaunal species richness and diversity at Doho, Kibimba and Lukaya rice farms

We hypothesize that bird diversity, richness and abundance will be higher at Lukaya rice farm, than the other two rice farms given that humans have been at Lukaya for about 5 years only, and at Doho and Kibimba for close to 5 decades. However, results indicate that Doho rice scheme has the highest bird diversity, while Lukaya has the highest bird abundance. This is probably due variation in size of the rice fields, given that area has an effect on the number of birds/ organisms (Paracuellos & Telleria, 2004). In addition, rice fields are artificial habitats that are attractive to water birds only when there are farming activities going on (Nachuha, 2009). There were a lot more activities at Doho rice scheme than the other two sites during the time of data collection.

Further results revealed that some birds (particularly Quelea spp) were the main rice pests at all the 3 rice schemes. These findings seem to agree with findings in several Southeast Asian nations, where farmers consider rats and birds as the major biotic stresses for lowland rice (Balasubramanian et al., 2007). However, some farmers mentioned that storks, particularly the open-billed storks eat snails that would otherwise destroy the germinating rice. These findings seem to suggest that waterbirds can act as biological controllers of these pests as also evidenced by studies elsewhere (Teo, 2001). Methods used by these farmers to control pests included poisoning and scaring, which are almost universal.

5.1.2. Social-economic effects of the rice farms on the local communities

Establishmsnt of Lukaya rice scheme is evidence that rice production is being increasingly used as a strategy to reduce poverty in households in Uganda; and this practice is greatly expanding beyond the gazzeted rice shemes. Almost all the respondents at the 3 study sites indicated that they depended entirely on the rice schemes, either as farmers or labourers, for their livelihood. These findings seem to agree with a study by Oonyu (2011) that showed that 45% of respondenets in Doho rice scheme indicated that paddy rice contributed to family welfare, and the income from rice was used to buy food and clothing, and paying fees for their children.

5.1.3. Conclusions

In conclusion, rice schemes provide employment and improve livelihoods at all the 3 sites. Some birds such as Quealea are rice pests, while others such as the Grey Crowned Crane, although present in fairly good numbers at Kibimba and Lukaya Rice Schemes, are declining in numbers. Birdlife is threatened by deliberate poisoning for food and, at the same time, the birds considered as pests. Although farmers use inorganic fertilizers and herbicides, the quality of water is good at all the 3 rice schemes. Sensitization, growing more upland crops, improving on education levels of people around the scheme and encouraging co-operative farming will be good ways of mitigating conflict between humans and nature.

5.1.4. Recommendations

i. Undertake a detailed study to document the status of the Grey crowned crane including locating new breeding and feeding grounds given the importance of this bird to Uganda and the international community.

ii. There is need for alternative income-generating activities; otherwise rice is the only source of income in these areas, so the farming and expansion of the rice fields will not end soon.

iii. Local Government staff working in partnership with NGOs and government agencies should continuously sensitize the farmers/users on the importance of birds and other biological organisms to human existence.

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10. Appendices

Appendix I: Data collection tools.

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Objective 1: Estimate avifaunal species richness, diversity and density

Site: Date: Time of day:

Stage of rice:

#	Common Name	Number

B. Physical parameters of the water

#	Point 1	2	3	4	5
pH					
Temp					
Turbidity					

C. Any other observations

	Tick
Presence of large flocks quelea quelaea	
Application of herbicides and pestcides	
Bird kills	
Presence of scare crows	
etc	

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Objective 2: Assessment of the possible conflicts present arising from the human-bird interaction (Farmers, District Agricultural officers, Manager of the farm)

1. Title of respondent: Parish…………………………..

2. List the rice pests in this rice scheme

3. How do you manage these pests?

4. What bird species are helpful in controlling these pests?

5. Do we still have the same number of birds as it were before?

6. Which bird species have declined in number?

7. Why?

8. Which bird species have increased in number?

9. Why?

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Objective 3: Determine the social-economic effect of the rice farms on the local communities: District Agricultural Officers, Managers, Farmers/casual laborers

Casual laborers and farmers

1. Age	5. Are you a farmer or causal laborer?	9. How much do you earn?	14. List five most common birds that use this rice field
2. Education level	6. For how long have you worked here?	10. Is it sufficient?	15. How important are these birds to the rice scheme?
3. Parish	7. For how long have you been growing rice? If	11. Do you have any other form	16. How does the rice growing affect

	farmer	of employment?	these birds?
4. Gender	8. What variety is grown? And why?	12. If yes, which one? 13. If no, Why?	

B. Manager of the farm

1. Name of the riche scheme:

2. Year of establishment:

3. Number of employees:

Middle managers:

Casual workers:

	Doho Scheme	**Kibimba Scheme**	**Lukaya Scheme**
Yield/Acre (Kg)			
Gross Income (Shs)			
Production costs (Shs)			
Net Income (Shs)			

Benefit of the rice scheme to the communities	Challenges from communities/rice industry	Mitigation measures

Any other challenges/Benefits

Appendix II: Permission Letter

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3rd November 2021

To the Manager

Kibimba rice scheme

Dear Sir,

Subject: Request for permission to carry out research on birds

This is to inform you that I am a senior lecture in the department of Biology and Kabale University and interested in documenting bird numbers in three rice growing areas in Uganda, namely: Doho rice scheme, Kibimba rice scheme and Lwera rice scheme as per academic proposal attached.

I therefore kindly request you to allow me:

1. Access to any report relating to the establishment and information relating to your operations
2. Watch and document birds using this rice scheme
3. Conduct interviews with some of your staff
4. Conduct interviews with some of your casual workers

I will be very grateful to your kind consideration.

Regards,

Sarah Nachuha

Researcher from Kabale University

Received
03/Nov/2021

Mukese Umar
HR
0774482210

KIBIMBA LIMITED
eTAX TIN
1000024724
Effective Date
19-Nov-1996
KAMPALA UGANDA

Appendix III: Dissemination of results

Agenda for meeting held on 26th 08 2022

1. Prayer
2. Communication form In-charge of the Rice Scheme
3. Words from the Farmer representative
4. Presentation of key findings
5. Matters arising
6. Closure

Minute 1. Opening prayer was said by one of the farmers

Minute 2. The in charge of the rice scheme, Mr Sagula Wilberforce welcomed members and informed them about the purpose of the meeting which was to listen to the findings of the recent study in which some of them had participated. He requested them to pay attention and participate actively for betterment of the rice scheme.

Minute 3. Mr. Gamusi Anasi, who represented farmers informed tham that the visistr had not come to take the rice scheme away from them but to tell us about the findings of the study on birds and rice growing. He requested them to pay attention and ask as many questions as they can

Minute 4: Presentation of Key findings

Introduced myself' and presented the following

1. Uganda now has 3 paddy rice growing areas gazzeted: Doho Rice Scheme, Kibimba, and Lukaya
2. Bird are tending to use these rice fields given their diminishing natural habitats
3. Results showed that more birds were recorded at Doho rice scheme than the rest of the rice fields, however, birds such as the Grey Crowned Crane is almost not present at DRS as it were in the past.
4. Some birds such as Quealea are rice pests

5. Birdlife is threatened by poisoning
6. Water quality is almost the same at the 3 rice schemes
7. Rice schemes provide employment and improve livelihoods at all the 3 sites
8. Most of you said that sensitization, growing more up land crops, improving on education levels of people around the scheme and encouraging co-operative farming will be good ways of mitigating conflict between you and nature.

Minute 5: Matters arising

Members agree that rice farming is no longer that beneficial like it was before with yields reducing

Some birds such as storks are good since they eat snails

There need to reduce on use of pesticides and herbicides

They agreed that Grey crowned cranes are no longer seen given that the wetland where they used to breed is all converted into gardens

Suggestion

Need for alternative income generating activities, otherwise rice is the only source f income in this area so, the farming and expansion of the rice fields will not end soon