5.2 Stage 2

Table 5.2-1 Evaluation Framework on Stage 2-1

Evaluation items			Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Economic and technical	Cost	Construction Cost (MUSD)	A	A	C	C	C	D	B
		Generation Cost (cent/kWh)	A	D	B	C	A	E	B
	Effectiveness	Maximum Power (MW)	C	E	B	C	A	D	A
		Construction time (year)	A	A	B	B	B	B	A
		Head (m)	E	E	B	C	A	D	A
		Distance to load centre or existing grid (km)	B	D	A	C	D	D	E
		Length of Waterway	A	A	D	D	C	E	B
		Geological Condition	B	B	C	C	C	C	C
		Excavation Volume	B	A	D	C	C	E	B
		Construction material (availability)	A	A	B	B	B	C	A
		Accessibility	A	A	A	B	C	D	B
		Loss of transmission	C	C	A	B	B	B	C
	Development progress	Lead Time	D	D	A	C	B	C	C
		Financial Negotiation and close	C	C	C	C	C	C	C
Environment	Length of water recession (km)		A	A	D	D	C	E	B
	Rate of recession (%)		A	A	D	D	D	D	D
	Impact on Protected area		C	C	B	D	D	D	E
	Impact on wetland		A	A	D	A	A	A	A
	Impact on protected species		A	A	D	C	D	D	E
	Degradation of underground water		A	A	D	D	C	E	A
	CO_2 emission from the reservoir		D	E	A	A	A	A	C
Social	Land acquisition		E	E	A	B	B	B	D
	Flooding area		D	E	A	A	A	A	C
	Number of affected people		D	E	D	A	A	A	A
	Impact on ethnic minority and indigenous people		C	C	D	B	B	B	B
	Impact on fish breeding and/or fishing		A	A	B	A	A	A	A
	Impact on Agriculture		C	D	E	A	A	A	A
	Impact on cultural property		E	A	D	A	A	A	C
	Impact on tourism		E	B	C	D	D	D	E
	Impact on existing infrastructure		C	C	E	A	A	A	B
	Impact on landscape		E	A	D	C	C	C	E
	Human health hazard		C	C	D	A	A	A	A
	Econo : Env : Soc 32 : 33 : 35		A	B	A	B	A	C	B
	Econo : Env : Soc 23 : 39 : 28		A	A	B	B	B	C	C
	Econo : Env : Soc 41 : 27 : 32		A	B	A	B	A	C	B

5.2.1 Economic and technical aspects

5.2.1.1 Cost

5.2.1.1.1 Construction Cost

Table 5.2-2 Construction Cost

	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Construction Cost (MUSD)	638	601	1,911	1,696	1,565	2,190	1,106
Rating	A	A	C	C	C	D	B

5.2.1.1.2 Generation Cost

The evaluation item of “Operation and Maintenance cost” is changed to “Generation Cost”.

Table 5.2-3 Generation cost

	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Generation Cost (cent/kWh)	3.3	7.3	4.2	5.8	3.3	9.5	(4.4)
Rating	A	D	B	C	A	E	B

*: Generation cost of Murchison is half of the capacity, because generation hours would be half day.

5.2.1.2 Effectiveness

5.2.1.2.1 Maximum Power

Table 5.2-4 Maximum Power

	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Maximum Power (MW)	330	138	587	392	616	292	655
Rating	C	E	B	C	A	D	A

5.2.1.2.2 Construction time

Table 5.2-5 Construction Time

	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Construction time (years)	4	4	5	5	5	5	4
Rating	A	A	B	B	B	B	A

5.2.1.2.3 Head

Table 5.2-6 Head

	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Head (m)	28	13	79	53	83	40	88
Rating	E	E	B	C	A	D	A

5.2.1.2.4 Distance to load centre or existing grid

Table 5.2-7 Distance to load centre or existing grid

	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Distance to load centre or existing grid (km)	28	47	1	34	46	56	122
Rating	B	D	A	C	D	D	E

5.2.1.2.5 Length of Waterway

Table 5.2-8 Length of Waterway

Length of Waterway	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Length (km)	0	0	12	12	8	14	2
Rating	A	A	D	D	C	E	B

5.2.1.2.6 Geological Condition

Table 5.2-9 Geological Condition

Geological Condition	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Rating	B	B	C	C	C	C	C

5.2.1.2.7 Volume of Excavation

Table 5.2-10 Volume of Excavation

Volume of Excavation	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Excavation Volume (10^3m^3)	1,036	824	6,008	5,424	4,164	7,152	1,684
Rating	B	A	D	C	C	E	B

5.2.1.2.8 Construction material (availability)

Table 5.2-11 Construction material

Construction material	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Concrete Volume (10^3m^3)	356	560	1,520	1,262	1,059	1,794	822
Rating	A	A	B	B	B	C	A

5.2.1.2.9 Accessibility

Table 5.2-12 Accessibility

Accessibility	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Length of new access road (km)	13	15	1	30	45	55	30
Rating	A	A	A	B	C	D	B

5.2.1.2.10 Transmission loss

Table 5.2-13 Relative Transmission loss compared to Karuma project

	Ishimba	Kalagala	Karuma	Oriang	Ayago	Kiba	Murchison
Voltage (kV)	220	220	-	400	400	400	400
Length (km)	47	28	0	34	46	56	122
Transmission Loss (%)	168	100		36	50	60	131
Rating	C	C	A	B	B	B	C

5.2.1.3 Development progress

5.2.1.3.1 Lead Time

Table 5.2-14 Lead Time

	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Time before commencement (Survey, design, financing, bidding, Relocation, etc.) (years)	6	6	5	5	5	5	5
Rating	C	C	A	A	A	A	A

5.2.1.3.2 Financial Negotiation and close

Table 5.2-15 Financial Negotiation and close

	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Donner							
Rating	C	C	C	C	C	C	C

5.2.2 Environmental aspect

5.2.2.1 Length of water recession

The evaluation of water recession was based on the distance of water recession. The ratings of Kalagala and Isimba are “A” because there is no water recession. The rating of Kiba is “E” because the length of water recession is more than 15 km.

Table 5.2-16 Length of Water Recession

	Kalagala	Isimba	Karuma	Oriang	Ayago	Kiba	Murchison
Length of water recession (km)	0	0	14.5	13.4	8.8	16.7	4.4
Rating	A	A	D	D	C	E	B

5.2.2.2 Rate of water recession

The rates of water recession were evaluated by the percentage of recession based on the brief design. The ratings of Kalagala and Isimba are “A” because of no water recession. The other projects have “D” because their recession rates are 89%.

Table 5.2-17 Rate of recession

	Kalagala	Isimba	Karuma	Oriang	Ayago	Kiba	Murchison
Rate of recession (%)	0	0	89	89	89	89	89
Rating	A	A	D	D	D	D	D

5.2.2.3 Impact on protected area

Impact on protected area was evaluated based on the number of protected areas which are affected and the extent of its impact; in other words, either the project area covers protected areas partially or it covers fully. The rating of Karuma is “B” because a part of the project area is inside the wildlife reserve. The rating of Murchison is “E” because the project area is inside three protected areas, the National Park, the Ramsar site, and the Important Bird Area.

Table 5.2-18 Impact on Protected Area

Evaluation items	Uganda							International				Rating
	National Park	Wildlife Reserve	Community Wildlife Management Area	Wildlife Sanctuary	Central Forest Reserve	Local Forest Reserve	Dual Joint Management Reserve	UNESCO-MAB Biosphere Reserve	World Heritage Convention	Ramsar	IBA	
Kalagala					X						X	C
Isimba					X						X	C
Karuma		X										B
Oriang	XX	X									XX	D
Ayago	XX	X									XX	D
Kiba	XX	X									XX	D
Murchison	XX									XX	XX	E

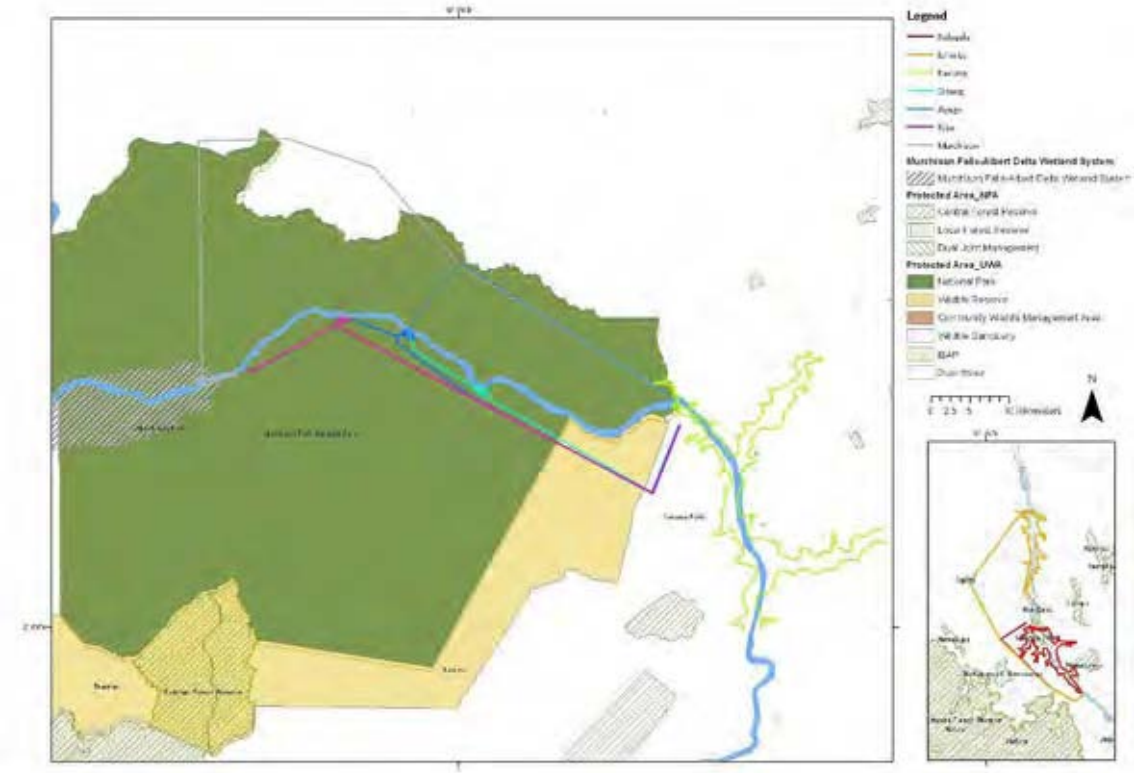


Figure 5.2-1 Protected Area

5.2.2.4 Impact on wetlands

Impact on wetlands was evaluated by how much the wetland area in the land use map is covered by the affected area (1 km buffer from the project area). Rating of Karuma is "C" because 63.28 km^2 of the wetland area is covered. The ratings of the other projects are "A."

Table 5.2-19 Impact on Wetland

Type	Wetland (km^2)	Rating
Kalagala	0	A
Isimba	0.16	A
Karuma	63.28	C
Oriang	0.06	A
Ayago	0.04	A
Kiba	0.02	A
Murchison	0.05	A

5.2.2.5 Impact on endangered species

Impact on endangered species was evaluated by the overlay of the distribution map of IUCN red list species and the map of project areas. The number of species on IUCN red list in Uganda is 1,823 in January 2010. However, UWA recorded only 51 species, which account for 3% of the 1,823 (See Table 5.2-20).

Table 5.2-20 Number of the IUCN red list species in Uganda

IUCN Category	Number of species on the list in Uganda	Number of the species which have information of distribution
CR – Critically Endangered	32	1
EN – Endangered	40	13
VU – Vulnerable	90	8
LR/cd – Lower Risk: Conservation Dependent	1	0
NT or LR/nt – Near Threatened	67	6
DD – Data Deficient	45	0
LC or LR/lc – Least Concern	1548	23

Impact on each species was evaluated as “XX” when the project is inside the distribution area, “X” when the project is near the distribution area, and “-” when the project is far from the distribution area. Ratings of Isimba and Kalagara are “A” because of no affected species. Rating of Murchison is “E,” because 26 endangered species may be affected.

Table 5.2-21 Habitat of Red list species and projects

Common names (Eng)	Red List status	Information Source				Projects						
		Polygon by IUCN	Ranger Survey (1988-2009)	Aerial survey (2005)	Point by UWA (1897-2007)	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Du Toit's Torrent Frog	CR	*										
Madagascar Pond-heron	EN				*							
Grauer's Swamp-warbler	EN				*							
Nahan's Francolin	EN				*							
Egyptian Vulture	EN				*							
Kahuzi Swamp Shrew	EN	*										
Ugandan Shrew	EN	*										
Montane Shaggy Rat	EN	*			*							
Mountain Gorilla	EN	*			*							
Rahm's Brush-furred Rat	EN	*										
African Wild Dog	EN	*										
Montane Mouse Shrew	EN	*			*							
Barbour's Vlei Rat	EN	*										
Chimpanzee	EN	*			*						X	X
Shoebill	VU		*									
Crested Crane	VU			*								
Mountain Monkey	VU				*							
Hippopotamus	VU		*	*	*			X	XX	XX	XX	XX
Lion, African Lion	VU		*		*			XX			XX	XX
Ruwenzori Horseshoe Bat	VU				*							
Crescent Shrew	VU				*							
Charming Thicket Rat	VU				*							
Stony Shrew	NT				*							
Straw-coloured Fruit Bat	NT				*							
Hyena	NT		*					X	X	X	X	X
African Elephant	NT		*	*	*			X	XX	XX	XX	XX
Leopard	NT		*		*			XX		XX	XX	XX
Volcano Shrew	NT				*							
Ground Hornbill	LC		*					XX	X	XX	X	XX
Saddle-billed Stork	LC		*		*					X		X
Fish Eagle	LC		*	*	*							XX
Great Cormorant	LC		*		*			X				
Hartebeest	LC		*	*	*			XX	XX	XX	XX	XX

Common names (Eng)	Red List status	Information Source				Projects						
		IUCN Polygon by (1988-2009)	Ranger Survey (2005)	Aerial survey	Point by UWA (1897-2007)	Kalagala	Ishimba	Karuma	Oriang	Ayago	Kiba	Murchison
Porcupine	LC		*									
Blue Duiker	LC		*	*	*			XX	XX	XX	XX	XX
Red-tailed Monkey	LC		*		*				X	X	X	X
Vervet Monkey	LC		*		*			XX	XX			X
Colobus (BW)	LC		*		*			XX	XX	XX	XX	XX
Giraffe	LC		*	*	*			XX	XX	XX	XX	XX
Waterbuck	LC		*	*	*			XX	XX	XX	XX	XX
Ugandan kob	LC		*	*	*			XX	XX	XX	XX	XX
Oribi	LC		*	*				XX	XX	XX	XX	XX
Baboon	LC		*	*	*			XX	XX	XX	XX	XX
Warthog	LC		*	*	*			XX	XX	XX	XX	XX
Bushpig	LC		*	*				XX	X	XX	X	X
Bohor Reedbuck	LC		*	*	*			XX				XX
Buffalo	LC		*	*	*			XX	XX	XX	XX	XX
Bushbuck	LC		*	*	*			XX	X	XX	XX	XX
Sitatunga	LC		*						XX	X	X	X
Crocodile	LC		*					XX			XX	XX
Monitor Lizard	LC		*					XX				
Number of species	CR					0	0	0	0	0	0	0
	EN					0	0	0	0	0	1	1
	VU					0	0	2	1	1	2	2
	NT					0	0	3	2	3	3	3
	LC					0	0	18	16	16	16	20
	Total					0	0	23	19	20	22	26
Rating						A	A	D	D	D	D	E

X: Project is near the habitat XX: Project is in the habitat

5.2.2.6 Recession of underground water

Recession of underground water was evaluated by the length of the tail race tunnels, because it is caused by tunnel excavation. The ratings of Kalagala and Isimba are A because of no tunnel excavation. The rating of Kiba is E because of long tail race tunnel.

Table 5.2-22 Impact on Underground Water

Projects	Length of tail race tunnel (m)	Rating
Kalagala	0	A
Isimmba	0	A
Karuma	11,277	D
Oriang	11,097	D
Ayago	7,400	C
Kiba	14,261	E
Murchison	1,800	B

5.2.2.7 CO_2 emission from the reservoirs

The amount of CO_2 emission from the reservoirs was calculated by the basic unit, which is 4000 mg (m^2/day) [5]. The rating of Isimba is "E" because of large reservoir. The ratings of Karuma, Oriang, Ayago, and Kiba are "A" because of run-off river type.

Table 5.2-23 CO_2 emission from the reservoirs

Projects	Riverbed Area (km^2)	CO_2(t/day)	Rating
Kalagala	9.4	37.6	D
Isimmba	11.8	47.2	E
Karuma	0.03	0.12	A
Oriang	0.03	0.12	A
Ayago	0.03	0.12	A
Kiba	0.03	0.12	A
Murchison	3.3	13.2	C

5.2.3 Social aspect

5.2.3.1 Land acquisition

Land acquisition was evaluated by the necessary size of the area for spoil bank, temporary facility, inundation, transmission tower, and ROW for transmission lines. The rating of Karuma is A because of no transmission line and no land acquisition. The ratings of Kalagala and Isimba are "E" because of larger inundation area.

[5] Tremblay, Alain (2006), "The Issue of Greenhouse Gases from Hydroelectric Reservoirs from Boreal Regions," Presentation, UNESCO Workshop on GHG emissions from freshwater reservoirs," December 2006, Paris, France

Table 5.2-24 Needed Land for the Projects

Items	Land acquisition					ROW for Transmission Line	Rank
	Spoil Bank	Temporary Facility Area	Inundation area	Transmission Towers	Total		
	m^2	m^2	m^2	m^2	m^2	m^2	
Kalagala	65,000	60,000	3,400,000	9,300	3,534,300	1,120,000	E
Isimba	54,000	60,000	6,600,000	15,600	6,729,600	1,880,000	E
Karuma	697,000	60,000	30,000	0	787,000	0	A
Oriang	605,000	60,000	30,000	11,300	706,300	2,040,000	B
Ayago	484,000	60,000	30,000	15,300	589,300	2,760,000	B
Kiba	849,000	60,000	30,000	18,600	957,600	3,360,000	B
Murchison	197,000	60,000	2,400,000	40,600	2,697,600	7,320,000	D

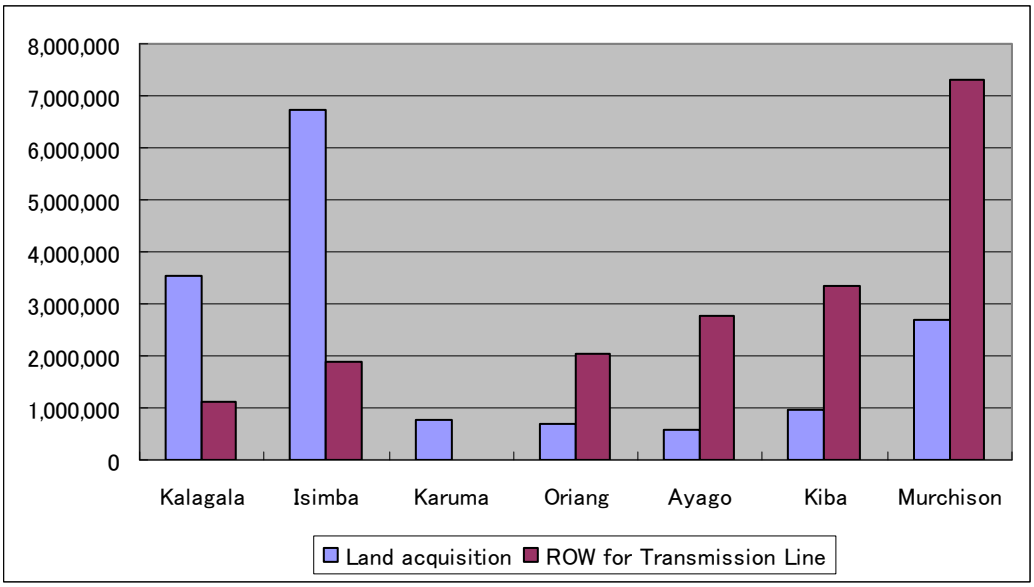


Figure 5.2-2 Area of land acquisition and ROW for new transmission line

5.2.3.2 Inundation area

Inundation area was evaluated by the riverbed area, which is calculated by subtracting acquisition area from reservoir area. The ratings of Karuma, Oriang, Ayago, Kiba are “A” because of no reservoir area. The rating of Isimba is “E” because of larger reservoir area.

Table 5.2-25 Inundated area

Project	Riverbed Area (km^2)	Acquisition Area (km^2)	Reservoir Area (km^2)	Rating
Kalagala	6.00	3.40	9.40	D
Isimmba	5.20	6.60	11.80	E
Karuma	0.00	0.03	0.03	A
Oriang	0.00	0.03	0.03	A
Ayago	0.00	0.03	0.03	A
Kiba	0.00	0.03	0.03	A
Murchison	0.90	2.40	3.30	C

5.2.3.3 Affected people

Impact on affected people was evaluated by the number of households for resettlement and the estimated population within a 1 km buffer from the project area. The ratings of Oriang, Ayago, Kiba, Murchison are "A", since they are inside the National Park. The ratings of Kalagala and Karuma are "D" because of the larger number of resettlement and population.

Table 5.2-26 Number of Affected People

Projects	Resettlement	Population Within 1 km[6]	Remarks	Rating
Kalagala	165 households[7]	36,145		D
Isimba	26 households	49,744		E
Karuma	200[8] (people)	33,015		D
Oriang	0	4,854		A
Ayago	0	5,049		A
Kiba	0	5,434		A
Murchison	0	1,890		A

5.2.3.4 Impact on ethnic minorities

Impact on ethnic minorities was evaluated by the number of ethnic groups which are affected by the project and the types of impact, because it is difficult to define which ethnic groups are minorities. The ratings of Oriang, Ayago, Kiba, Murchison are "B" because they are located in the National Park. The rating of Karuma is "D" since many ethnic groups can be affected.

Table 5.2-27 Impact on ethnic Group

Projects	Ethnic Group	Affected by the project	Rating
Kalagala	Basoga, Banyole, Jopadhola, Basamia, Bagwere, Iteso, Baganda, Bagisu	Resettlement, Loss of farm land, Noise, Vibration, Dust	C
Isimba	Basoga, Jopadhola, Baganda, Bagisu, Ik-teuso, Iteso, Bakenyi, Banyole, Lugbara, Basamia, Bagwere	Resettlement, Loss of farm land, Noise, Vibration, Dust	C
Karuma	Acholi, Iteso, Kumam, Banyakole, Bagungu, Alur, Chope, Baruli, Langi, Kuku, Lugbara, Jonam, Babwisi, Bagisu, Basamia, Banyarwanda, Karimojongo, Madi, Banyoro, Ik-teuso, Babukusu, Baganda, Kebu-okebu	Resettlement, Loss of farm land, Noise, Vibration, Dust	D
Oriang	Acholi, Iteso, Alur, Chope, Langi, Lugbara, Jonam, Babwisi	Hunting might be affected	B
Ayago	Acholi, Lugbara, Jonam, Chope, Langi, Iteso, Alur, Bafumbira, Babwisi	Hunting might be affected	B
Kiba	Acholi, Jonam, Chope, Langi, Iteso, Alur, Bafumbira, Banyakole, Lugbara, Bakiga, Bakhonzo, Kakwa, Babwisi	Hunting might be affected	B
Murchison	Acholi, Madi, Banyoro, Jonam, Langi, Alur, Bafumbira, Banyakole, Iteso, Lugbara, Bakiga, Bakhonzo, Kakwa, Baamba, Babwisi, Chope, Lendu, Baganda	Hunting might be affected	B

[6] Estimated by population data of Parish from Census 2002
[7] Based of 1:50,000 topographic map
[8] EIA report of Karuma (1996)

5.2.3.5 Impact on fisheries

Impact on fisheries was evaluated by the fishery activity around the project area. The rating of Karuma is “B” because of the existence of small scale fishery. The ratings of the others are “A” because of no fishery activities.

Table 5.2-28 Impact on fish breeding and/or fishing

Projects	Fish breeding	Fishing	Rating
Kalagala		-	A
Isimba		-	A
Karuma	-	Small Scale Fishing	B
Oriang	-	-	A
Ayago	-	-	A
Kiba	-	-	A
Murchison	-	-	A

5.2.3.6 Impact on Agriculture

Impact on agriculture was evaluated by the agricultural area within a 1 km buffer from the project area. The ratings of Oriang, Ayago, Kiba, and Murchison are “A” because of no farmland. The rating of Karuma is “E.”

Table 5.2-29 Direct and Indirect Impact on Agriculture

Type	Subsistence Farmland(km^2)	Subsistence Farmland (Permanently wet) (km^2)	Subsistence Farmland (Seasonally wet) (km^2)	Commercial Farmland(km^2)	Rating
Kalagala	54.95	0.00	20.59	2.13	C
Isimba	78.27	0.10	25.96	2.55	D
Karuma	140.27	0.00	14.06	0.00	E
Oriang	21.17	0.00	0.14	0.00	A
Ayago	21.84	0.00	0.20	0.00	A
Kiba	22.49	0.00	0.29	0.00	A
Murchison	26.78	0.00	0.00	0.00	A

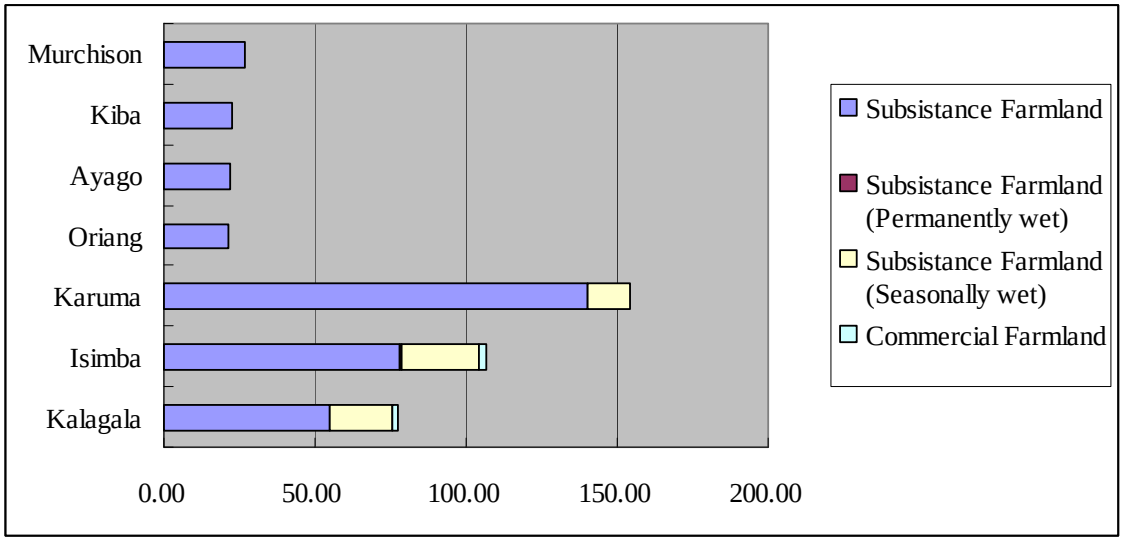


Figure 5.2-3 Impact on Agricultural Land

5.2.3.7 Impact on historical and cultural properties

Impact on historical and cultural properties was evaluated by their existence and the impact on them. The ratings of Isimba, Oriang, Ayago, and Kiba are "A" because of no existence and no impact. The rating of Kalagala is "E" because of Kalagala shrine and Itanda Falls.

Table 5.2-30 Impact on cultural property

Project	Cultural Property	Impact	Rating
Kalagala	Kalagala shrine Itanda Falls	XXX XXX	E
Isimba	Mbuiamuti Landing Site	-	A
Karuma	Karuma Falls	XXX	D
Oriang	-	-	A
Ayago	-	-	A
Kiba	-	-	A
Murchison	Murchison Falls	X	C

5.2.3.8 Impact on tourism potentials

Impact on tourism potentials was evaluated by their existence and the impact on them. The rating of Isimba is "A" because of no tourism potential. The ratings of Kalagara and Murchison are "E" because of serious damage on the tourism potentials.

Table 5.2-31 Impact on tourism potentials

Project	Nature observation	Sight seeing	Sports and relaxing	Rating
Kalagala	-	Itanda falls XXX	XX (Rafting)	E
Isimba	-	-	-	A
Karuma	X	Karuma Falls XXX	-	C
Oriang	National Park XX	-	-	D
Ayago	National Park XX	-	-	D
Kiba	National Park XX	-	-	D
Murchison	National Park XXX	Murchison Falls XX	X (Fishing)	E

5.2.3.9 Impact on current tourism

Impact on current tourism was evaluated by the types of tourism, tourism facilities, and the number of tourists. The rating of Isimba is “A” because of no existing tourism. The ratings of Kalagala and Murchison are “E” because of active tourism such as rafting and safari.

Table 5.2-32 Impact on current tourism

Project	Interest on tourism	Tourism Facility	Number of the tourists	Rating
Kalagala	Itanda falls, Rafting	Rafting business, Lodge	XXX	E
Isimba	-	-	-	A
Karuma	Karuma Falls		X	B
Oriang	National Park	Safari Tour, Chobe Lodge	X	B
Ayago	National Park	Safari Tour, Chobe Lodge Safari Tour, Chobe Lodge	X	B
Kiba	National Park	Safari Tour, Chobe Lodge	X	B
Murchison	National Park	Safari Tour, Parra Lodge	XXX	E

5.2.3.10 Impact on existing infrastructure

Impact on existing infrastructure was evaluated by the number of the roads within 1 km buffer from the project area. The ratings of Oriang, Ayago, Kiba are “A” because of no existing roads. The rating of Karuma is “D” because of 7 roads can be affected.

Table 5.2-33 Impact on existing road

Projects	Number of affected Road	Rating
Kalagala	3	C
Isimba	4	C
Karuma	7	D
Oriang		A
Ayago		A
Kiba		A
Murchison	1	B

5.2.3.11 Impact on landscape

Impact on landscape was evaluated by the existence of attractive landscape and impact on them. The rating of Isimba is "A" because of no attractive landscape. The ratings of Kalagara and Murchison are "E" because of famous landscape known as Kalagala Falls and Murchison Falls.

Table 5.2-34 Impact on landscape

Evaluation items	Attractive landscape	Impact	Rating
Kalagala	Kalagala Falls	XXX	E
Isimba			A
Karuma	Karuma Falls	XXX	D
Oriang	Natural landscape	XX	C
Ayago	Natural landscape	XX	C
Kiba	Natural landscape	XX	C
Murchison	Murchison Falls, Natural landscape	XXX	E

5.2.3.12 Impact on human health

Impact on human health was evaluated by the size of population within 1 km from the project, the sources of drinking water, and the type of toilet. The ratings of Oriang, Ayago, Kiba, and Murchison are "A" because of better hygienic environment and smaller population. The rating of Karima is "D" because of the higher dependence rate of rain water for drinking.

Table 5.2-35 Impact on health hazard

Evaluation items	People in affected area	Dependence rate of rain water for drinking	Rate of uncovered pit latrine and no toilet	Rating
Kalagala	36,145	1.5%	23.4%	C
Isimba	49,744	1.4%	22.6%	C
Karuma	33,015	3.2%	44.1%	D
Oriang	4,854	0.9%	28.8%	A
Ayago	5,049	0.8%	28.7%	A
Kiba	5,434	0.8%	27.0%	A
Murchison	1,890	1.0%	30.2%	A

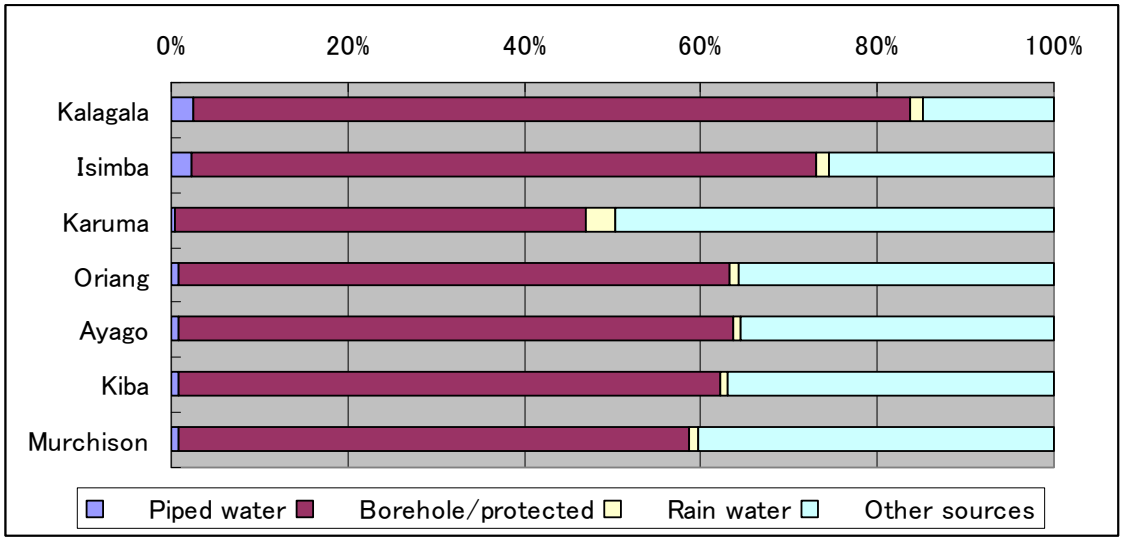


Figure 5.2-4 Sources of Drinking Water

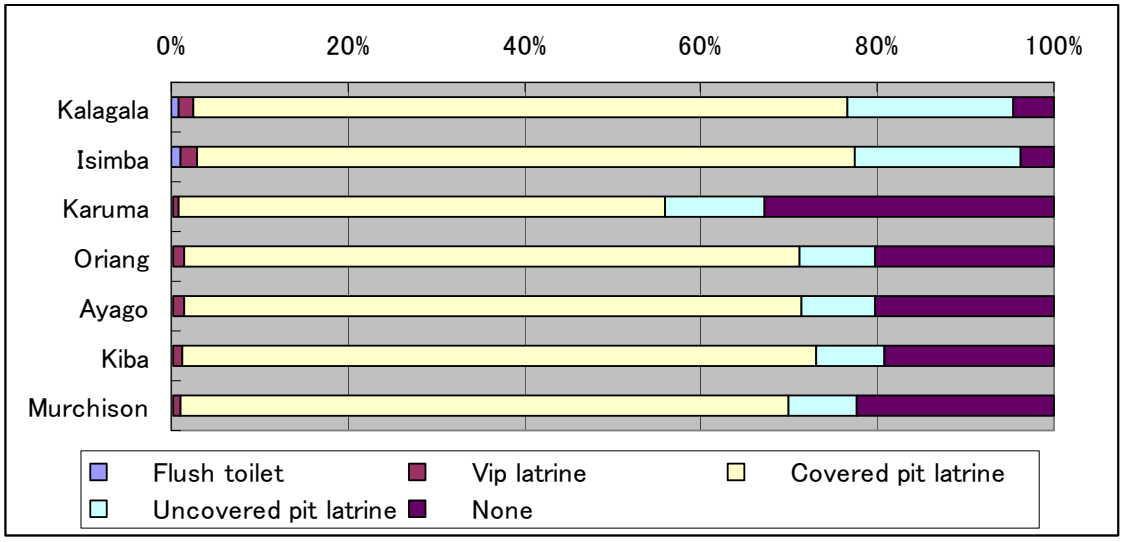


Figure 5.2-5 Type of Toilet

5.2.4 General Evaluation

5.2.4.1 Weighting of the evaluation criteria for the candidate projects

Multi Criteria Decision Analysis was conducted for the comparative evaluation of the candidate projects. The evaluation criteria included economic and technical aspects such as development cost and geological condition, environmental aspects such as length of water recession and impact on protected area, and social aspects such as resettlement and impact on tourism. The total number of criteria was 33. All candidate projects were evaluated from A to E by all criteria. The evaluations from A to E were converted from 5 to 1, multiplied by the weights, and summed up by the projects. For sensitivity analysis, four cases of weightings were applied: even case, environmental weighting case, social weighting case, and economic weighting case. The evaluation items and weightings are shown in the table below.

Table 5.2-36 Evaluation Items and Weighting

Evaluation items			Even Case			Environmental weighting case			Social weighting case			Economic Weighting Case		
Economic and technical	Cost**	Construction Cost (MUSD)	34	9	**2**	30	8	**2**	30	8	**2**	40	11	**3**
		Generation Cost (cent/kWh)			**7**			**6**			**6**			**8**
	Effectiveness*	Maximum Power (MW)		19	**5**		17	**4**		17	**4**		22	**5**
		Construction time (years)			**2**			**2**			**2**			**2**
		Head (m)			**2**			**2**			**2**			**2**
		Distance to load centre or existing grid (km)			**2**			**2**			**2**			**3**
		Length of Waterway			**1**			**1**			**1**			**1**
		Geological Condition			**2**			**1**			**1**			**3**
		Excavation Volume			**1**			**1**			**1**			**1**
		Construction material (availability)			**1**			**1**			**1**			**1**
		Accessibility			**2**			**2**			**2**			**3**
		Loss of transmission			**1**			**1**			**1**			**1**
	Development progress	Lead Time		6	**5**		5	**4**		5	**4**		7	**6**
		Financial Negotiation and close			**1**			**1**			**1**			**1**
Environment	Length of water recession (km)		33		**4**	40		**6**	30		**5**	30		**5**
	Rate of recession (%)				**3**			**4**			**2**			**2**
	Impact on Protected area*				**7**			**8**			**7**			**7**
	Impact on wetland*				**3**			**4**			**2**			**2**
	Impact on protected species*				**7**			**8**			**7**			**7**
	Degradation of underground water				**4**			**4**			**2**			**2**
	CO_2 emission from the reservoir				**5**			**6**			**5**			**5**
Social	Land acquisition		33		**4**	30		**2**	40		**4**	30		**2**
	Flooding area*				**2**			**2**			**4**			**2**
	Number of affected people				**4**			**3**			**4**			**3**
	Impact on ethnic minorities and indigenous people				**1**			**2**			**2**			**2**
	Impact on fish breeding and/or fishing				**1**			**2**			**2**			**2**
	Impact on Agriculture				**1**			**2**			**2**			**2**
	Impact on cultural property				**2**			**2**			**2**			**2**
	Impact on tourism potential				**6**			**5**			**7**			**5**
	Impact on current tourism				**7**			**6**			**5**			**6**
	Impact on existing infrastructure				**1**			**1**			**2**			**1**
	Impact on landscape				**3**			**2**			**4**			**2**
	Human health hazard				**1**			**1**			**2**			**1**

5.2.4.2 General evaluation of the Candidate Projects

As a result of weighting and summing up all items by the projects, the general evaluations showed that Ayago, Isimba, and Karuma have relatively higher score than the other projects.

Table 5.2-37 General Evaluation of Candidate Hydropower Projects

Evaluation items			Kalagala	Isimba	Karuma	Oriang	Ayago	Kiba	Murchison
Economic and technical	Cost**	Construction Cost (MUSD)	5	5	3	3	3	2	4
		Generation Cost (cent/kWh)	5	2	4	3	5	1	4
	Effectiveness*	Maximum Power (MW)	3	1	4	3	5	2	5
		Construction time (years)	5	5	4	4	4	4	5
		Head (m)	1	1	4	3	5	2	5
		Distance to load centre or existing grid (km)	4	2	5	3	2	2	1
		Length of Waterway	5	5	2	2	3	1	4
		Geological Condition	4	4	3	3	3	3	3
		Excavation Volume	4	5	2	3	3	1	4
		Construction material (availability)	5	5	4	4	4	3	5
		Accessibility	5	5	5	4	3	2	4
		Loss of transmission	5	5	5	4	5	4	4
	Development progress	Lead Time	2	2	5	3	4	3	3
		Financial Negotiation and close	1	3	3	3	3	3	1
Environment	Length of water recession (km)		5	5	2	2	3	1	4
	Rate of recession (%)		5	5	2	2	2	2	2
	Impact on Protected area*		3	3	4	2	2	2	1
	Impact on wetland*		5	5	3	5	5	5	5
	Impact on protected species*		5	5	2	2	2	2	1
	Degradation of underground water		5	5	2	2	3	1	5
	CO_2 emission from the reservoir		2	1	5	5	5	5	3
Social	Land acquisition		1	1	5	4	4	4	2
	Flooding area*		2	1	5	5	5	5	3
	Number of affected people		2	1	2	5	5	5	5
	Impact on ethnic minorities and indigenous people		3	3	2	4	4	4	4
	Impact on fish breeding and/or fishing		5	5	4	5	5	5	5
	Impact on Agriculture		3	2	1	5	5	5	5
	Impact on cultural property		1	5	2	5	5	5	3

Evaluation items			Kalagala	Isimba	Karuma	Oriang	Ayago	Kiba	Murchison
	Impact on tourism potential		1	5	3	2	2	2	1
	Impact on current tourism		1	5	4	4	4	4	1
	Impact on existing infrastructure		3	3	2	5	5	5	4
	Impact on landscape		1	5	2	3	3	3	1
	Human health hazard		3	3	2	5	5	5	5
General Evaluation		Even Case	315	343	340	326	365	285	295
			B	A	A	B	A	C	C
		Environmental Weighting Case	335	355	330	326	362	286	302
			B	A	B	B	A	C	C
		Social Weighting Case	307	337	335	336	369	299	296
			C	B	B	B	A	C	C
		Economic Weighting Case	329	340	344	328	367	282	303
			B	B	A	B	A	C	C

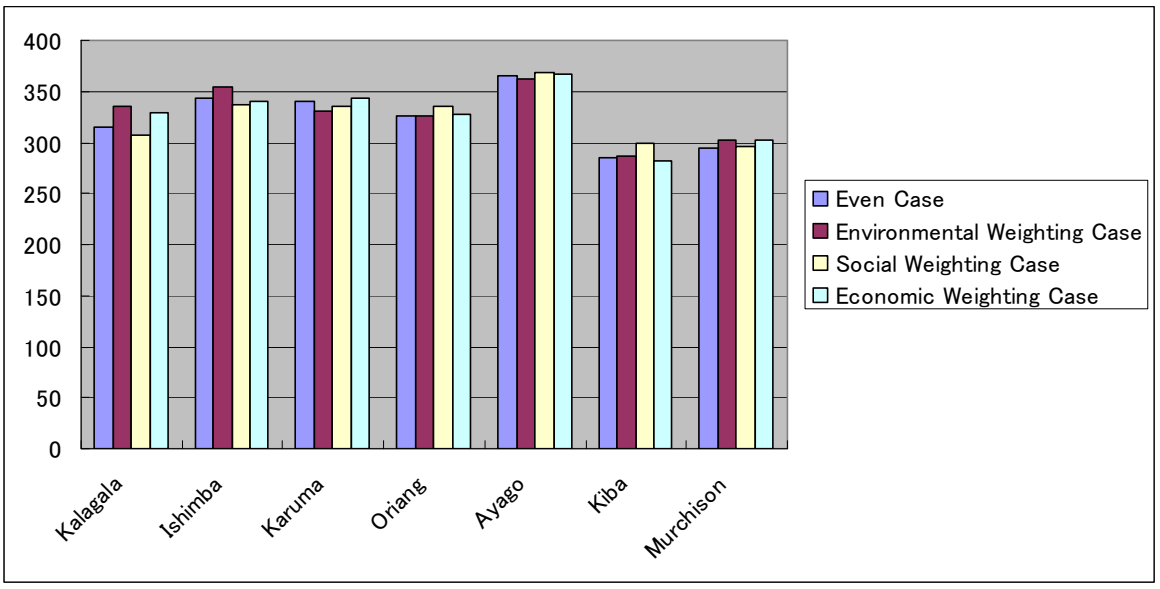
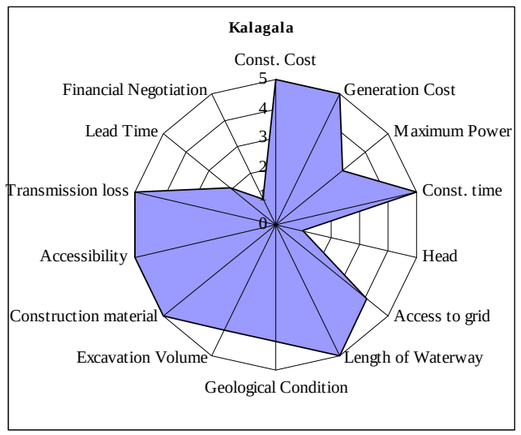
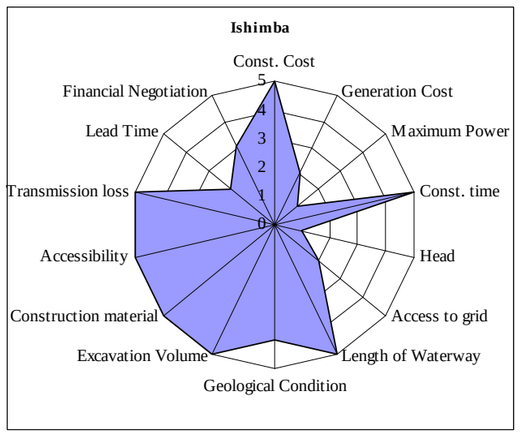
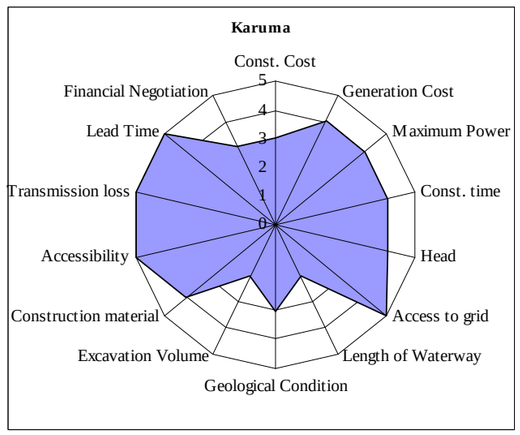


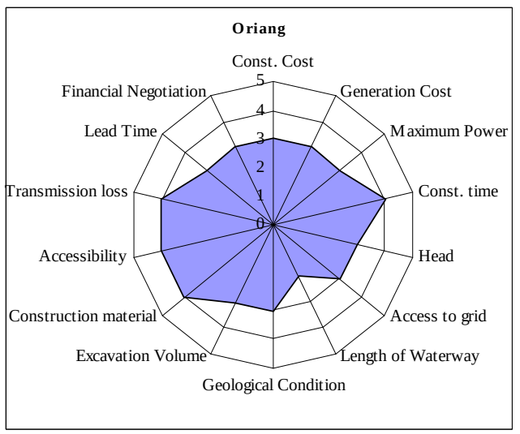
Figure 5.2-6 Evaluation of Each Site

Economic and technical

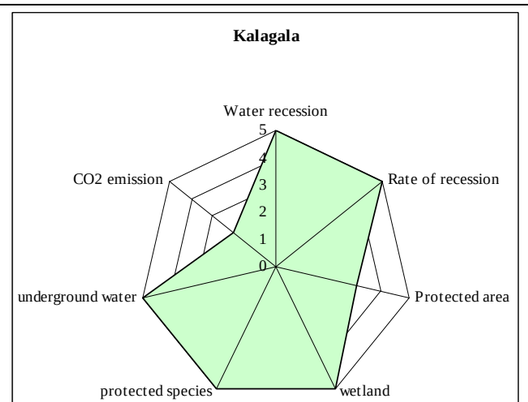


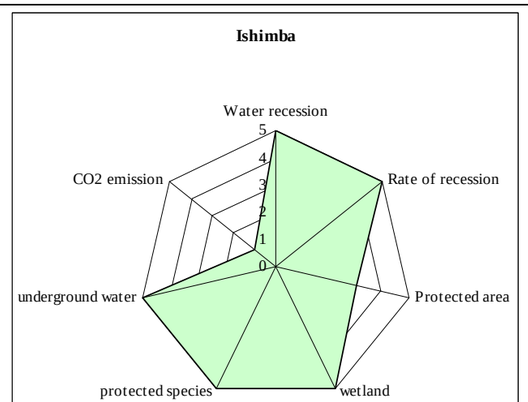


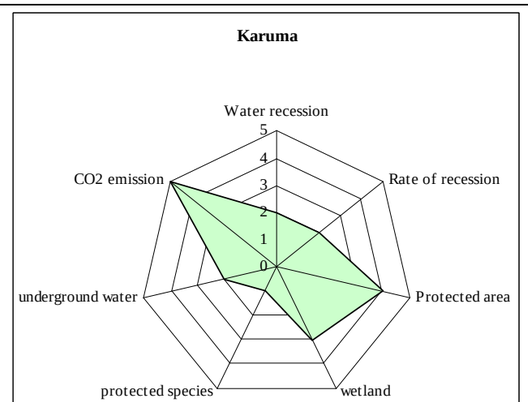


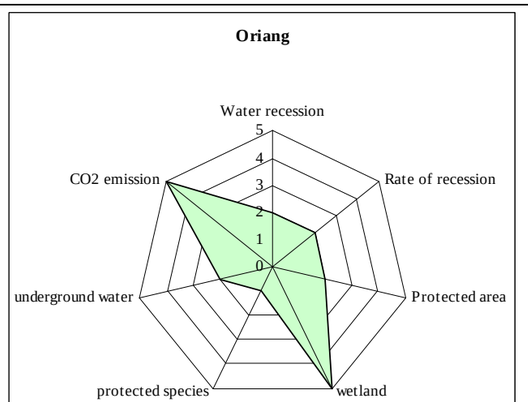


Environmental

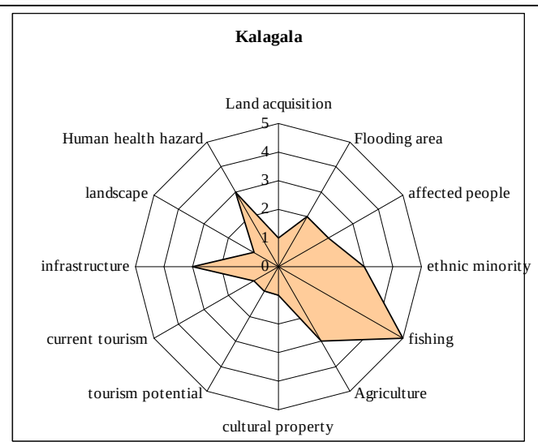


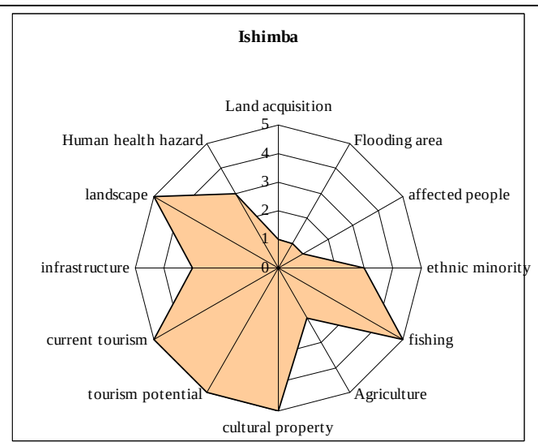


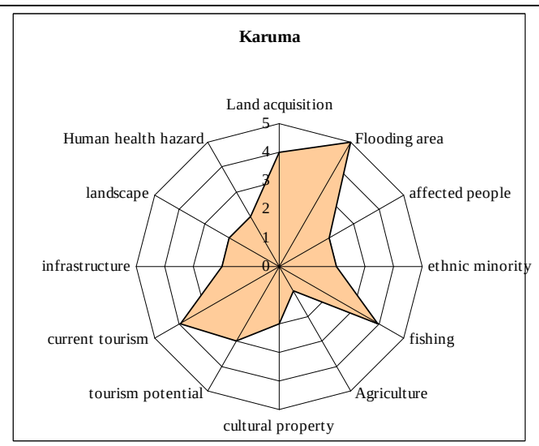




Social







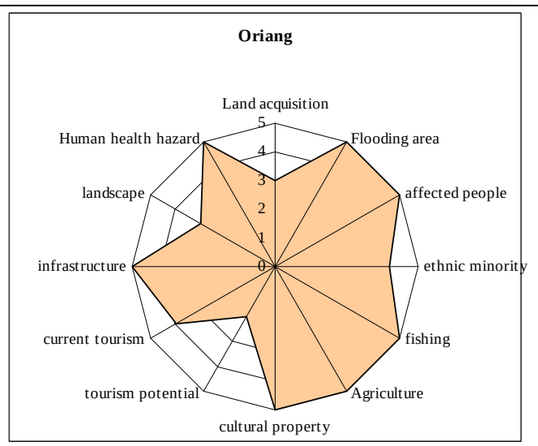


Figure 5.2-7 General Evaluation of Each Site-1

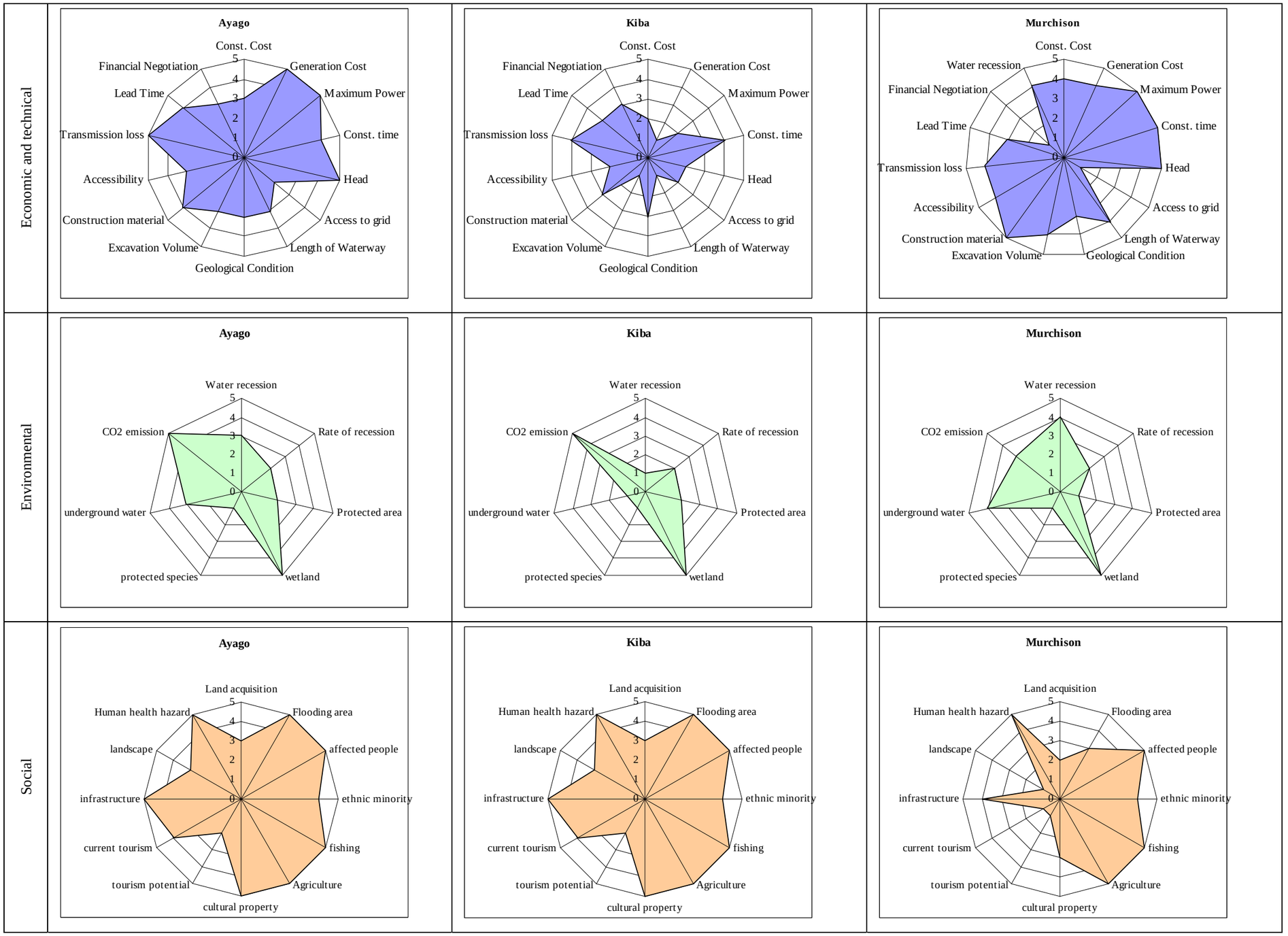


Figure 5.2-8 General Evaluation of Each Site-2

5.3 Stage 3

5.3.1 Technical and Economic aspects

5.3.1.1 Construction cost

Construction costs for three layouts were calculated based on basic specs shown in Table 5.3-1 and Figure 3.3-8 to Figure 3.3-10.

Table 5.3-1 Cost Summary of Layout Alternatives at Ayago Site

Item	Dam and Waterway Type	Run of River Type		Note
		Left Bank Route	Right Bank Route	
1. Preparation and Land acquision	37,451	36,030	41,692	
(1) Access road	13500	13,500	13,500	$100x10^3$US$/km × 135 km
(2) Compensation & Resettlment	5,000	5,000	5,000	
(3) Camp & Facilities	18,951	17,530	23,192	(3. Civil work)× 2%
2. Environmental mitigation cost	47,379	43,825	57,979	(3. Civil work)× 5%
3. Civil work	947,574	876,494	1,159,589	
(1) Weir	77,114	28,613	28,613	
(2) Intake	19,531	19,531	19,531	
(3) Headrace	166,638	21,053	21,053	
(4) Penstock	5,060	5,060	5,060	
(5) Access tunnel	10,226	13,018	11,424	
(6) Powerhouse	77,226	78,520	77,226	
(7) Draft Pond	23,712	23,712	23,712	
(8) Tailrace tunnel	476,480	601,861	862,108	
(9) Outlet	5,444	5,444	5,444	
(10) Miscellaneous	86,143	79,681	105,417	
4. Hydraulic euipment	47,653	38,886	38,886	
5. Electro-mechanical equipment	255200	255,200	255,200	Installed Capacity 610 MW
6. Transmission line	28,000	29,000	25500	Ayago-Karuma
Direct cost	1,363,257	1,279,434	1,578,846	
7. Administration and Engineering servi	204,489	191,915	236,827	Direct cost × 15%
8. Contingency	136,326	127,943	157,885	Direct cost × 10%
Total cost	**1,704,071**	**1,599,293**	**1,973,557**	
Rating	**C**	**A**	**E**	

(Source: Study Team)

5.3.1.2 Disposal Volume of Excavated Muck

Excavated volume of soil and rock material for open and underground construction of the alternatives based on the typical layout drawings. The excavated materials are planned to be utilized for the concrete aggregate for the construction work and renovation of the existing road close to the Project site and then remaining volume of the excavated muck is planned to be disposed. Based on the assumption, disposed volume of the excavated muck was estimated.

Accordingly, the dam & waterway type requires the least amount of the disposal. The waterway type (left bank route) requires second-least amount and the waterway type (right bank route) is followed.

Volume of the excavated muck was estimated considering the overbreak due to excavation work

and increasing of the muck in volume. Required aggregate volume was estimated under the assumption of typical concrete mix proportion and specific weight. Beak down of the estimation is shown in following table.

Table 5.3-2 Disposal Volume of Layout Alternatives

Item	Dam-Waterway Type		Left Bank Route		Right Bank Route		Note
	Excavation (m3)	Concrete (m3)	Excavation (m3)	Concrete (m3)	Excavation (m3)	Concrete (m3)	
1. Dam / Weir	57,000	**80,460 *1)**	10,500	83,400	10,500	83,400	
2. Intake	433,500	25,700	433,500	25,700	433,500	25,700	
3. Headrace	557,400	195,500	80,800	25,600	80,800	25,600	
4. Penstock	26,000	13,100	26,000	13,100	26,000	13,100	
5. Access Tunnel	75,700	5,500	99,100	7,000	85,000	6,100	
6. Powerhouse	272,786	66,600	278,719	68,300	272,786	66,600	
7. Draft Tunnel / Pond	122,400	30,900	122,400	30,900	122,400	30,900	
7. Tailrace Tunnel	2,507,560	550,600	3,578,360	689,400	4,732,420	987,900	
8. Outlet	25,200	7,800	125,800	7,800	125,800	7,800	
Sub Total	4,077,546	976,160	4,755,179	951,200	5,889,206	1,247,100	
(a) Spoiled rock volume (m3)	6,116,319		7,132,769		8,833,809		(a) = Excavation Volume x 1.5
(b) Concrete Aggregate (m3)	864,183		842,086		1,104,043		(b) =Conc. Volume x 2.046/2.6x1.125
(c) Subbase (m3)	150,000		150,000		150,000		(c) =0.3m×5m×100km
(d) Disposal Volume (m3)	**5,102,136**		**6,140,682**		**7,579,766**		(d) = (a)-(b)-(c)
Rating	A		C		E		

(Source: Study Team)

*1) Construction period of the concrete placing for the concrete dam will be overlapped with excavation work of the powerhouse and tunnels. All of concrete aggregate for the dam construction can not be obtained from the excavated muck. It is assumed that 30% of the concrete aggregate for the dam will be supplied by the exacted muck. The disposal volume of the excavated muck was estimated based on the above assumption.

5.3.1.3 Volume of Aggregate Mining from Quarry Site

Since concrete volume of the dam & waterway type is about 270,000m3. Since the volume is relatively big amount and the construction period of the dam will be overlapped with excavation work of the powerhouse and the tunnels, all of the concrete aggregate cannot be obtained from the excavated muck. Therefore, the aggregate should be obtained from quarry site instead of the excavation work.

It is assumed that 30% of the concrete aggregate for the dam will be supplied by the exacted muck and remaining 70% of the aggregate should be supplied from the quarry site.

The aggregate volume is estimated by the equation described in Table 5.3-3, as follows;

$$ConcreteAggregateVolume = 270{,}000 \times 0.7 \times 2.046 \div 2.6 \times 1.125 \approx 170{,}000\,m^3$$

Waterway type will not obtain extra concrete aggregate from the quarry site except slightly volume of aggregate for high quality concrete, since amount of the concrete aggregate is not so large significantly and most of concrete work will be carried out after completion of the excavation work.

Required aggregate volume from quarry site is shown in

Table 5.3-3.

Table 5.3-3 Concrete Aggregate Volume from Quarry Site

Item	Dam-Waterway Type	Left Bank Route	Right Bank Route
Volume of Aggregate from Quarry (m^3)	170,000	negligible	negligible
Rating	**E**	**A**	**A**

(Source: Study Team)

5.3.1.4 Geological condition along the waterway

Rock classification rate along the waterway is estimated based on analysis of aerial photos, topographic maps, site survey, and boring survey. The estimation results are shown in Table 5.3-4.

Table 5.3-4 Rock Classification Rate along the Waterway

Rock Classification	Dam-Waterway Type	Left Bank Route	Right Bank Route
B	42.7	55.9	49.5
CH	30.4	38.6	33.0
CM	17.1	3.3	5.6
CL to D and Portal	9.8	2.1	11.9
Rating	**E**	**A**	**C**

(Source: Study Team)

5.3.1.5 Peak Duration Time

Since waterway type is so-called “run of river type”, peak power regulation cannot be carried out (or slightly). On the other hand, the dam & waterway type has 20miliion m3 of regulating pond and the maximum plant discharge is 840m3/s. Hence 6-hours peak regulation can be carried out as a result of following calculation.

$$\frac{20{,}000{,}000}{840m3/s \times 60\,\text{sec.} \times 60\,\text{min.}} \approx 6.6 hours$$

Table 5.3-5 Peak Power Generation Control

Item	Dam-Waterway Type	Left Bank Route	Right Bank Route
Peak Power Generation Control	Available	Not Available	Not Available
Rating	**A**	**E**	**E**

(Source: Study Team)

5.3.1.6 Construction period

Critical construction works are 1) main access tunnel of the powerhouse, 2) powerhouse excavation work 3) powerhouse concrete work, and 4) installation of generating unit and the critical works are common in all of alternatives. Since principal dimensions of the powerhouse in all alternatives are same, the construction period has no difference in all alternatives.

Required construction period including preparation works is shown in Table 5.3-6.

Table 5.3-6 Required Construction Term

Item	Dam-Waterway Type	Left Bank Route	Right Bank Route
Construction Term (month)	66	66	66
Rating	**A**	**A**	**A**

(Source: Study Team)

5.3.1.7 Uncertainly Conditions for Construction Work (Risk)

Generally, construction of a hydropower project is subject to natural conditions and construction period and cost of the project will be beyond a original plan due to unexpected conditions. These uncertainly construction work will mostly be derived from underground work which has unexpected geological conditions. Major underground works of the Project are powerhouse and tunnel works and the powerhouse works of the alternatives are similar conditions. Hence, construction risk was estimated based on the tunnel length as shown in Table 6.3-7.

Table 5.3-7 Construction Risk

Item	Dam-Waterway Type	Left Bank Route	Right Bank Route
Tunnel Length (m/line)	6,100	7,900	9,900
Rating	**A**	**B**	**C**

(Source: Study Team)

5.3.2 Environmental aspect

5.3.2.1 Evaluation Methods

Evaluation of the impact on flora and vegetation is conducted based on the following five criteria.

Table 5.3-8 Criteria for rating of severity of impacts of flora and vegetation

Negligible Impacts	• No noticeable, or limited local effect upon the environment, rapidly returning to original state by natural action • Unlikely to affect resources to a noticeable degree • No noticeable effects on globally or regionally endangered species • No significant contribution to global air pollution problem • No increase of air/water/noise level legal requirements • No reported nuisance effects
Minor Impacts	• Noticeable effects on the environment, but returning naturally to original state in the medium term • Slight local degradation of resources but not jeopardizing further usage • Slight contribution to a known global environmental problem when compared with the industry worldwide • Disruption/disturbance to normal behaviour of a globally or regionally endangered species returning to normal in the short term • Single increase of air/water/noise level legal requirements • Infrequent localized nuisance
Moderate Impacts	• Noticeable effects on the environment, reversible over the long term • Causing human injury. • Localized degradation of resources restricting potential for further usage • Small contribution to a known global environmental problem when compared with the industry worldwide • Sub-lethal effects upon a globally or regionally endangered species with no effect on reproductive fitness and/or resulting in disruption/disturbance to normal behaviour returning to normal in the medium term • Repeated increase in air/water/noise level legal requirements • Causing localized nuisance both on and off site
Major Impacts	• Highly noticeable effects on the environment, difficult to reverse • Causing single human fatality or multiple injuries. • Widespread degradation of resources restricting potential for further usage • Significant contribution to a known global environmental problem when compared with the industry worldwide • Sub-lethal effects upon a globally or regionally endangered species compromising reproductive fitness and/or resulting in long-term disruption/disturbance to normal behaviour • Continual increase in air/water/noise level legal requirements • Periodic widespread nuisance both on and off site
Catastrophic Impacts	• Highly noticeable, irreparable effect upon the environment • Causing multiple human fatalities • Significant, widespread, and permanent loss of resources • Major contribution to a known global environmental problem with demonstrable effects causing mortality to individuals of a species classified as globally or regionally endangered • Major continual increase in level of air/water/noise legal requirements • Causing widespread nuisance both on and off site

Evaluations of the impact on animal groups other than fish are conducted based on the following four criteria. Evaluation on fish is conducted based on the length of recession area and so on.

Table 5.3-9 Criteria for rating of severity of impacts of animal groups

Negligible Impacts (score of 1)	・ No noticeable, or limited local effect upon the environment, rapidly returning to original state by natural action ・ Unlikely to affect animal home ranges to a noticeable degree ・ No noticeable effects on globally or regionally endangered species ・ No significant impact on grazing grounds ・ No significant interference with movement patterns ・ Disruption of normal behaviour of the protected species in the park (due to movement of humans, machines, etc.)
Minor Impacts (score of 2)	・ Noticeable effects on the animal habitats, but with capacity to recover naturally to original state in the medium term ・ Low level impact on animal habitats but not limiting continued use of area by animals ・ Disruption/disturbance to normal behaviour of a globally or regionally endangered species but with potential to quickly revert to normal in the short term ・ Accidental animal kills from operations in the project area from machinery or vehicles ・ Introduction into the park of materials hazardous to animals
Moderate Impacts (score of 3)	・ Clearance of a major section of animal's range but with possibility of recovery in the long term ・ Clearance of major animal resources (e.g. lekking, preferred foraging and breeding grounds, etc.) but with capacity of recovery in the long term. ・ Introduction of invasive species of plants that could alter the ecology the animals' range and forage areas ・ Increased incidents of poaching due to increased human presence in the Park
Major Impacts (score of 4)	・ Highly noticeable effects on the environment, difficult to reverse ・ Soil compaction in camps sites, construction areas, and roads, leading to increased runoff and flooding of prime foraging, lekking, or other areas ・ Increased human presence in the park significantly affecting the normal behaviour of species of conservation concern. ・ Increased monitoring of illegal activities in the park due to increased presence of human activity within the park ・ Large scale and permanent destruction of preferred habitats for animals ・ Significant reduction in population and home range of species of conservation concern.

5.3.2.2 Impact on flora and vegetation

Impact on flora and vegetation is evaluated during construction, operation, and general. The evaluation result shows Left Bank Option is the minimum impact and Dam option is the maximum impact.

Table 5.3-10 Assessment of significance of impacts on flora and vegetation (without mitigation)

	Dam Option	Left Bank option	Right Bank option
Construction impacts			
Vegetation loss due access road construction, dam construction, etc.	major	minor	moderate
Loss of habitats & sensitive riverine vegetation types	major	minor	moderate
Loss of globally threatened species	major	minor	moderate
Increase in erosion and decreased stabilization of river banks	major	minor	moderate
Proliferation of invasive species	moderate	moderate	moderate
Operation impacts			
Human presence, visual intrusion, and waste	minor	moderate	moderate
Habitat fragmentation	minor	minor	minor
Proliferation of invasive species	moderate	moderate	moderate
Illegal logging	moderate	moderate	moderate
General relative assessment of the dam options/layouts			
Reduction of most important vegetation	high	low	medium
Reduction of important flora	high	low	medium
Impacts of Invasive alien plant species	medium	medium	medium
Illegal logging activities	medium	medium	medium
Overall rating	**C**	**A**	**B**

A: Relatively minimal loss of sensitive habitats, plant communities, and globally threatened species over a given area

B: Relatively modest loss sensitive habitats, plant communities, and globally threatened species over a given area

C: Relatively large loss of sensitive habitats, plant communities, and globally threatened species over a given area

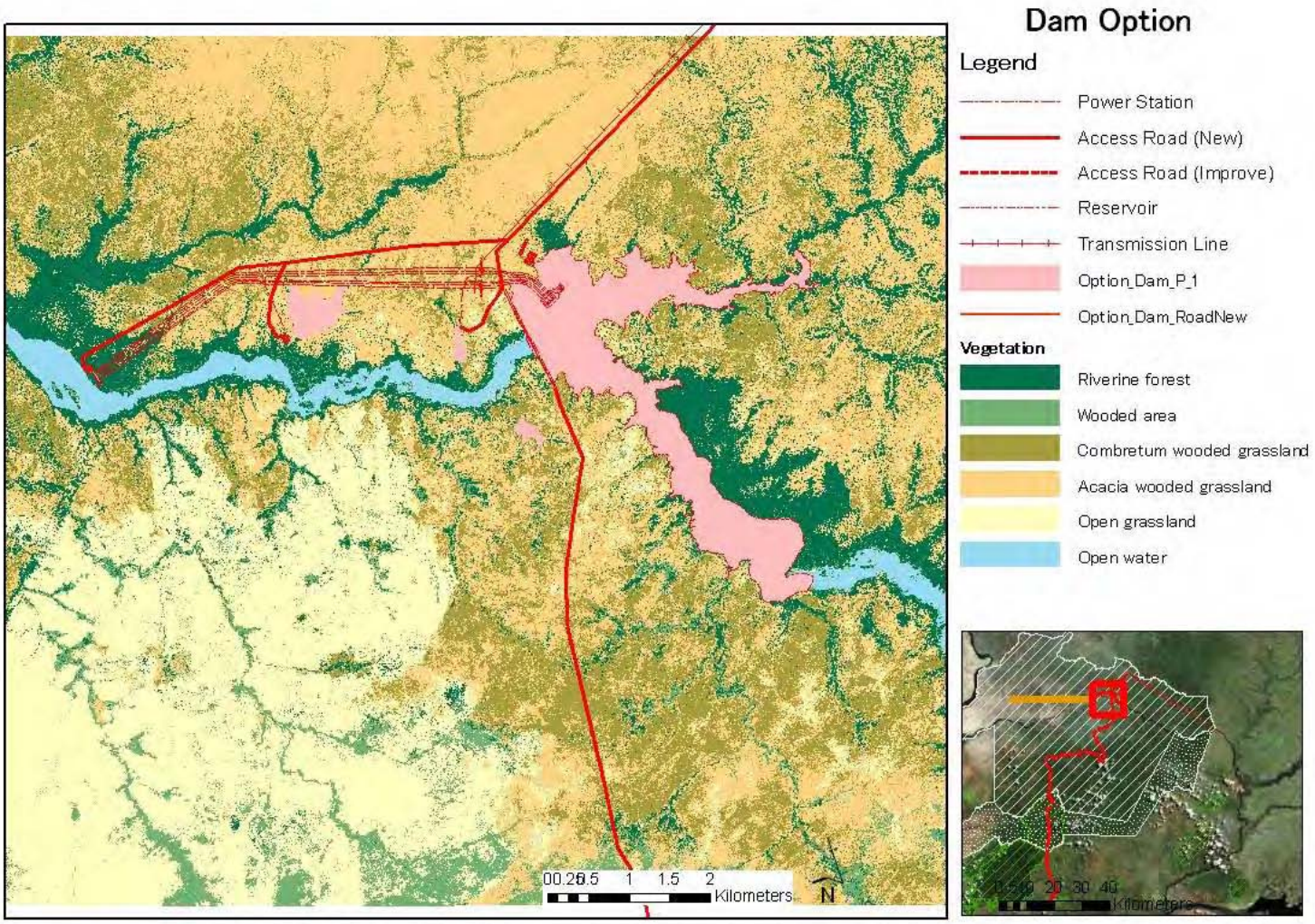
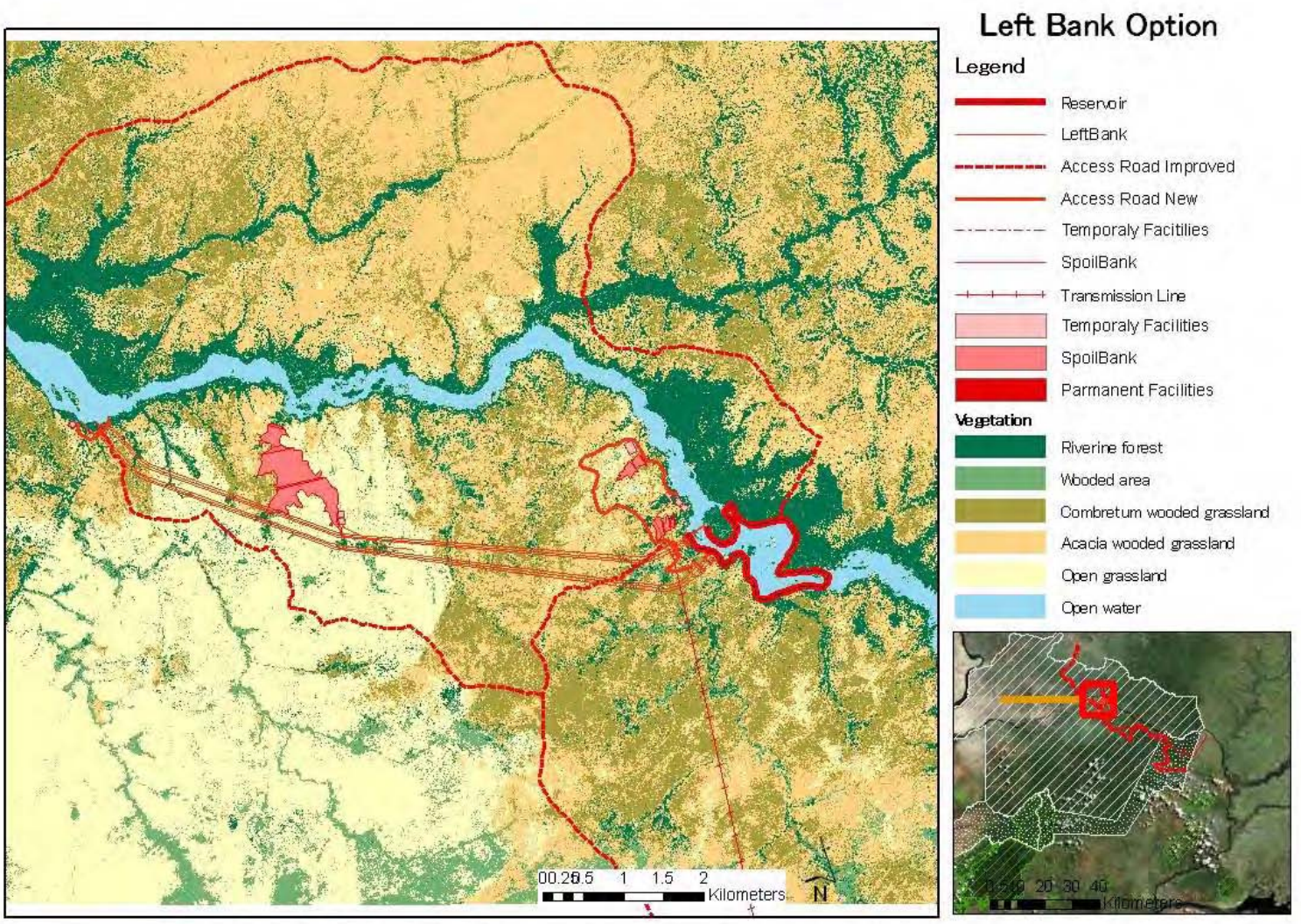


Figure 5.3-1 Dam Waterway Type and Vegetation



Project for Master Plan Study on Hydropower Development in the Republic of Uganda (2010, JICA)

Figure 5.3-2 Left Bank Route and Vegetation

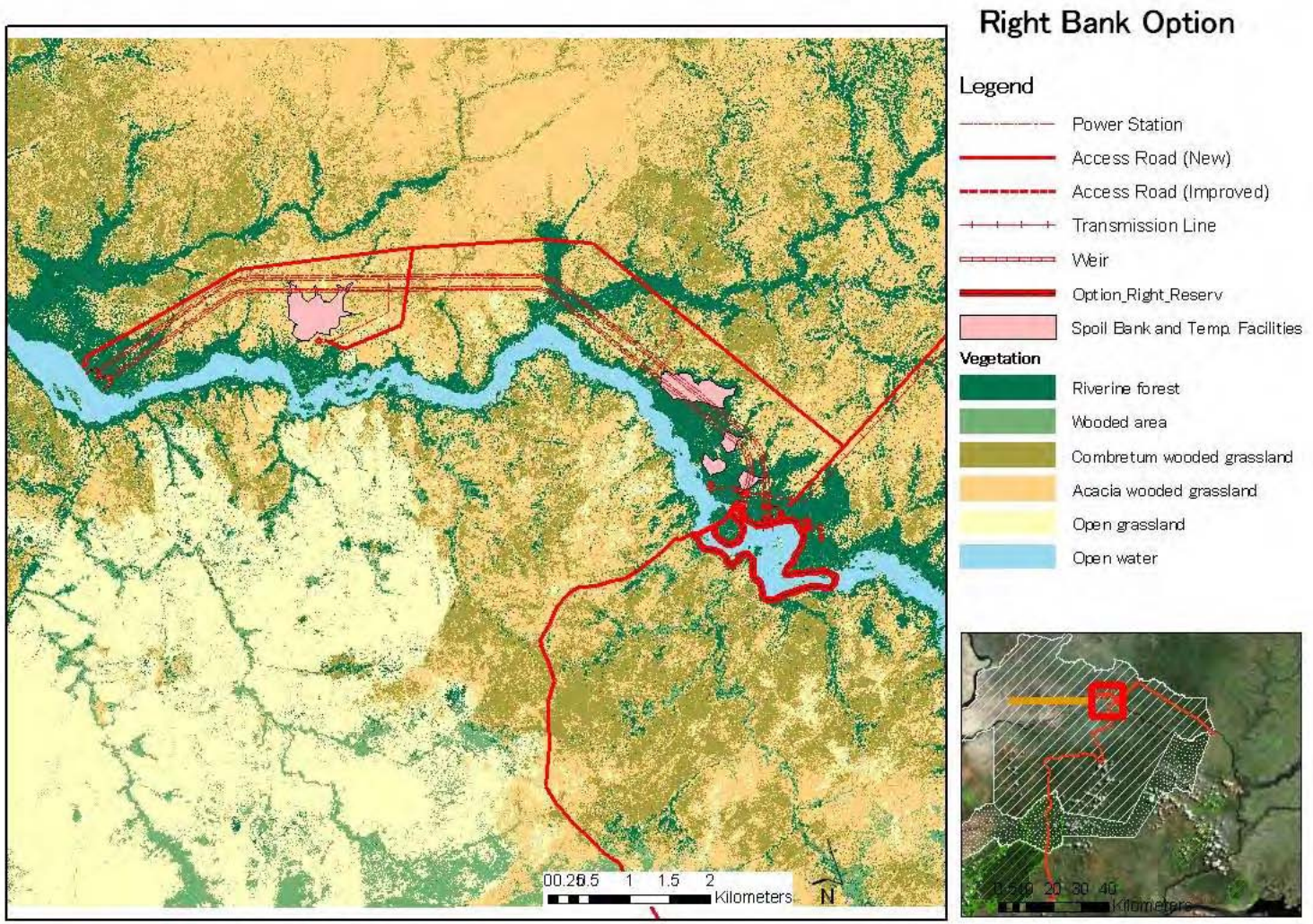


Figure 5.3-3 Right Bank Route and Vegetation

5.3.2.3 Impact on medium sized and large mammals

Impact assessment on medium sized and large mammals is conducted on main possible mammals in the survey area. Relatively bigger impacts are estimated on Black & White Colobus, Leopard, and Hippopotamus.

Table 5.3-11 Potential Species specific Impacts due to the different option

Name			Relative Impact Assessment		
Family	**English name**	**Scientific name**	**Dam Option**	**Left Bank option**	**Right Bank option**
Cercopithecidae	Olive Baboon	*Papio anubis*	1	1	1
	Black & White Colobus	*Colobus guereza*	3	2	3
	Pata's Monkey	*Cercopithecus patas*	1	1	1
	Vervet Monkey	*Cercopithecus aethiops*	1	1	1
	Red-tailed Monkey	*Cercopithecus ascanius*	2	1	2
Felidae	Leopard	*Panthera pardus*	3	2	2
	Lion	*Panthera leo*	1	2	2
Herpestidae	Egyptian Mongoose	*Herpestes ichneumon*	1	1	1
Mustelidae	(African) Spot-necked Otter	*Lutra maculicollis*	2	1	1
Viveridae	East African Civet	*Civettictis civetta*	1	1	1
Hyenidae	Spotted Hyena	*Crocuta crocuta*	1	1	1
Hippopotamidae	Hippopotamus	*Hippopotamus amphibius*	4	3	3
Suidae	Bush Pig	*Potamochoerus porcus*	2	1	2
Suidae	Common Warthog	*Phacochoerus africanus*	2	1	1
Bovidae	African Buffalo	*Syncerus caffer*	2	2	2
	Bushbuck	*Tragelaphus scriptus*	1	1	1
	Sitatunga	*Tragelaphus spekii*	1	1	1
	Common (Bush) Duiker	*Sylvicapra grimmia*	1	1	1
	Hartebeest	*Alcelaphus buselaphus*	1	1	1
	Uganda Kob	*Kobus kob*	1	1	2
	Oribi	*Ourebia ourebia*	1	1	1
	(Defassa) Waterbuck	*Kobus ellipsiprymnus*	1	1	1
Giraffidae	Giraffe	*Giraffa camelopardalis*	1	2	2
Elephantidae	African Elephant	*Loxodonta africana*	2	2	2
Manidae	Giant Pangolin	*Smutsia gigantea*	1	1	1
Hystricidae	Crested Porcupine	*Hystrix cristata*	1	1	1
Scuiridae	Striped Ground Squirrel	*Euxerus erythropus*	1	1	1
Thryonomidae	Savannah (Common) Cane Rat	*Thryonomys swinderianus*	1	1	1
Orycteropodidae	Aardvark (Ant Bear)	*Orycteropus afer*	1	1	1

A: Smaller impact B: Medium impact C: Bigger impact

Impact assessment on whole mammals is conducted during construction and operation. The general evaluation shows that the Left Bank Option is of relatively lower impact than the Dam Option and the Right Bank Option, because of lower population of mammals on the left bank.

Table 5.3-12 Assessment of significance of impacts on medium sized and large mammals (without mitigation)

Item	Dam Option	Left Bank option	Right Bank option
CONSTRUCTION IMPACTS			
Loss of Habitat	4	3	3
Habitat alteration	4	3	3
Reduction of Home range	2	2	2
Reduction extent of feeding ground	2	3 (for Hippos)	3
Disruption of routes	3	3 (for Hippos)	3 (for Hippos)
Reduction of lekking grounds	1	1	3
Destruction of wallows	2	1	3
Introduction of invasive species	2	2	2
Introduction of hazardous materials	3	2	2
Increasing Extinction risk	1	1	1
OPERATION IMPACTS			
Loss of Habitat	4	3	3
Habitat alteration	4	3	3
Reduction of Home range	4	2	3
Reduction extent of feeding ground	3	3	3
Reduction of lekking grounds	1	2	3
Destruction of wallows	1	1	3
Introduction of invasive plant species	2	2	2
Introduction of hazardous materials	2	2	2
Increasing Extinction risk	1	1	1
Total Points	**46**	**40**	**45**
Rating	**C**	**B**	**C**

A: Smaller impact B: Medium impact C: Bigger impact

5.3.2.4 Impact on Birds

Impact assessment is conducted during construction and operation. The general evaluation shows that the Left bank option and the Right bank option are of lower impact than the Dam option, because of smaller impact on forest area.

Table 5.3-13 Assessment of significance of impacts on birds (without mitigation)

Item	Dam option	Left bank option	Right bank option
CONSTRUCTION IMPACTS			
Loss of Habitat	3	2	2
Habitat alteration	3	2	3
Reduction of Home range	2	1	1
Destruction of nesting grounds	3	2	2
Introduction of invasive plant species	2	2	2
Introduction of hazardous materials	2	2	2
Increasing Extinction risk	1	1	1
OPERATION IMPACTS			
Loss of Habitat	3	2	2
Habitat alteration	3	2	2
Reduction of Home range	2	1	1
Introduction of hazardous materials	1	1	1
Increasing Extinction risk	1	1	1
Total Score	**26**	**19**	**20**
Rating	**C**	**B**	**B**

A: Smaller impact B: Medium impact C: Bigger impact

5.3.2.5 Amphibians and reptiles

Impact on amphibians and reptiles during construction and operation is evaluated. The general evaluation shows that the Left bank option and the Right bank option are of lower impact than the Dam option, because of smaller impact on riparian forest, which is the most important habitat for amphibians and reptiles.

Table 5.3-14 Assessment of significance of impacts on amphibians and reptiles (without mitigation)

Item	Dam option	Left bank option	Right bank option
CONSTRUCTION IMPACTS			
Loss of Habitat	1	1	1
Habitat alteration	3 (for crocodiles)	2 (for crocodiles)	2 (for crocodiles)
Reduction of Home range	1	1	1
Destruction of breeding grounds	3	1	1
Introduction of invasive plants and microbe species	3 (for amphibians)	3 (for amphibians)	3 (for amphibians)
Introduction of hazardous materials	1	1	1
Increasing local Extinction risk	2	2	2
OPERATION IMPACTS			
Loss of Habitat	1	1	1
Habitat alteration	3 (for crocodiles)	2 (for crocodiles)	2 (for crocodiles)
Reduction of Home range	1	1	1
Reduction extent of breeding ground	3	1	1
Introduction of invasive plants and microbe species	3 (for amphibians)	3 (for amphibians)	3 (for amphibians)
Increasing local Extinction risk	2	2	2
Total	**27**	**21**	**21**
Rating	**C**	**B**	**B**

A: Smaller impact B: Middle impact C: Bigger impact

5.3.2.6 Impact on butterflies

Impacts on butterflies are assessed during construction and operation. The general evaluation shows that the Left bank option and the Right bank option are of lower impact than the dam option, because of smaller impact on forest, which is the most preferable habitat for butterflies.

Table 5.3-15 Assessment of significance of impacts on butterflies (without mitigation)

Items	Dam option	South bank option	North bank option
CONSTRUCTION IMPACTS			
Loss of Habitat	3	2	3
Habitat alteration	3	2	3
Reduction of Home range	2	1	2
Reduction extent of foraging ground	2	1	1
Introduction of invasive species	2	2	2
Increasing Extinction risk	1	1	1
OPERATION IMPACTS			
Loss of Habitat	3	2	2
Habitat alteration	3	2	2
Reduction of Home range	2	1	1
Reduction extent of foraging ground	2	2	2
Introduction of invasive species	1	2	2
Increasing Extinction risk	1	1	1
Total Score	**25**	**19**	**22**
Rating	**C**	**B**	**B**

A: Smaller impact B: Medium impact C: Bigger impact

5.3.2.7 Impact on fishes

Impacts on fishes are evaluated based on length of recession, impact on big basin, height of the barrier, and so on. Evaluation results show that the Left bank option and the Right bank option are of relatively lower impact than the Dam option, because of the lower height of the barrier and the smaller inundation area.

Table 5.3-16 Assessment of significance of impacts on fishes (without mitigation)

Options	Dam option	Left bank option	Right bank option
Length of recession	B 6.6 km	C 9.7 km	C 10.0 km
Impact on big basin	C Big basin will be seriously affected.	B Medium size basin will be affected.	C Big basin will be affected a bit.
Height of the barrier	C 45 m	B 15 m	B 15 m
Inundation area and facility area	C 470 ha	B 140 ha	B 142 ha
Impact on rare fish fauna	C Big impact on Ayago River	B Middle impact on small tributaries	B Middle impact on small tributaries
Rating	**C**	**B**	**B**

A: Smaller impact B: Medium impact C: Bigger impact

5.3.3 Social aspect

5.3.3.1 Land acquisition

Land acquisition was evaluated by area necessary for the transmission towers and ROW for transmission line. For spoil bank, temporary facilities, and inundation, land acquisition is not necessary. The rating of the Left bank option is "C," since the option requires acquisition of more land than the other options due to the transmission line which passes through the residential area.

Table 5.3-17 Assessment on land acquisition

Items	Dam	Left	Right
Area for transmission towers (m^2)	800	3300	800
Area for ROW for transmission lines (ha)	11	49	11
Area for spoil bank (m^2)	0	0	0
Area for temporary facilities (m^2)	0	0	0
Area for inundation (m^2)	0	0	0
Rating	B	C	B

5.3.3.2 Flooding area

Flooding area was evaluated by the size of the riverbed area and reservoir area. The rating of the Dam option is "C," since it requires a bigger riverbed area.

Table 5.3-18 Assessment on Flooding Area

Items	Dam	Left	Right
Riverbed area (ha)	417.9	0.1	0.1
Reservoir area (ha)	419.0	419.0	419.0
Rating	C	B	B

5.3.3.3 Number of Resettlements/ Affected People

Impact on local people was evaluated by the possibility of resettlement, the estimated population within 200 m of the transmission lines, and 500 m from the existing and newly constructed roads. Since the project is located in the National Park, there are no residents to be resettled. However, there may be some impacts outside the Park, such as relocation of houses, buildings, livestock, and crops along the transmission line and the roads. Traffic accidents are other possible impacts along the existing and new roads.

The rating for the Left bank option is C, since there is a slight possibility of resettlement along the transition lines and roads which pass through the residential area. Also, the number of affected people within 200 m of a transmission line is larger for the Left bank option than the other options.

Table 5.3-19 Assessment on Number of Affected People

Items	Dam	Left	Right
Possibility of resettlement along transmission lines and roads	None	23	None
Number of affected people within 200 m from transmission line	134	497	134
Number of people within 500 m from the existing and new roads	4040	1431	4040
Rating	B	C	B

5.3.3.4 Impact on Agriculture

Impact on agriculture was evaluated by the size of agricultural area within a 1 km buffer from the project area, 100 m from the transmission line, and 100 m from the existing and new roads. The rating for the Right bank option is "C," since it affects bigger agricultural lands.

Table 5.3-20 Impact Assessment on Agriculture

Items	Dam	Left	Right
Agricultural area within 1 km buffer from the project area (ha)	81,089	41,453	81,089
Agricultural area within 100 m from transmission line (ha)	37	7,651	37
Agricultural area within 100 m from the existing and new roads (ha)	293	10,619	8,771
Total agricultural area affected (ha)	81,419	59,723	89,897
Rating	B	A	C

5.3.3.5 Impact on Historical and Cultural Properties

Impact on historical and cultural properties was evaluated by the level of disturbance to cultural/historical and archaeological sites within the project area and along the newly constructed roads. The rating of dam option is "C," since the level of disturbance is much higher due to a bigger riverbed area.

Table 5.3-21 Impact Assessment on Historical and Cultural Properties

Items	Dam	Left	Right
Disturbance to cultural/ historical and archaeological sites within project area	XXX	XX	X
Disturbance to cultural/ historical archaeological sites along newly constructed roads	XX	XX	X
Rating	C	B	A

5.3.3.6 Impact on Poaching Activities

Impact on poaching activities in the National Park was evaluated by the possibility of increase in illegal hunting, illegal fishing, and encroachment for cultivation as a result of the newly constructed or improved roads. The rating for the Left bank option is "C," since the locations of planned roads are near the sites where a lot of poaching activities have been recorded.

Table 5.3-22 Impact Assessment on Poaching Activities in Murchison Falls Protected Area

Items	Dam	Left	Right
Increase in hunting wildlife	XX	XXX	XX
Increase in illegal fishing	X	XX	X
Increase in case of encroachment for cultivation	X	XX	X
Rating	B	C	B

5.3.3.7 Impact on Tourism

Impact on tourism in the National Park was evaluated by the level of disturbance to potential tourism activities such as sports fishing, white water rafting, walking safari, and game drive in the project area and by newly constructed and improved roads. The rating for the Dam option is "C," since it affects most potential tourism activities.

Table 5.3-23 Impact Assessment on Tourism

Items	Dam	Left	Right
Disturbance to potential sports fishing area	XX	X	XX
Disturbance to potential white water rafting area	XXX	X	X
Disturbance to potential walking safari area	XX	XX	X
Disturbance to existing and future game drive roads by newly constructed and improved roads	XX	XX	XX
Rating	C	B	B

5.3.4 General Evaluation

5.3.4.1 Weighting of the evaluation criteria for the proposed layouts

Multi Criteria Decision Analysis was conducted for the comparative evaluation of the proposed layouts. The evaluation criteria included economic and technical aspects such as construction cost and disposal volume, environmental aspects such as mammals and birds, and social aspects such as historical/cultural property and poaching activities. The total number of criteria was 19. All proposed layouts were evaluated from A to E or A to C for all criteria. The evaluations from A to E were converted from 5 to 1 (evaluations from A to C were converted from 3 to 1), multiplied by the

weighs, and summed up by the projects. For sensitivity analysis, four cases of weightings were applied: even case, environmental weighting case, social weighting case, and economic weighting case. The evaluation items and weightings are shown in the table below.

Table 5.3-24 Evaluation Items and Weighting

		Even Case		Environment weighting case		Economic Weighting Case	
Economic and technical	Construction Cost	36	5	29	4	43	6
	Disposal Volume		5		4		6
	Concrete Aggregate Volume		5		4		6
	Rock Classification Rate		6		5		6
	Peak Power Generation Control		5		4		7
	Construction Term		5		4		6
	Construction Risk		5		4		6
Environmental	Flora and Vegetation	33	7	40	8	26	6
	Mammals		8		9		7
	amphibians and reptiles		6		8		5
	butterflies		6		7		4
	Fishes		6		8		4
Social	Land acquisition	31	5	31	5	31	5
	Flooding area		5		5		5
	Number of resettlements/ affected people		4		4		4
	Impact on agriculture		4		4		4
	Impact on historical/cultural property		5		5		5
	Impact on poaching activities		3		3		3
	Impact on tourism		5		5		5

5.3.4.2 General evaluation of the proposed layouts

As a result of weighting and summing up all items by the projects, the general evaluations showed that the Left Bank Option has a higher score than the other layouts.

Table 5.3-25 General Evaluation of proposed layouts

			Weight (even)	Dam Option	Left Bank Option	Right Bank Option
Economic and technical	Construction Cost		5	2	3	1
	Disposal Volume		5	3	2	1
	Concrete Aggregate Volume		5	1	3	3
	Rock Classification Rate		6	1	3	2
	Peak Power Generation Control		5	3	1	1
	Construction Term		5	3	3	3
	Construction Risk		5	3	3	2
Environmental	Flora and Vegetation		7	1	3	2
	Mammals		8	1	2	1
	amphibians and reptiles		6	1	2	2
	butterflies		6	1	2	2
	Fishes		6	1	2	2
Social	Land acquisition		5	2	1	2
	Flooding area		5	1	2	2
	Number of resettlements/ affected people		4	2	1	2
	Impact on agriculture		4	2	3	1
	Impact on historical/cultural property		5	1	2	3
	Impact on poaching activities		3	2	1	2
	Impact on tourism		5	1	2	2
General Evaluation	Even Case	161		218		188
	Environment weighting case	152		215		188
	Economic Weighting Case	172		218		187

6 Mitigation measures

6.1 On site mitigation

It is a bit difficult to identify exact mitigation measures during the SEA stage, because exact impacts are not identified. In this stage just following possible mitigations might be suggested.

- Rehabilitation plan of the vegetation
- Speed limits should be instituted to ensure that road kills never happen or that the risk of their occurrence is reduced
- Night driving should strictly be disallowed to allow animals to continue with their normal activity and also to reduce the risk of road kills.

- Any hazardous materials introduced in the park must be properly managed and also removed on completion of their usefulness to the implementation of the project.
- Support UWA's park management
  - Biological survey (including periodical aerial survey)
  - Biodiversity action plan
  - Control invasive plant and animals
  - Biodiversity awareness program for community
  - Biodiversity awareness program for rangers
  - Pouching, illegal logging control
- Establishment Biological fund for monitoring
- Secure animal migration route (avoidance, minimize, compensate)

6.2 Off site mitigation

Even if the selected layout causes minimum impact, impact on vegetation and flora in the national park will remain. Then not only onsite mitigation but also offsite mitigation will be needed to compensate for the impact. Possible off site mitigations would be

- Offset plan in Karuma Wildlife Reserve: Without depriving the right of community use of the reserve, ecologically upgrading program might be effective.
- Restoration program of rock quarry site (Amuru, Masindi)
- Establishment biological survey institute especially for ecological survey in MFNP

7 Suggestion

7.1 Survey during EIA and after

Environmental continuous survey will be needed for EIA, before construction, during construction, and during operation. This monitoring information will identify not only the impact but also natural tendency of the wildlife. The following are the suggestions for fauna survey provided by the biologists who conducted the SEA site survey.

7.1.1 Mammals

- Niche breadth, distribution of suitable habitats types, and correlation analyses of these will need to be done using historical data on species occurrence to enable a better understanding of actual and potential distribution of mammal species in MFNP.
- In order to identify the real home range, number of herds, migration routes, and preferred areas for different species, telemetry survey for more than four years might be needed for some important species.
- Aerial surveys at least twice a year for two years would contribute to a better estimate of animal populations, distribution, and trends

- Ground truth surveys will be needed particularly in the areas of denser woodlands where aerial counts may not be adequate for observing presence of mammals. This will be particularly useful in the heavily wooded areas.

7.1.2 Birds

For purposes of guiding the EIA study it will be useful to conduct niche breadth assessments as well as assessments for occurrence of suitable habitats for:-

i. species of conservation concern,

ii. species of restricted range,

iii. top predators

iv. species with particular habitat requirements

7.1.3 Reptiles

Attention should be placed on the survey of the Nile Crocodile, since there seems to be no readily available data as observed in Hutton (1991).

- Its home range, breeding ground, feeding grounds, resting areas, and its daily activities need to be studied.
- The recognized survey techniques for crocodiles, including spotlight and day Boat Surveys, Foot Surveys, Aerial Surveys, and Nest Surveys as explained by Aust (2009) and Shacks (2006) should be employed.
    - Note that 3-4 aerial surveys would provide some indicator as to the status and distribution of the Nile Crocodile in the shortest time possible; while Boat Surveys and Foot Surveys could be rather cumbersome and expensive because of the nature of the terrain along which the Nile River flows, along with the danger posed by the rapids and the hippopotamus.
    - Sites where there should be established further intensive sampling for amphibian species using pitfall traps in addition to VES, and for future monitoring.

7.2 Scoping for EIA

Impact scoping is conducted briefly as follows. Waste, Noise and vibration, Biota and ecosystems, Accidents, Local conflicts, and Infectious diseases are selected as relatively bigger impacts. These impacts should be considered in EIA survey.

Table 7.2-1 Scoping table for EIA

Items	Impact	Task in EIA		
		Survey	Impact Assessment	Mitigation
Air pollution	C: Exhaust gas by trucks	-	Need	Need
Water pollution	C: Turbid water during construction	Need	Need	Need
Soil pollution	C: Small risk of contamination by oil	-	-	Need
Waste	A: Rock disposal	Need	Need	Need
Noise and vibrations	A: Noise from blasting, construction machines, and trucks	Need	Need	Need
Ground subsidence	-	-	-	-
Offensive odours	C: Small risk from garbage	-	-	Need
Geographical features	-	-	-	-
Bottom sediment	-	-	-	-
Biota and ecosystems	A: Habitat loss, human disturbance,	Need	Need	Need
Water usage	B: During construction and operation	Need	Need	Need
Accidents	A: Car accident, Blasting, etc.	Need	Need	Need
Global warming	-	-	-	-
Involuntary resettlement	C: It might happen near transmission line	Need	Need	Need
Local economies, such as employment, livelihood, etc.	A (Positive): The project provides job opportunities.	Need	Need	Need
Land use and utilization of local resources	C: Private land or farm land might be acquired for transmission line.	Need	Need	Need
Social institutions such as social infrastructure and local decision-making institutions	-	-	-	-
Existing social infrastructures and services	C: Community usage of MFNP might be affected.	Need	Need	Need
Poor, indigenous, or ethnic people	C: They might affected by land acquisition.	Need	Need	Need
Misdistribution of benefits and damages	B: Benefits for all Ugandans and damage for the neighbours	-	-	-
Local conflicts of interest	A: Conflicts with hunting and tourism	Need	Need	Need
Limitation of accessibility to information, meetings, etc. for a specific person or group	B: Their mother language is not English and some of them are illiterate.	-	-	Need
Gender	C: Information disclosure	-	-	Need

Items	Impact	Task in EIA		
		Survey	Impact Assessment	Mitigation
	should be considered.			
Children's rights	-	-	-	-
Cultural heritage	B: Some cultural assets might be found in the project site.	Need	Need	Need
Infectious diseases such as HIV/AIDS	A: Infection diseases might be spread by workers.	-	-	Need
Other (Local spirits)	B: Spirit sites might be affected.	Need	Need	Need

A: Bigger impact B: Medium impact C: Smaller impact

7.3 Permission

In addition to EIA certificate, many permits are needed before construction.

Table 7.3-1 Needed permits before construction

Permits	Legal Basis	Issuing Authority
Certificate of Approval of EIA	National Environment Act CAP 153	NEMA
License to dredge the Nile River	Rivers Act	Ministry of Water and Environment
Construction permit	Water Act CAP 152	Directorate of Water Resources Development
Surface Water Abstraction Permit	Water Act CAP 152	Directorate of Water Resources Development
Wetlands, River Banks use permit	National Environment (Wetlands, River Banks and Lakeshores Management) Regulations	NEMA
Pollution licenses including waste storage, transportation, and disposal	National Environment (Waste Management) Regulations, 1999	NEMA
Permit to enter or reside in a Wildlife Reserve, OR authority to carry out an otherwise illegal activity	Wildlife Act CAP 200	UWA
Waivers on limits on use of lakes and rivers	National Environment Act CAP 153	NEMA
EIA for approval of storage and dispensing facilities	Petroleum Supply Act, 2003 Petroleum Supply (General) Regulations of 2009	NEMA Commissioner of Petroleum Supply
Construction permit of storage and dispensing facilities	Petroleum Supply Act, 2003 Petroleum Supply (General) Regulations of 2009	Commissioner of Petroleum Supply
Operating license of storage and dispensing facilities	Petroleum Supply Act, 2003 Petroleum Supply (General) Regulations of 2009	Commissioner of Petroleum Supply

Appendix D

Annex

Annex 1: Baseline Survey Report <Flora and Vegetation>
Annex 2: Baseline Survey Report <Territorial Fauna>
Annex 3: Baseline Survey Report <Fish>
Annex 4: Baseline Survey Report <Land Use>
Annex 5: Baseline Survey Report < Population, Ethnic Groups, and Settlement Patterns>
Annex 6: Baseline Survey Report <Housing and Infrastructure>
Annex 7: Baseline Survey Report < Education and Health>
Annex 8: Baseline Survey Report <Local Economy>
Annex 9: Baseline Survey Report <Tourism>
Annex 10: Baseline Survey Report <MFNP and Community>
Annex 11: Baseline Survey Report <Cultural and Historical Property>
Annex 12: Baseline Survey Report <Archaeology>
Annex 13: Project Brief and Approval by NEMA

Annex 1: Baseline Survey Report <Vegetation>

1 Introduction

With financial assistance from the Government of Japan through Japan International Cooperation Agency (JICA), the Government of Uganda is carrying out a Hydropower Development Master Plan study for Uganda.

The objective of this Study is to prepare a Hydropower Development Master Plan that is in line with the long term power and transmission development plan. It is covering the prioritisation of potential hydropower sites considering technical, environmental, economical and financial aspects as well as preparation of preliminary designs and Capacity Building.

The study aims at thorough investigation and prioritization of potential hydropower sites in Uganda and preparation of the Hydropower Development Master Plan that shall articulate development plans of selected hydropower projects for the period of 15 years within the framework of power sector development plan.

The outcome of this study is a Hydropower Development Master Plan and Preliminary Design of the first Priority Project.

JICA aims at environmentally- sound- planning through SEA. SEA is a kind of impact assessment tool adopted during project planning stage before Environmental Impact Assessment (EIA). SEA looks at environmental consequences and policy plans or programmes and alternatives to ensure they are addressed early. Basic principles of SEA include treating economic, environmental and social issues equally, comparing alternatives, disclosing information and consulting with local people. In order to minimize environmental impact and to accomplish sustainable development, SEA is indispensable.

This report is a contribution to the process of the preparation of the SEA for the Ayago hydropower project.

1.1 Vegetation assessment

1.1.1 Introduction

This report gathers the results of an extensive literature review and field trips aimed at the survey of the flora and vegetation within the Ayago river basin, in particular to identify sensitive communities and habitats. Furthermore, some botanic description of the area within the zones of interest (i.e. the basic survey area of 1621 km^2 and the detailed survey area of 191 km^2) on unpublished data and on my own experience and knowledge.

At the same time, it should be stated that published materials concerning the Ayago area are in general scanty or not available. Consequently, special field studies have been conducted to obtain

more detailed information to fill existing gaps and to provide basic materials for proper SEA of the Ayago river from the botanical point of view.

The Ayago river basin includes different botanic-geographic regions with a great diversity of flora and vegetation due to geological, geomorphological, climate and soil conditions.

Within the Ayago river basin project impact zone, a great number of communities and species of different conservation value (threatened – CR, EN & VU; rare and endemic) as well as economic plants (for a number of application: medicinal, aromatic, wild fruits, timber, fuel wood, etc) are represented.

Along with endangered and sensitive habitats, with different conservation values, special attention is given to forested area.

1.1.2 General overview of history of vegetation change of MFNP

According to UWA (2001), the vegetation of MFNP has been greatly altered by fire and elephants. About four decades ago elephants destroyed woodlands and created passages enabling fire to penetrate and cause damage. However due to the political instability in the 1970's and 1980's that led to poaching, the elephant numbers were greatly reduced by about 90%. This enabled the recovery of the woody vegetation in the southern and eastern sections of the park. Wildfires are still common in the park and have a profound effect on the vegetation of the park with varying degrees of severity. Forested areas tend to be more affected than wooded grassland areas. Today, early burning is practiced as a management regime in the park, , to break-up fire fronts that could cause more damage late in the dry season. It also reduces the fuel load for hot-dry season burns and leads to the 'green flush' of new growth suitable for ungulates like the Uganda Kob.

Smart et al. (1985) reported that following the poaching of large herbivores during the 1978 civil war and the concomitant vegetation changes, the vegetation of MFNP has regenerated with *Acacia sieberiana* dominating most of the wooded grasslands. They further report that the removal of grazing and browsing pressure resulted into the marked tree regeneration in both grassland and woodland areas and the development of a more diverse all-aged stands in most woodlands. Lock (1977), Spence & Angus (1971) and, Beuchner & Dawkins (1961) argue that the combined effects of fire and elephants on the vegetation of MFNP resulted into the replacement of *Terminalia glausescens* woodlands by *Lonchocarpus laxiflorus* grasslands. It also resulted into the replacement of *Cynometrea alexandrii* with possibly *Holoptelea grandis* in forests including Rabongo.

1.2 Methods used

1.2.1 Field sampling

The vegetation survey followed a standard experimental design according to Braun-Blanquet's system (1965). The approach is by recording field observation by releve. A releve is a list of

species observed in a plot together with estimate of their abundance/dominance or cover. A 20-m radius releves circular plot representing various vegetation types (deduced from previous vegetation maps of the park by Langdale-Brown et al. 1964 and Jackel et al. 1997) in the detailed study area were established to collect data on plant community composition. The transect length ranged from 800 m to 3km running north –south and the plots had a spacing of 100m along the transect. This helped to capture as many micro habitats as possible. In each plot, species were recorded with their estimated abundances. The locations of the plots were recorded using a Global Positioning System (GPS) and these were very useful in generating the vegetation map. Additional information including species' names, and canopy height were recorded. When collecting field data, photographs of the releves were taken for reference. Because of the insufficient quantitative vegetation survey and without prior knowledge of the vegetation types in that area, the sampling and mapping is created broadly through GIS. A total of 90 plots in five transects were surveyed in the detailed study area. Initial plant species identification was done using identification guides including Hamilton (1981) and Polhill et al. (1952). Voucher specimens of species that could not readily be identified in the field were collected and subsequently identified at the Makerere University Herbarium.

1.2.2 Vegetation classification, abundance and sociability value

There are many ways that can be used to classify vegetation. Some are based on vegetation physiognomy, vegetation structure or environmental factors. In this study a floristic approach by Braun-Blanquet (1965) is used for vegetation classification, abundance and sociability value (Table 1).

Table 1 Abundance class and sociability value

Abundance class	
Class	**Range of cover or abundance (%)**
5	75 – 100% cover of total area regardless of number of individuals
4	50 – 75% cover of total area regardless of the number of individuals
3	25 – 50% cover of total area regardless of number of individuals
2	5 – 25% cover of the total area but usually with less than 5% cover
1	Covering < 5% of total plots but are either abundant with very low cover or less abundant but more cover
†	Few individuals, occurring sparsely and covering < 5% of total plots
Sociability class	
Value	**Meaning**
5	Growing in large crowd (≥ 76%)
4	Growing in small colonies or carpets (51 - 75%)
3	Forming small patches or cushions (26 - 50%)
2	Forming small clumps
1	Growing singly (solitary)

The abundance class of the vegetation was classified into six classes. Every class has been fixed to a percentage of cover estimation. The estimation of cover abundance has been evaluated regardless of the number of individuals in a species. Sociability or gregariousness is an expression of the horizontal pattern of species. It measures the value of clustering or contagion of the species and 1 represents an individual of a species growing singly or solitary and 5 represents a species growing in a huge numbers or extensive mats covering almost the whole plot. The Braun-Blanquet method has also been used to find constancy. Constancy refers to how many plots a species occurs in. This term is used in the Braun-Blanquet method to refer to how 'constant' a species is within a set of samples. It is equivalent to frequency.

1.2.3 Generation of Vegetation map

The vegetation map was created through supervised image classification using the maximum likelihood classifier. The used satellite image is a worldview-2 data taken in February 2010. It is 0.41-meter resolution (resampled up to 0.5-meter).

- First world view satellite images of 2.5cm resolution were imported into Remote Sensing and Geographical Information Systems software called Tntmips.
- The images were overlain onto imported shape files of Uganda such as roads, rivers to check for georeferencing consistencies.
- Then a pin map was created from a table that contained field vegetation information from Ayago. The vegetation information was collected during the field work that was conducted on the North and Southern bank in Ayago from 30th July to 2nd August 2010.
- Training sites representing different vegetation types were digitised around each of the points on the pinmap. Other training sites were digitized in those areas that appeared to have unique vegetation characteristics based upon visual interpretation of the image. These areas were difficult to reach during field work.
- The training sites map was then used to generate a raster vegetation map through supervised classification and the maximum likelihood classifier.
- The raster vegetation map was then filtered from 2.5cm resolution to 0.5m to remove all the vegetation categories that were covering less than 24.5m2. The final vegetation map contained five classes Riverine woodland, Acacia wooded grassland, Combretum wooded grassland, wooded area, Open grassland in a previously burnt area, and open water.

1.2.4 Surveyors

Name	Position	Organization
Paul Ssegawa	Plant ecologist/botanist	WSS/MUK
Ben Kirunda	Assistant	MUK

1.2.5 Survey date and time

Date	Time	Area	Surveyors
29th July – 2nd August 2010	9 am– 5pm	Detailed and large area	Paul Ssegawa Ben Kirunda

1.2.6 Survey area and routs

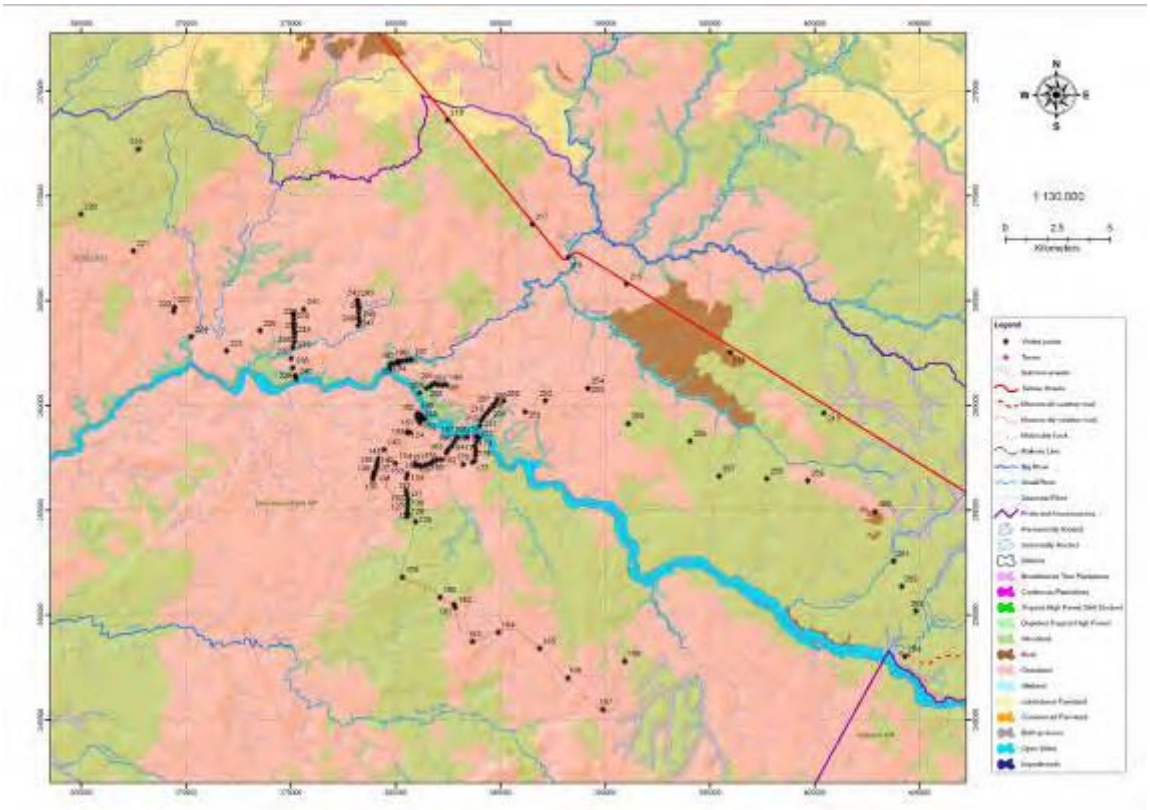


Figure 1 Survey area and survey routs (GPS log) (WGS_1984_UTM_Zone_36N)

2 Results and discussion

2.1 Floristics

The detailed study area of the Ayago river basin was found to be floristically rich. A total of 244 vascular plant species belonging to 54 families and 168 genera were recorded. Of these trees constituted 29.9% of the total species recorded whereas forbs and graminoids contributed 39.3% and 12.3% respectively (See Appendix 1). The riverine vegetation areas had a relatively higher observed species richness compared to the wooded grasslands. The commonest species included; *Platystoma africana, Brachiaria decumbens,* and *Combretum collinum* recorded in at least 42 of the 90 plots surveyed whereas the rare species recorded include; *Phyllanthus odontadenius, Polygala albida* and *Pseudarthria hookeri.*

2.2 Plant vegetation types and conservation significance

2.2.1 Vegetation types in the Detail Survey Area

2.2.1.1 Riverine vegetation

The riverine vegetation was found along the water course of the Ayago river and other streams in the study area. The dominant tree species in this vegetation included *Allophyllus africanus, Vepris nobilis, Albizia coriaria, Kigelia africana, Ficus sur, Trichilia rubescens, Ficus dicranostyla, Ficus sycomorus, Acacia abyssinica and Psydrax parviflora. Khaya anthotheca*, a redlisted tree species is occasional in this vegetation type. The common lianas include *Cissus oliveri, Secamone Africana, Clerodendrum silvanum, Clerodendrum formicarum, Monanthotaxis buchananii, Uvaria angolensis, Rhaphiostylis beninensis, Adenia bequartii, Adenia cissampeloides and Keetia pursegloveai.* The ground vegetation is dominated by *Cyathula prostrata, Asystasia gangetica, Achyranthes aspera, Setaria sphacelata, Kyllinga sp., Justicia matamensis, Desmodium dregeanum, Hydrocotyle mannii, Cyathula prostrata* and *Triumfetta rhomboidea* (Figures 1 & 3). The riverine vegetation is the most diverse vegetation type with two redlisted species occurring in this type of vegetation (i.e. *Khaya anthotheca* and *Milicia excelsa*). This vegetation is also critical in the stabilization of the river banks and prevention of soil erosion. They also provide habitats for various faunal species including warthogs. The northern bank, however, has a higher number of individuals of the threatened species compared to the southern bank.

Figure 2: Typical riverine forest vegetation of the Ayago river

2.2.1.2 Combretum dominated grassland

This vegetation is widespread both in the northern and southern banks of the Ayago river. The dominated species in this vegetation type include the *Vepris nobilis, Clausena anistata, Combretum collinum, Acacia sieberiana* and *Kigelia Africana* (Figure 2*).* The ground vegetation is dominated by *Cyperus cyperoides, Phyllanthus amarus, Brachiaria decumbens, Sporobolus pyramidalis* and *Oplismenus hirtellus*. This vegetation is very important to ungulates as a habitat and source of food. There are no globally threatened species recorded in this habitat.

Figure 3: Combretum dominated wooded grassland

2.2.1.3 Acacia dominated wooded grassland

This is more widespread in the northern bank than the southern bank. The dominant woody species include Acacia sieberiana, Kigelia africana, Aphania senegalensis, Psydrax parviflora, Daniellia oliveri, Morinda lucida, Margaritaria discoidea, Ficus ovata, Bridelia micrantha and scattered Euphorbia candelabrum. The ground vegetation is dominated by Brachiaria decumbens, Sporobolus pyramidalis, Acalypha villicaulis, Hibiscus cannabis and Hyperthelia dissoluta. This habitat type is also important to ungulates as a habitat and source of food.

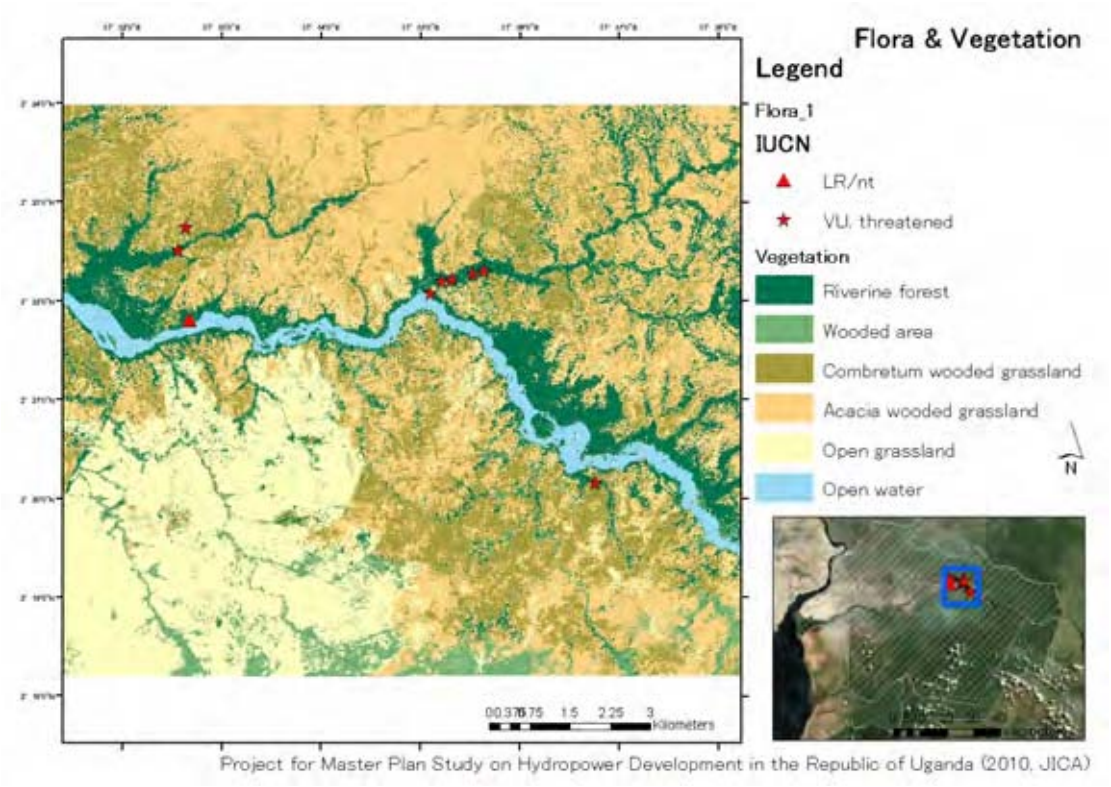


Figure 4: Map showing the various vegetation types in the detailed study area

2.2.1.4 Piliostigma-Acacia wooded grassland

This is more common in the northern bank than the southern bank. It is dominated by *Acacia sieberiana* and *Piliostigma thonningi* (Figure 4). Other common species include *Terminalia glaucescens, Combretum collinum* and *Stereospermum kunthianum.* The ground vegetation is dominated by *Brachiaria brizantha, Sporobolus pyramidalis* and *Loudetia arundinacea* as the commoner grasses. In this vegetation you may find the water buck, buffalo and occasionally elephant.

Figure 5: Piliostigma-Acacia-Grewia dominated grassland

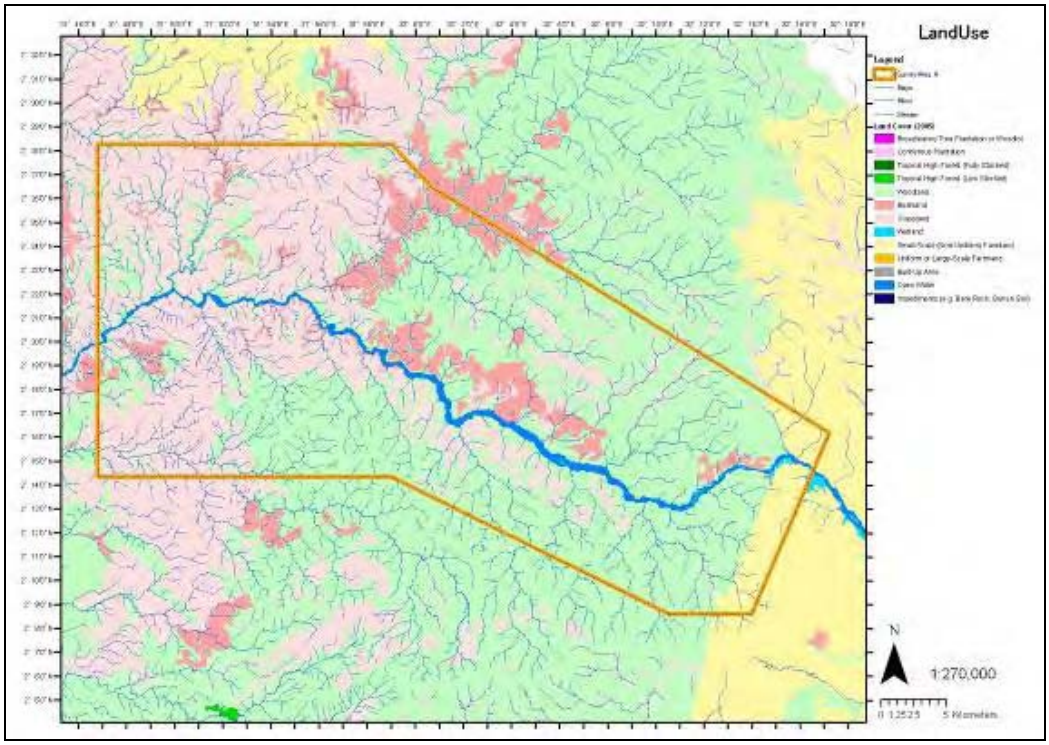
2.2.2 Vegetation types in the Sparse survey area

Observations were made to identify key vegetation types and plant communities that occur in the larger area outside core area. The Table 2 below shows some of the key vegetation types observed in different localities and Figure 5 shows the vegetation types.

Table 2 Plant community types in the larger project area

Eastings	Northings	General Description of vegetation
380351	252328	*Combretum collinum* & *Piliostigma* dominated. Associated with Brachiaria and Hyparrhenia
380257	251801	*Terminalia glauscecens* and *Combretum collinum* woodland
382126	250826	*Combretum collinum* and *Bridelia scleroneura* dominated woodland, associated *with Lonchocarpus laxiflora, Imperata cylindrica* and *Brachiaria decumbens*
386877	248391	Woodland dominated by *Combretum collinum* and *Terminalia glausescens.* Canopy cover about 80%
389905	245478	*Bridelia sclereneura* and *Combretum, Grewia mollis* wooded grassland. Associated with *Hyparrhenia, Panicum maximum* and *Aframomum*
390943	247790	Wooded grassland dominated by *Albizia grandebracteata* and *Terminalia glausescens*
400444	259640	*Combretum collinum* & *Piliostigma thonningii* dominated valleys. Associated with *Acacia polyacantha, Setaria spacelata* and *Panicum maximum*. Canopy cover 70%
395977	262525	*Combretum collinum, Terminalia glausescens* and *Piliostigma thoningii* dominated woodland. Associated with Aframomum and Hyparrhenia. Canopy cover 65%
391015	265786	*Combretum molle, Grewia mollis* and *Piliostigma* dominated wooded grassland.

Eastings	Northings	General Description of vegetation
		Associated with Terminalia and Albizia gradebracteata
386523	268635	*Combretum molle* and *Ficus sycomorus* dominated wooded grassland. Associated with Piliostigma and Pseudocedrella
382471	273616	Wooded grassland dominated by Ficus sp and *Combretum molle*. Associated with Hyparrhenia, and Brachiaria
367726	272234	Grassland of *Hyparrhenia, Brachiaria* and *Imperata cylindrica*. Associated with *Ficus sycomorus* and scattered *Kigelia africana*
364980	269120	Grassland of Hyparrhenia and Imperata. Associated with *Ficus sycomorus*
367478	267370	Wooded grassland dominated by *Loudetia arundinacae* and Brachiaria. Associated with *Ficus sycomorus* and *Pseudocedrella*
369411	264478	*Combretum collinum* and *Lonchocarpus* dominated wooded grassland associated with Brachiaria
370245	263276	Riverine forest (Kibaa river). Khaya and Acacia sp dominated
373530	263562	Combretum and Piliostigma dominated wooded grassland
386189	259691	*Combretum molle* dominated wooded grassland
387141	260221	Woodland dominated by Combretum and Piliostigma. Associated with Acacia and Terminalia
389182	260806	Combretum dominated woodland
391108	259124	*Combretum* and *Terminalia glausescens* dominated woodland. Associated with Piliostigma
395446	256624	Combretum and Piliostigma dominated wooded grassland
397714	256494	Combretum and Terminalia wooded grassland. Associated with *Albizia grandebracteata* and *Acacia sieberiana*
399669	256410	Grassland of Protea, Hymenocardia and Vitex doniana, rocky
402618	255491	Wooded grassland dominated by *Vitex doniana*, *Acacia sieberiana* and *Lonchocarpus*. Associated with *Loudetia arundinacea* grass
404805	250197	Wooded grassland dominated by *Acacia sieberiana*. Associated with *Brachiaria decumbens* and *Urena lobata*



Source: NFA

Figure 6 Vegetation types in the larger project area

According to Figure 5, there are four distinct vegetation types in the larger project area. These include:

2.2.2.1 Small scale (subsistence) farmland

This is largely dominated by gardens of Simsim, Tomatoes, Cassava and millet. The gardens are interspersed with scattered trees and fallow land dominated by *Albizia zygia, Leonotis nepetifolia, Bidens pilosa, Chloris gayana, Imperata cylindrica, Acacia hockii, Panicum maximum, Albizia zygia, Markhamia lutea, Vernonia amygalina, Acacia polyacantha, Combretum molle* and *Terminalia glausescens.*

Figure 7 Crop of beans and cassava with scattered trees of mainly *Albizia zygia* and *Acacia sieberiana*

2.2.2.2 Grassland

These are largely dominated by grasses including Hyparrhenia rufa, Hyparrhenia fillipendula, Panicum maximum and Brachiarua decumbens. Scattered trees and shrubs of Combretum molle, Acacia sieberiana, Terminalia glausescens, Ficus sycomorus and scattered Kigelia africana.

Figure 8 Panicum-Hyparrhenia dominated grassland with scattered trees and shrubs of Acacia, Combretum and Terminalia

2.2.2.3 Bushland

The bushes and thickets are largely dominated by Baleria maderaspatensis, Achyranthes aspera, Rhus natalensis, Stereospermum kunthianum, Capparis erythrocarpos, Trimeria grandifolia, Solenostemon platostomoides, Hoslundia opposita, Setaria sphacaelata and Sporobolus spp. Within this area, there are scattered patches of varying communities. Other common woody species include;- Acacia sieberiana and Albizia coriaria, Trichilia preuriana and Kigelia africana.

2.2.2.4 Woodland

These area sites with a larger percent cover under woody vegetation. The dominant tree and shrub species include Combretum molle, Terminalia glausescens, Albizia grandebracteata, Acacia sieberiana, Hymenocardia and Vitex doniana, Lonchocarpus laxiflorus. These are associated with the grasses Loudetia arundinacea, Brachiaria decumbens and Panicm maximum and Hyparrhenia filipendula and Hyparrhenia rufa.

2.2.2.5 Wetland

These are largely found in the river valleys following river courses and streams. Common species include Alchornea cordifolia, Panicum maximum, Acacia polyacantha, Setaria sphacelata,

Pennisetum purperium, Ficus sycomorus, Alchornea cordifolia, and Acacia hockii. Other species recorded within the rivers and streams include Eichhornia crassipes (Water hyancith), Phragmites mauritianum, Aeschynomene sp., Aspilia africana, Hibiscus diversifolius, Cyperus papyrus, Cyperus sphacelata, and Pycreus mundtii.

2.3 Species, habitats and vegetation types of conservation importance

Among the species recorded as redlisted include *Milicia excelsa* and *Khaya anthotheca* (Figure 6). The latter is a globally threatened species according to IUCN (2007). Both species are sources of high quality timber. The GPS locations where these species were recorded are given in Table 2 below. Therefore in terms of dam construction, the southern bank option will have less negative impact in terms of conservation value, plant species loss and habitats

According to Kalema (2005), other globally threatened species that occur in MFNP include Afzelia Africana, Vitellaria paradoxa, Entandrophragma cylindricum, Hallea stipulosa, Khaya grandifolia, Pouteria altissima, and Dalbergia melanoxylon. Other nationally restricted range species (i.e. occurring in one floristic region only according to the Polhill et al. 1952) that occur in MFNP include Chasmopodium caudatum, Tephrosia subtriflora, Maytenus putterlickioides, Panicum phragmitoides, Chloris lamproparia, Ficus cordata ssp salicifolia, Hymenodictyon parviflorum ssp. Scabrum var. scabrum, Digitaria gayana, and Crotalaria leprieurii.

Table 3 Location of the redlisted species

River bank	Eastings	Northings	Family	Species	IUCN category	Habit	Vegetation type
Southern bank	382807	258260	Meliaceae	Khaya anthotheca	VU, threatened	T	Riverine forest
Northern bank	379730	261772					Riverine forest
Northern bank	379940	262004					Riverine forest
Northern bank	380147	262038					Riverine forest
Northern bank	380526	262146					Riverine forest
Northern bank	380744	262191					Riverine forest
Northern bank	375163	263010					wooded grassland
Northern bank	375033	262593					Riverine forest
Northern bank	375247	261271	Moraceae	Milicia excelsa	LR/nt	T	wooded grassland

The riverine vegetation of the northern bank is more species-diverse compared to the southern bank. It also has a higher number of the IUCN redlisted species individuals compared to the southern bank. However, this vegetation is not unique to MFNP. It also extends towards the Queen Elizabeth National Park ecosystem in Ishasha Sector. Therefore biodiversity action plans should be developed to protect the riverine forest vegetation types because of their relatively higher sensitivity to disturbance, presence of globally threatened species, higher species richness, role in stabilization of river banks and control of erosion as well as, unique habitats. However, it should be noted that more sampling effort on either side of the bank is likely to yield more species. Figure 6 below shows the locations of the redlisted species on the detailed project area map.

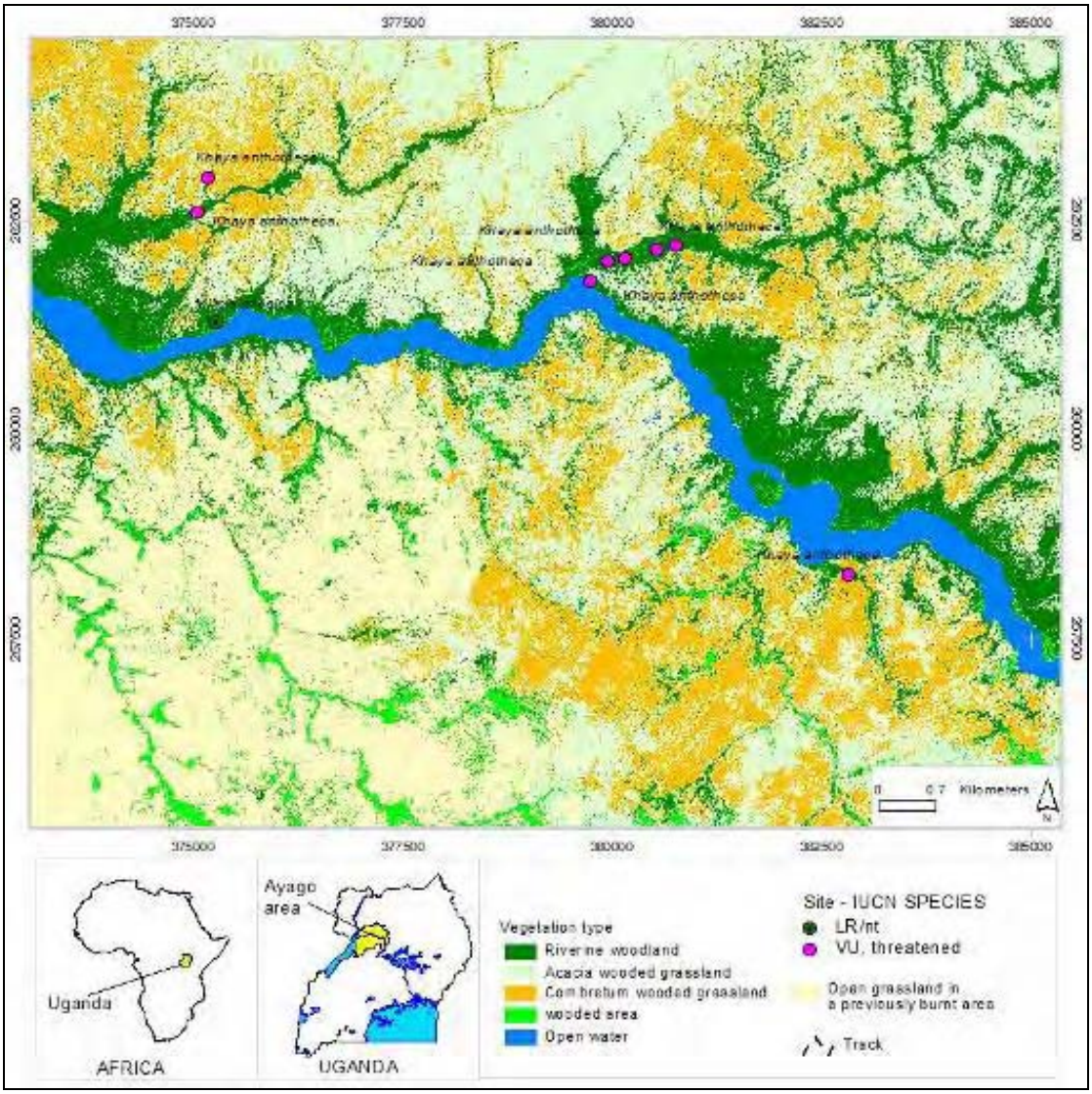


Figure 9 IUCN redlist species locations in the detailed project area

2.4 Economically useful plants

The list in Table 4 gives species that are economically useful according to Katende et al. (1995) and Katende et al. (1999). These are found in various habitat types within the project area.

Table 4 Economically useful plants that occur in the project area

Family	Species	Habit	Purpose
Asteraceae	*Vernonia cinerea*	H	Medicinal
Apiaceae	*Centella asiatica*	H	Medicinal
Fabaceae	*Indigofera arrecta*	H	Medicinal
Fabaceae	*Senna occidentalis*	H	Medicinal
Zingiberaceae	*Aframomum verrucosum*	H	Medicinal
Amaranthaceae	*Achyranthes aspera*	H	Medicinal
Asteraceae	*Acmella caulorrhiza*	H	Medicinal
Commelinaceae	*Commelina diffusa*	H	Medicinal
Solancaeae	*Solanum incanum*	H	Edible
Fabaceae	*Indigofera spicata*	H	Medicinal

Family	Species	Habit	Purpose
Capparaceae	*Capparis erythrocarpos*	S	Medicinal
Lamiaceae	*Hoslundia opposita*	S	Medicinal
Apocynaceae	*Carissa edulis*	S	Medicinal
Rutaceae	*Clausena anistata*	S	Medicinal
Asteraceae	*Vernonia amydalina*	S	Medicinal
Oleaceae	*Jasminum eminii*	S	Medicinal
Acanthaceae	*Mimulopsis bagshawei*	S	Medicinal
Fabaceae	*Pseudarthria hookeri*	S	Medicinal
Combretaceae	*Combretum collinum*	T	Charcoal & Fuel wood
Fabaceae	*Acacia sieberiana*	T	Charcoal & Fuel wood
Fabaceae	*Acacia hockii*	T	Charcoal & Fuel wood
Euphorbiaceae	*Margaritaria discoidea*	T	Charcoal & Fuel wood
Bignoniaceae	*Markhamia lutea*	T	Poles
Combretaceae	*Combretum molle*	T	Charcoal & Fuel wood
Bignoniaceae	*Kigelia africana*	T	Charcoal & Fuel wood
Fabaceae	*Albizia coriaria*	T	Charcoal & Fuel wood
Euphorbiaceae	*Bridelia scleroneura*	T	Charcoal & Fuel wood
Simaroubaceae	*Harrisonia abyssinica*	T	Charcoal & Fuel wood
Rubiaceae	*Vangueria apiculata*	T	Edible
Fabaceae	*Albizia grandibracteata*	T	Timber
Fabaceae	*Tamarindus indica*	T	Edible
Meliaceae	*Trichilia rubescens*	T	Charcoal & Fuel wood
Fabaceae	*Acacia polyacantha*	T	Charcoal & Fuel wood
Fabaceae	*Albizia glaberrima*	T	Charcoal & Fuel wood
Moraceae	*Antiaris toxicaria*	T	Charcoal & Fuel wood
Euphorbiaceae	*Bridelia micrantha*	T	Charcoal & Fuel wood
Meliaceae	*Khaya anthotheca*	T	Timber
Fabaceae	*Lonchocarpus laxiflora*	T	Charcoal & Fuel wood
Celastaceae	*Maytenus senegalensis*	T	Charcoal & Fuel wood
Moraceae	*Milicia excelsa*	T	Timber
Fabaceae	*Piliostigma thonningii*	T	Charcoal & Fuel wood
Fabaceae	*Senna sp.*	T	Charcoal & Fuel wood
Bignoniaceae	*Stereospermum kunthianum*	T	Charcoal & Fuel wood
Euphorbiaceae	*Suregada procera*	T	Charcoal & Fuel wood
Lamiaceae	*Tinnea aethiopica*	T	Charcoal & Fuel wood
Rubiaceae	*Tricalysia niamniamensis*	T	Charcoal & Fuel wood
Verbenaceae	*Vitex doniana*	T	Charcoal & Fuel wood
Fabaceae	*Albizia shimperiana*	T	Charcoal & Fuel wood
Fabaceae	*Albizia zygia*	T	Timber
Annonaceae	*Annona senegalensis*	T	Charcoal & Fuel wood
Fabaceae	*Baphia wollastonii*	T	Charcoal & Fuel wood
Celastraceae	*Cassine buchananii*	T	Charcoal & Fuel wood
Annonaceae	*Cleistopholis patens*	T	Charcoal & Fuel wood
Combretaceae	*Combetum collinum*	T	Charcoal & Fuel wood
Combretaceae	*Combretum apiculatum*	T	Charcoal & Fuel wood
Ebenaceae	*Diospyros abyssinica*	T	Charcoal & Fuel wood
Combretaceae	*Terminalia glaucescens*	T	Charcoal & Fuel wood
Meliaceae	*Trichilia preuriana*	T	Charcoal & Fuel wood
Rutaceae	*Vepris nobilis*	T	Poles

2.5 Invasive alien species

These include the water hyancith (*Eichhornia crassipes*), *Senna spectabilis and Lantana camara. L. camara* colonizes new areas when its seeds are dispersed by birds. Once it reaches an area, *L. camara* spreads quickly. It coppices so well, that efforts to eradicate it can fail. It is resistant to fire, and quickly grows in and colonizes burnt areas. It can become a serious obstacle to the natural regeneration of important native species where it establishes itself. It is common in some of Uganda's protected areas including QENP and MFNP. *Senna spectabilis* is common in Karuma Wildlife Reserve and many other protected areas and CFR including Budongo and Matiri in western Uganda. The water hyancith is common on most of the water bodies in the country. There have been efforts to biologically control the species but there still is continuous flow through the Kagera river.

3 Anticipated impact and mitigation measures

3.1 During construction

In the first place, construction work will change accessibility or attractiveness of habitats or will destroy them in the worst case. Local sensitive habitats such as the riverine vegetation will be affected by clearing vegetation at the site, removal of top soil, building of access road and dust. Sensitive sites in the Ayago river basin include those areas where the redlist plant species are located (See Figure 5).

Stressors like noise, change or loss of habitats or resources, roads, change of hydrological conditions, human presence can have direct impact at an individual or species level. In consequence, this can lead to the elimination of threatened taxa and economically useful taxa.

3.2 During Operation

After the construction phase, the vegetation will come to an equilibrium level, but further investigations will be necessary to assess this development. Apart from changed or lost habitats or resources, a further change of local sensitive habitats or coenoses can be conditional in habitat fragmentation or direct impact by increased human presence. In the case of Ayago river basin, that latter is more important.

Therefore stressors like roads and possibilities of change in hydrological conditions affecting the water table will have long term effects, which can lead to the elimination of endemic, threatened or sensitive species with a change of local communities.

Section 5.3 a broad overview of severity of impact using the three dam options based on the flora, plant communities and sensitive habitats in the project area.

3.3 Impact assessments for the three dam options

A quantitative assessment is then made of the potential for each of the identified hazards to impact on the environment. This process is done by assessing the severity of the potential impact if the hazard is allowed to occur. By considering the severity, the significance of the impact can be defined accordingly.

The severity of the potential impact is assessed using predefined impact rating criteria, as shown in Table 5 . The severity is ranked as Negligible, Minor, Medium, High or Catastrophic.

Table 5 Criteria for rating of severity of impacts

Negligible Impacts	• No noticeable or limited local effect upon the environment, rapidly returning to original state by natural action • Unlikely to affect resources to a noticeable degree • No noticeable effects on globally or regionally endangered species • No significant contribution to global air pollution problem • No increase of air/water/noise level legal requirements • No reported nuisance effects
Minor Impacts	• Noticeable effects on the environment, but returning naturally to original state in the medium term • Slight local degradation of resources but not jeopardising further usage • Slight contribution to a known global environmental problem when compared with the industry world-wide • Disruption/disturbance to normal behaviour of a globally or regionally endangered species returning to normal in the short term • Single increase of air/water/noise level legal requirements • Infrequent localised nuisance
Moderate Impacts	• Noticeable effects on the environment, reversible over the long term • Causing human injury. • Localised degradation of resources restricting potential for further usage • Small contribution to a known global environmental problem when compared with the industry world-wide • Sub-lethal effects upon a globally or regionally endangered species with no effect on reproductive fitness and/or resulting in disruption/disturbance to normal behaviour returning to normal in the medium term • Repeated increase in air/water/noise level legal requirements • Causing localised nuisance both on and off site
Major Impacts	• Highly noticeable effects on the environment, difficult to reverse • Causing single human fatality or multiple injuries. • Widespread degradation of resources restricting potential for further usage • Significant contribution to a known global environmental problem when compared with the industry world-wide • Sub-lethal effects upon a globally or regionally endangered species compromising reproductive fitness and/or resulting in long-term disruption/disturbance to normal behaviour

	• Continual increase in air/water/noise level legal requirements • Periodic widespread nuisance both on and off site
Catastrophic Impacts	• Highly noticeable, irreparable effect upon the environment • Causing multiple human fatalities • Significant, widespread and permanent loss of resource • Major contribution to a known global environmental problem with demonstrable effects causing mortality to individuals of a species classified as globally or regionally endangered • Major continual increase in level of air/water/noise legal requirements • Causing widespread nuisance both on and off site

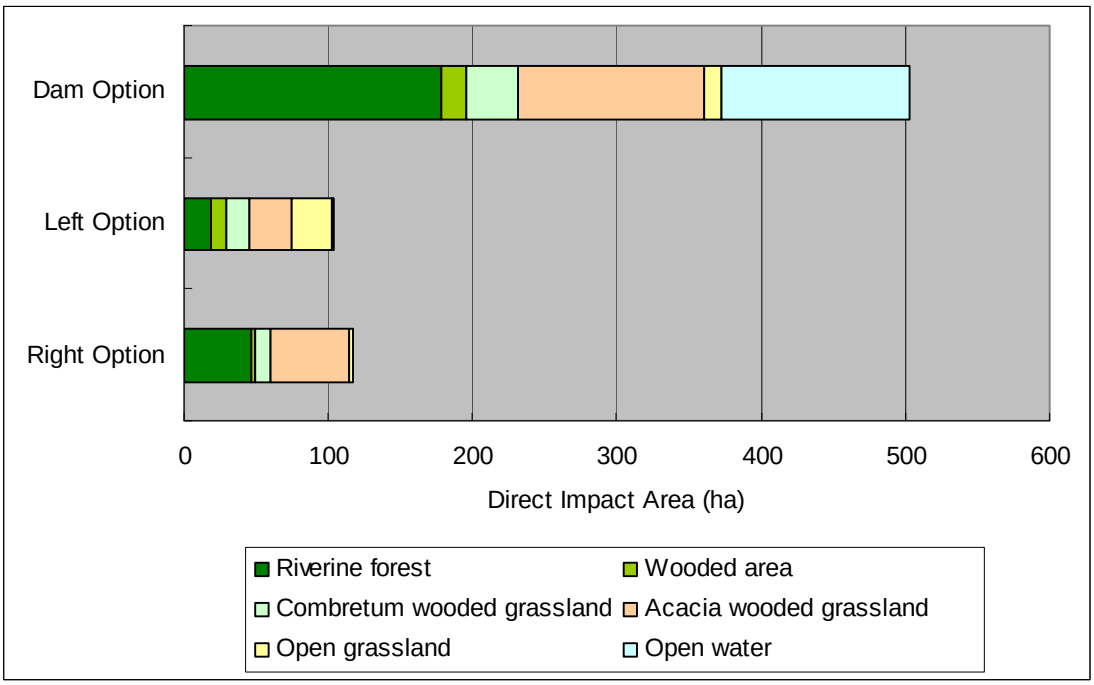


Figure 10 Vegetaion in direct impact area (10 m buffer) by three options

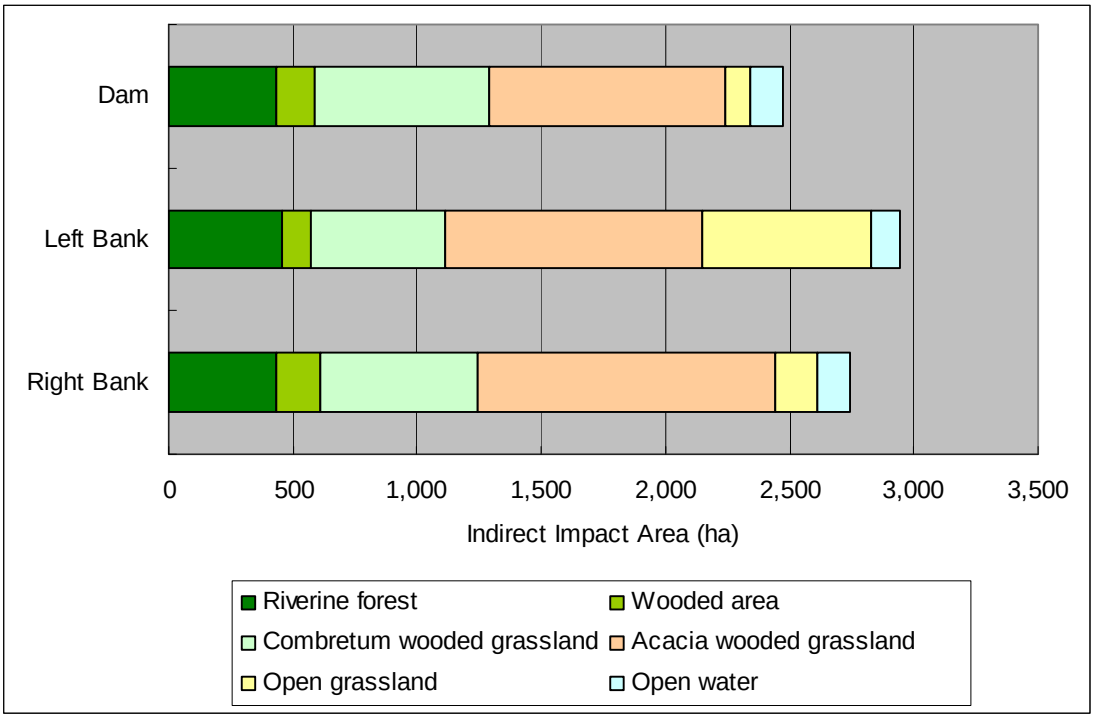


Figure 11 Vegetation in indirect impact area (1km buffer) by three options

Table 6 Assessment of significance of impacts of the various dam options (without mitigation)

	Dam Option (Layout 1)	Left Dam option (Layout 2)	Right dam option (Layout 3)
Construction impacts			
Vegetation loss due access road construction, dam construction etc	major	minor	moderate
Loss of habitats & sensitive riverine vegetation types	major	minor	moderate
Loss of globally threatened species	major	minor	moderate
Increase in erosion and decreased stabilization of river banks	major	minor	moderate
Proliferation of invasive species	moderate	moderate	moderate
Operation impacts			
Human presence, visual intrusion and waste	minor	moderate	moderate
Habitat fragmentation	minor	minor	minor
Proliferation of invasive species	moderate	moderate	moderate
Illegal logging	moderate	moderate	moderate

	Dam Option (Layout 1)	Left Dam option (Layout 2)	Right dam option (Layout 3)
General relative assessment of the dam options/layouts			
Reduction of most important vegetation	high	low	medium
Reduction of important flora	high	low	medium
Impacts of Invasive alien plant species	medium	medium	medium
Illegal logging activities	medium	medium	medium
Overall rating	high	low	medium

High: Relatively large loss of sensitive habitats, plant communities and globally threatened species over a given area

Medium: Relatively modest loss sensitive habitats, plant communities and globally threatened species over a given area

Low: Relatively minimal loss of sensitive habitats, plant communities and globally threatened species over a given area

In conclusion, the left bank option is most appropriate option for development given the minimal potential negative impact from the vegetation/flora point of view.

3.4 Mitigation measures

- Take precautionary action in advance of development
- Prepare biodiversity action plans in case of high risk sites/habitats. These should include aspects to cater for potential impacts of invasive plant species.
- Institute biodiversity awareness programs
- Biodiversity offsets
- UWA should liaise with the project staff to control illegal logging activities in the project area. Facilitation of UWA (logistical and financial) to fight illegal logging activities is encouraged.

4 References

Braun-Blanquet, J. 1965. Plant Sociology: The study of plant communities. London, Hafner.

Beuchner, H. K., and H. C. Dawkins. 1961. Vegetation Change Induced by Elephants and Fire in Murchison Falls National Park, Uganda. Ecology 42:752–766.

Hamilton, A. C.1981. A field Guide to Uganda Forest Trees 279 pp. Makerere University Press, Kampala.

Jackel, W., Heist, M and Mugisha, S. 1997. Murchison Falls National Park Vegetation map, Makerere University Institute of Environment and Natural Resources, Kampala.

Kalema, J. 2005. Diversity and distribution of vascu;lar plants in Uganda's Important Bird Area. Unpublished PhD Thesis. Makerere University, Kampala.

Katende, A. B., Ssegawa, P., Birnie, A. and Tengnas, B.1999. Wild Food Plants and Mushrooms of Uganda. Regional Land Management Uniti/SIDA. *Technical Handbook Series* 19. Nairobi.

Katende, A.B., Birnie, A and Tengnas, B. 1995. Useful trees and shrubs of Uganda. Regional Soil Conservation Unit/SIDA, *Technical Handbook Series* 10, Nairobi.

Langdale-Brown, I., Osmaston, H. A. and Wilson, J .G. 1964. The vegetation of Uganda and its bearing on Land-use. 159 pp. Government Printer, Entebbe.

Lock, J. M. 1977. Preliminary results from fire and elephant exclusion plots in Kabalega National Park, Uganda. African Journal of Ecology, 15: 229–232.

Polhill, R.M., Milne-Redhead, E., Turrill, W.B., and Hubbard, C.E. (from 1952 *et seq.*). Flora of Tropical East Africa (in many parts). Crown Agents, London and Balkema, Rotterdam.

Smart, J., Hattona, C. and Spence, D.H.N 1985. The effect of long-term exclusion of large herbivores on vegetation in Murchison Falls National Park, Uganda. Biological Conservation 33 (3): 229-245.

Spence, D.H.N. and Angus, A. 1971. African grassland management— burning and grazing in Murchison Falls National Park, Uganda. Biol. Conserv. 33, 229–245.

UWA 2001. Murchison Falls National Park, Bugungu Wildlife Reserve and Karuma Wildlife Reserve (Murchison Falls Protected Area) General Management Plan for 2001 - 2011. Uganda Wildlife Authority, Kampala

5 Appendix 1: List of species recorded in study area

Family	Species	Habit	IUCN	Constancy	Abund class	Sociability class
Cyperaceae	*Abilgaardia ovata*	H		9	3	2
Fabaceae	*Abrus precatorius*	C		3	1	2
Fabaceae	*Acacia abyssinica*	T		6	2	2
Fabaceae	*Acacia hockii*	T		29	5	5
Fabaceae	*Acacia polyacantha*	T		2	1	2
Fabaceae	*Acacia sieberiana*	T		31	5	5
Euphorbiaceae	*Acalypha bipartita*	H		3	1	2
Euphorbiaceae	*Acalypha cordata*	H		2	1	2
Euphorbiaceae	*Acalypha ornata*	H		4	2	2
Euphorbiaceae	*Acalypha racemosa*	H		2	1	2
Euphorbiaceae	*Acalypha villicaulis*	H		4	2	2
Amaranthaceae	*Achyranthes aspera*	H		4	2	2
Asteraceae	*Acmella caulorrhiza*	H		4	2	2
Passifloraceae	*Adenia bequartii*	C		4	2	2
Passifloraceae	*Adenia cissampeloides*	C		4	2	2
Zingiberaceae	*Aframomum verrucosum*	H		5	2	2
Asteraceae	*Ageratum conyzoides*	H		3	1	2
Fabaceae	*Albizia coriaria*	T		14	4	4
Fabaceae	*Albizia glaberrima*	T		2	1	2
Fabaceae	*Albizia grandibracteata*	T		7	2	2
Fabaceae	*Albizia shimperiana*	T		1	†	1
Fabaceae	*Albizia zygia*	T		1	†	1
Sapindaceae	*Allophyllus africanus*	T		18	4	4
Fabaceae	*Alysicarpus rugosus*	H		2	1	2
Commelinaceae	*Aneilema johnstonii*	H		1	†	1
Annonaceae	*Annona senegalensis*	T		1	†	1
Moraceae	*Antiaris toxicaria*	T		2	1	2
Sapindaceae	*Aphania senegalensis*	T		2	1	2
Asparagaceae	*Asparagus africanus*	H		1	†	1
Asparagaceae	*Asparagus racemosa*	S		2	1	2
Asteraceae	*Aspilia kotschyi*	H		2	1	2
Acanthaceae	*Asystasia gangetica*	H		8	3	2
Fabaceae	*Baphia wollastonii*	T		1	†	1
Acanthaceae	*Barleria ventricosa*	H		2	1	2
Oxalidaceae	*Biophytum petersianum*	H		3	1	2
Poaceae	*Brachiaria brizantha*	G		30	5	5
Poaceae	*Brachiaria decumbens*	G		51	5	5
Poaceae	*Brachiaria jubata*	G		1	†	1
Euphorbiaceae	*Bridelia micrantha*	T		2	1	2
Euphorbiaceae	*Bridelia scleroneura*	T		13	3	3
Rubiaceae	*Canthium sp.*	C		1	†	1
Capparaceae	*Capparis erythrocarpos*	S		8	3	2
Capparaceae	*Capparis tomentosa*	C		1	†	1
Sapindaceae	*Cardiospermum halicacabum*	C		2	1	2
Apocynaceae	*Carissa edulis*	S		3	1	2
Fabaceae	*Cassia mimosoides*	H		12	3	3
Celastraceae	*Cassine buchananii*	T		1	†	1
Apiaceae	*Centella asiatica*	H		12	3	3

Family	Species	Habit	IUCN	Constancy	Abund class	Sociability class
Menispermaceae	*Chasmanthera dependens*	C		2	1	2
Poaceae	*Chloris gayana*	G		3	1	2
Anthericaceae	*Chlorophytum comosum*	H		3	1	2
Vitaceae	*Cissus oliveri*	C		24	4	5
Vitaceae	*Cissus petiola*	C		4	2	2
Rutaceae	*Clausena anistata*	S		3	1	2
Annonaceae	*Cleistopholis patens*	T		1	†	1
Verbenaceae	*Clerodendrum formicarum*	C		7	2	2
Verbenaceae	*Clerodendrum schweinfurthii*	C		2	1	2
Verbenaceae	*Clerodendrum silvanum*	C		8	3	2
Combretaceae	*Combetum collinum*	T		1	†	1
Combretaceae	*Combretum apiculatum*	T		1	†	1
Combretaceae	*Combretum capituliflorum*	C		3	1	2
Combretaceae	*Combretum collinum*	T		42	5	5
Combretaceae	*Combretum molle*	T		17	4	4
Combretaceae	*Combretum paniculatum*	C		3	1	2
Commelinaceae	*Commelina africana*	H		3	1	2
Commelinaceae	*Commelina benghalensis*	H		2	1	2
Commelinaceae	*Commelina capitata*	H		2	1	2
Commelinaceae	*Commelina diffusa*	H		4	2	2
Fabaceae	*Crotalaria erecta*	H		1	†	1
Fabaceae	*Crotalaria spinosa*	H		8	3	2
Commelinaceae	*Cyanotis foecunda*	H		3	1	2
Amaranthaceae	*Cyathula prostrata*	H		11	3	3
Poaceae	*Cymbopogon nardus*	G		1	†	1
Poaceae	*Cynodon dactylon*	G		2	1	2
Cyperaceae	*Cyperus cyperoides*	H		1	†	1
Cyperaceae	*Cyperus rotundus*	H		1	†	1
Vitaceae	*Cyphostemma cyphopetalum*	H		1	†	1
Fabaceae	*Daniellia oliveri*	T		8	3	2
Fabaceae	*Desmodium dregeanum*	H		5	2	2
Fabaceae	*Desmodium gagenticum*	H		1	†	1
Convolvulaceae	*Dichondra repens*	H		4	2	2
Poaceae	*Digitaria abyssinica*	G		1	†	1
Poaceae	*Digitaria diagonalis*	G		1	†	1
Poaceae	*Digitaria longiflora*	G		3	1	2
Poaceae	*Digitaria maitlandii*	G		7	2	2
Poaceae	*Digitaria ternata*	G		1	†	1
Dioscoreaceae	*Dioscorea bulbifera*	C		1	†	1
Ebenaceae	*Diospyros abyssinica*	T		1	†	1
Sterculiaceae	*Dombeya bagshawei*	T		10	3	3
Adiantaceae	*Doryopteris kirkii*	H		1	†	1
Verbenaceae	*Duranta erecta*	T		2	1	2
Acanthaceae	*Dyschorite radicans*	H		2	1	2
Meliaceae	*Ekebergia capensis*	T		1	†	1
Fabaceae	*Eleusine indica*	G		1	†	1
Acanthaceae	*Elytraria marginata*	H		1	†	1
Asteraceae	*Emilia javanica*	H		1	†	1

Family	Species	Habit	IUCN	Constancy	Abund class	Sociability class
Euphorbiaceae	*Euphorbia candelabrum*	T		1	†	1
Convolvulaceae	*Evolvulus alsinoides*	H		1	†	1
Moraceae	*Ficus dicranostyla*	T		11	3	3
Moraceae	*Ficus glumosa*	T		5	2	2
Moraceae	*Ficus ovata*	T		1	†	1
Moraceae	*Ficus sur*	T		1	†	1
Moraceae	*Ficus sycomorus*	T		18	4	4
Moraceae	*Ficus thonningi*	T		1	†	1
Moraceae	*Ficus vallis chaude*	T		4	2	2
Cyperaceae	*Fimbristylis dichotoma*	H		6	2	2
Euphorbiaceae	*Flueggea virosa*	T		9	3	2
Rubiaceae	*Gardenia ternifolia*	T		5	2	2
Iridaceae	*Gladiolus sp.*	H		1	†	1
Fabaceae	*Glycine wightii*	H		1	†	1
Tiliaceae	*Grewia mollis*	S		11	3	3
Simaroubaceae	*Harrisonia abyssinica*	T		12	3	3
Malvaceae	*Hibiscus calyphyllus*	H		1	†	1
Malvaceae	*Hibiscus cannabinus*	H		1	†	1
Malvaceae	*Hibiscus cannabis*	G		1	†	1
Lamiaceae	*Hoslundia opposita*	S		6	2	2
Acanthaceae	*Hygrophila sp.*	H		1	†	1
Poaceae	*Hyparrhenia collina*	G		2	1	2
Poaceae	*Hyparrhenia cymbaria*	G		8	3	2
Poaceae	*Hyparrhenia diplandra*	G		8	3	2
Poaceae	*Hyparrhenia filipendula*	G		3	1	2
Poaceae	*Hyparrhenia sp.*	G		33	5	5
Poaceae	*Hyperthelia dissoluta*	G		1	†	1
Acanthaceae	*Hypoestes aristata*	H		16	4	4
Poaceae	*Imperata cylindrica*	G		8	3	2
Fabaceae	*Indigofera arrecta*	H		11	3	3
Fabaceae	*Indigofera atriceps*	H		1	†	1
Fabaceae	*Indigofera breviycalyx*	H		4	2	2
Fabaceae	*Indigofera circinella*	H		3	1	2
Fabaceae	*Indigofera spicata*	H		1	†	1
Convolvulaceae	*Ipomoea ochracea*	C		8	3	2
Poaceae	*Isachne mauritiana*	G		13	3	3
Oleaceae	*Jasminum eminii*	S		1	†	1
Oleaceae	*Jasminum pauciflorum*	C		1	†	1
Acanthaceae	*Justicia matamensis*	H		1	†	1
Acanthaceae	*Justicia sp.*	H		1	†	1
Rubiaceae	*Keetia pursegloveai*	C		4	2	2
Meliaceae	*Khaya anthotheca*	T	redlisted	2	1	2
Bignoniaceae	*Kigelia africana*	T		16	4	4
Cyperaceae	*Kyllinga colorata*	H		10	3	2
Cyperaceae	*Kyllinga sp.*	H		18	4	4
Anacardiaceae	*Lannea schimperi*	T		1	†	1
Anacardiaceae	*Lannea sp.*	T		4	2	2
Celastraceae	*Loeseneriella africana*	C		9	3	2
Fabaceae	*Lonchocarpus laxiflora*	T		2	1	2
Poaceae	*Loudetia arundinacea*	G		1	†	1

Family	Species	Habit	IUCN	Constancy	Abund class	Sociability class
Euphorbiaceae	*Margaritaria discoidea*	T		29	5	5
Cyperaceae	*Mariscus dubius*	H		14	4	4
Bignoniaceae	*Markhamia lutea*	T		19	4	4
Celatraceae	*Maytenus heterophylla*	T		1	†	1
Celastaceae	*Maytenus senegalensis*	T		2	1	2
Poaceae	*Microchloa kunthii*	G		5	2	2
Asteraceae	*Microglossa pyrifolia*	H		6	2	2
Moraceae	*Milicia excelsa*	T	redlisted	2	1	2
Fabaceae	*Mimosa pigra*	S		2	1	2
Acanthaceae	*Mimulopsis bagshawei*	S		1	†	1
Rubiaceae	*Mitracarpus villosus*	H		1	†	1
Annonaceae	*Monanthotaxis buchananii*	C		1	†	1
Annonaceae	*Monanthotaxis lucida*	C		2	1	2
Asclepiadaceae	*Mondia whyteii*	C		21	4	5
Acanthaceae	*Monothecium aristatum*	H		5	2	2
Rubiaceae	*Morinda lucida*	T		1	†	1
Cucurbitaceae	*Mukia maderaspata*	H		2	1	2
Rubiaceae	*Multidentia crassa*	C		1	†	1
Commelinaceae	*Murdannia simplex*	H		1	†	1
Rubiaceae	*Oldenlandia herbacea*	H		1	†	1
Flacourtiaceae	*Oncoba spinosa*	T		4	2	2
Poaceae	*Oplismenus hirtellus*	G		1	†	1
Poaceae	*Panicum maximum*	G		3	1	2
Poaceae	*Panicum repens*	G		12	3	3
Asclepiadaceae	*Parquetina nigrescens*	C		8	3	2
Poaceae	*Paspalum scrobiculatum*	G		3	1	2
Malvaceae	*Pavonia urens*	H		3	1	2
Asclepiadaceae	*Periploca linearifolia*	C		2	1	2
Arecaceae	*Phoenix reclinata*	T		1	†	1
Euphorbiaceae	*Phyllanthus amarus*	H		1	†	1
Euphorbiaceae	*Phyllanthus odontadenius*	H		1	†	1
Euphorbiaceae	*Phyllanthus somalensis*	S		4	2	2
Fabaceae	*Piliostigma thonningii*	T		2	1	2
Lamiaceae	*Platystoma africana*	H		52	5	5
Commelinaceae	*Pollia mannii*	H		2	1	2
Polygalaceae	*Polygala albida*	H		1	†	1
Verbenaceae	*Premna angolensis*	T		5	2	2
Fabaceae	*Pseudarthria hookeri*	S		1	†	1
Meliaceae	*Pseudocedrela kotschyi*	T		3	1	2
Rubiaceae	*Psydrax parviflora*	T		11	3	3
Icacinaceae	*Rhaphiostylis beninensis*	C		8	3	2
Rubiaceae	*Richardia sp.*	H		6	2	2
Acanthaceae	*Ruellia patula*	H		1	†	1
Apocynaceae	*Saba comorensis*	C		2	1	2
Draceanaceae	*Sansevieria nilotica*	H		5	2	2
Amaryllidaceae	*Scadoxus multiflorus*	H		6	2	2
Cyperaceae	*Scleria distans*	H		1	†	1
Cyperaceae	*Scleria racemosa*	H		2	1	2
Cyperaceae	*Scleria sp.*	H		3	1	2
Flacourtiaceae	*Scolopia rhamnophylla*	T		1	†	1

Family	Species	Habit	IUCN	Constancy	Abund class	Sociability class
Asclepiadaceae	*Secamone africana*	C		3	1	2
Fabaceae	*Senna occidentalis*	H		6	2	2
Fabaceae	*Senna sp.*	T		2	1	2
Fabaceae	*Sesbania sesban*	S		1	†	1
Poaceae	*Setaria sphacelata*	G		1	†	1
Malvaceae	*Sida alba*	H		19	4	4
Malvaceae	*Sida rhomboidea*	H		14	4	4
Malvaceae	*Sida ternata*	H		3	1	2
Solancaeae	*Solanum incanum*	H		4	2	2
Rubiaceae	*Spermacoce princeae*	H		1	†	1
Rubiaceae	*Spermacoce pusilla*	H		2	1	2
Poaceae	*Sporobolus pyramidalis*	G		1	†	1
Poaceae	*Sporobolus stapfianus*	G		33	5	5
Bignoniaceae	*Stereospermum kunthianum*	T		2	1	2
Loganiaceae	*Strychnos innocua*	T		7	2	2
Loganiaceae	*Strychnos lucens*	C		1	†	1
Euphorbiaceae	*Suregada procera*	T		2	1	2
Asteraceae	*Synedrella nodiflora*	H		1	†	1
Fabaceae	*Tamarindus indica*	T		5	2	2
Fabaceae	*Tephrosia elegans*	H		4	2	2
Fabaceae	*Tephrosia linearis*	H		7	2	2
Fabaceae	*Tephrosia pumila*	H		8	3	2
Fabaceae	*Teramnus sp.*	H		3	1	2
Fabaceae	*Teramnus uncinatus*	H		2	1	2
Combretaceae	*Terminalia glaucescens*	T		1	†	1
Acanthaceae	*Thunbergia alata*	H		3	1	2
Acanthaceae	*Thunbergia mildbraedii*	H		20	4	5
Lamiaceae	*Tinnea aethiopica*	T		2	1	2
Menispermaceae	*Tinospora caffra*	C		1	†	1
Rubiaceae	*Tricalysia niamniamensis*	T		2	1	2
Meliaceae	*Trichilia preuriana*	T		1	†	1
Meliaceae	*Trichilia rubescens*	T		3	1	2
Tiliaceae	*Triumfetta rhomboidea*	H		2	1	2
Meliaceae	*Turraea robusta*	T		8	3	2
Malvaceae	*Urena lobata*	C		6	2	2
Annonaceae	*Uvaria angolensis*	C		6	2	2
Rubiaceae	*Vangueria apiculata*	T		12	3	3
Rutaceae	*Vepris nobilis*	T		1	†	1
Asteraceae	*Vernonia amydalina*	S		2	1	2
Asteraceae	*Vernonia cinerea*	H		25	4	5
Asteraceae	*Vernonia smithiana*	H		5	2	2
Fabaceae	*Vigna parkeri*	H		2	1	2
Fabaceae	*Vigna vexillata*	H		7	2	2
Verbenaceae	*Vitex doniana*	T		2	1	2
Annonaceae	*Xylopia parviflora*	T		6	2	2
Sapindaceae	*Zahna golungensis*	T		6	2	2
Rhamnaceae	*Ziziphus mucronata*	T		5	2	2

Annex 2: Baseline Survey Report <Fauna>

1 Introduction

A report by Gibbs et al (1986) reviewed 5 alternative potential hydropower developments proposals. Among these was the Ayago Hydroelectric scheme option within Murchison Falls National park. At the time the scheme considered a south and north bank schemes with a total installed capacity of 540 MW.

Due to the already considerable regulation of the river by Lakes Victoria and Kyoga, it was not considered necessary at the time to have a dam installed to further regulate the river flow.

The preferred alternative considered the construction of longer tailrace tunnels to generate the required head.

The alternative schemes would have had a 480 MW power station on the South bank and a 60 MW on the Northern bank.

SNCeLAVALIN International (2007) showed that the Ayago South Hydroelectric Development project would be located on the Victoria Nile, about 3.5 km upstream of the confluence with the Ayago River in Murchison National Park.. At the time they also reported, as part of the main environmental issues ,that following the proposed designs then: -

Whatever reservoir would be constructed for the dam would have minimal impact due to its small area (67 ha) and volume.

There would be a 10 km river stretch with reduced flow between dam and tailrace.

A minimum flow release of some 200 m3/s in the dry season would be maintained in the bypassed river to have minimal impacts in the section, which would preserve natural habitats, including mist flora habitats.

The creation of the pondage reservoir would provide additional habitats for wildlife.

The dam would constitute a barrier to fish movement.

The Gibbs et al (1986) report noted that the fundamental impact of the Ayago south hydroelectric scheme was that it is sited in a designated national Park. In addition, this would result into reduced flow in the section of the River Nile bypassed by the tailrace.

Other impacts were classified into two categories, i) During construction and ii) Permanent.

During construction it was envisaged that:-

The main access road to the construction site and the construction roads would disturb the movement of animals in the section of the National Park, but would have the positive effect of acting as firebreaks

Ecologically significant riparian and riverine forest would have been destroyed on the north bank and on the Patooan Island

There was expected to be exclusion and disturbance of big game in the construction area and adverse impacts on the aquatic fauna in the direct area of impact.

The location of the construction camp in a rural setting outside the Park, as was considered at the time, would have grave negative social impacts.

It was envisaged that the permanent impacts would:-

Create a small loss of wilderness atmosphere, but could have become a tourist attraction if access to the underground power station was to be permitted for the general public

The substation and transmission lines for evacuation of the electricity would be visually obtrusive especially where the overhead lines would cross the river

The works and associated roads would give the rangers improved access to the part of the park for controlling illegal activities

The Ayago Hydroelectric power project area straddles the Nile River in Murchison Falls National Park (MFNP). MFNP covers an area of about 3,900 km2 in North Western Uganda (Williams 1967). The Park is bounded by Lake Albert on the west and bisected by the Victoria Nile which in the 1960 was thought to perhaps have the highest concentration of Crocodiles in Africa.

MFNP sits on relatively flat land 2° north of the equator, has an elevation that averages 800 m from a low of 625 m along the Albert Nile River but with high areas on Rabongo Hill (1,303 m) in the eastern portion of the Park, and Igisi Hill (1,286 m) in the south of the park.

The vegetation of MFNP is quite diverse with areas of vast undulating grassland of both short open and tall grasslands, woodlands of varying densities of woody biomass, Riverine vegetation of forest, papyrus swamp and other formations as well as high tropical forest in Rabongo.

Plate 1 Diversity of vegetation formations in MFNP ranging from grass lands to wooded grasslands

Smart et al (1985) demonstrated through experimentation that removal of grazing and browsing pressure resulted into (1) marked tree regeneration in both grassland and woodland; (2) a relatively species-poor herbaceous layer in the grassland areas; and (3) the development of a more diverse all-aged stand in the woodlands. Large sections of the Ayago field project development area are covered in wooded vegetation which could reflect low densities of grazing and browsing mammals.

The Most developed part of MFNP is immediately west of Para, the Park Headquarters and Buligi Circuit a popular tourism track that follows the Albert Nile to its confluence with Victoria Nile an area especially rich in water birds including the rare Whale headed Stork.

The Chobe sector of MFNP just above the Karuma falls, which has remained largely undeveloped for tourism since the late 1970s holds the larger population of the Rothschild Giraffe in the Park.

2 Other developments in MFNP area

MFNP has several other developments within the park that have a bearing to the landscape, habitats and the wildlife. These include but are not limited to the following: -

- Para Lodge
- Para Park Headquarters and other subsidiary support infrastructure
- Chobe Lodge
- Sambia River Lodge
- Oil Exploration Wells
- Karuma Hydroelectric power scheme

All the developments in the list are quite intrusive within the protected areas of MFNP conservation area.

3 General Methodology

Leading to the field work, 8 base tracks were marked on the Ayago project map with the intention to work along these routes for:-

- assessing habitat structure and distribution
- Animal (butterflies, Reptiles and amphibians, birds and Mammals) occurrence
- Understanding the patterns of the distribution of these animal groups

3.1 Survey Area and survey route

The initial plan was to use these as the base transects for the field surveys, the actual field situation however proved that working along these base transects was not very practicable. Instead a total of another 8 workable transects were used for conducting the observations and surveys.

Two of the transects worked, followed the two roads crossing through the park north and south of River Nile, while the other 6 were placed to specifically target the different vegetation types in the section of the MFNP covered by the Ayago project development area. The strategy we adopted sampled a good proportion of the areas defined by the base transects we had earlier established.

Much of the project area east of the 32° Longitude is covered with dense wooded vegetation types including woodlands and bush lands, while the area to the west of the same longitude tends into more open grassland and lightly wooded grassland. Survey area A comprises about 45% of the dense wooded and 55% of the more open vegetation types. While Survey area B comprises largely the open grassland areas with the denser wooded areas confined to the riverine situations.

The fauna surveys were conducted to primarily understand site constraints that would be important to consider and/or mitigate for during the implementation of the Ayago development project.

For logistical reasons, all the fauna surveys (mammals, birds, reptiles and insects) were conducted along the same transects with the same effort invested in the surveys of all taxa and their habitats.

3.2 Surveyors

Name	Position	Organization
Dr. Kityo Robert	Zoologist / Fauna Specialist	WSS Services (U) Ltd.
Dr. Behangana Mathias	Herpetofauna Specialist	WSS Services (U) Ltd.
Ms. Akite Perpetra	Butterflies Specialist	WSS Services (U) Ltd.
Dr. Eric Sande	Birds Specialist	WSS Services (U) Ltd.
Ms. Jalia Kiyemba	Field Assistant Butterflies Surveys	WSS Services (U) Ltd.

3.3 Survey date and time

Date	Time	Area	Surveyors
9th August – 15 August 2010	6am – 9pm	Survey Areas A and B	Dr. Robert Kityo Dr. Behangana Mathias Ms. Akite Perpetra Dr. Eric Sande Ms. Jalia Kiyemba

4 Survey results

4.1 Mammals

4.1.1 Methods

Mammal surveys were conducted along the transects described in the general methodology section. The transects were walked in at a speed of 1 km per hour on average ,with observations made either side of the transect as far as the line of vision could see. The approach of necessity will have over-represented mammals or mammal signs that were within a few meters in the direct line of transect. On the transects, mammals, mammal signs including trucks, right feeding evidences, skeletal material, trails and burrows were noted and enumerated. A GPS coordinate was kept for all locations where such evidence was encountered. In addition, locations of habitat features of impotance to animals (for example salt lick areas and wallows) were also identified and recorded. Using this method some individuals will inevitably get away before being detected, it was assumed however that all mammals and/or mammal signs were detected along the transect.

4.1.2 Leterature survey results

Most detailed studies on mammal populations and movements in MFNP predate the 1980s. For example Buechner et al (1963) reported that major movements of elephants into the Park were associated with long, heavy rains while movements out of the park were significant during the long dry season. Well as there may continue to be movements of Elephants within the Park it is not likely that major movement continue to be experienced into or out of the Park. Already in the 1960's Buechner et al (1963) had observed that, the elephants seemingly concentrated in ever-increasing numbers in the Park area, and pointing to the need to regulate their numbers to avoid

damage to the vegetation and for the future welfare of the population of elephants. Over the years of course, the situation changed as elephant populations got heavily affected by poaching.

More recent studies such as Douglas-Hamilton et al, (1980) in Lamprey et al (2003) reported on Elephant population declines in MFNP (from 12,000 in the 60's to only 1,420 by 1980) and buffalo (from 15,000 buffalo in the 1960's to just 1500 in 1991).

The project area is roughly divided into two major sections; i) a section of dense closed vegetation and ii) a section of more open vegetation types. The two major areas have different implications for the mammalian fauna.

The area of MFNP in which the Ayago field development project is located is largely removed from the busy tourism circuit areas. However, the area north of the Nile in which Chobe Safari lodge is located is undergoing development to enhance it for tourism.

Observations including trails, trucks, dung, feeding signs and actual animals sightings were made to record species presence. Notes on the nature of habitats were also made to assess their suitability for different species of birds and mammals.

Most of the dense wooded areas are not suitable for large congregations of most grazing mammals (including Kob, Water buck and Hartebeest). For the same reasons, these areas would also not be suitable habitats for the large predators (Lions and Hyenas).

The areas of dense vegetation will however be suitable ranging grounds for Buffalo, elephants and bush pigs among others. These areas are in addition likely to support the richest diversity of birds.

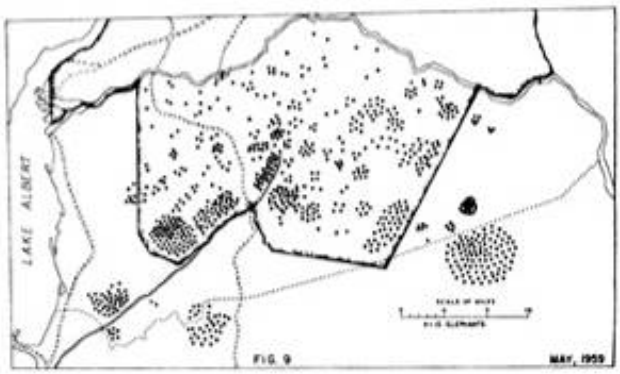
The more open grassland areas also presented more than one scenario, with short grass areas, tall grass areas, grassland with scattered trees and several other categories. Most suitable habitats among these for mammal congregations would be the areas with shorter grass.

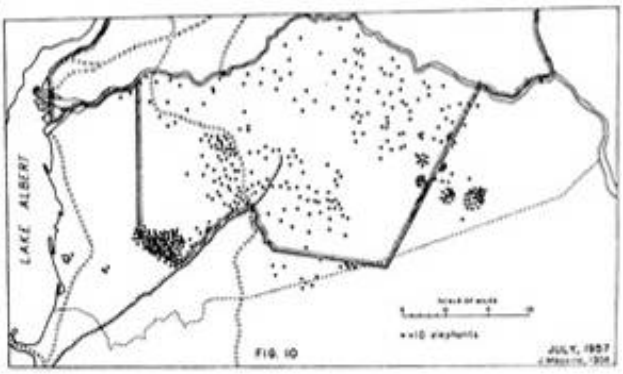
26 species of medium to large sized mammals (Table M1) were recorded altogether in the project area.

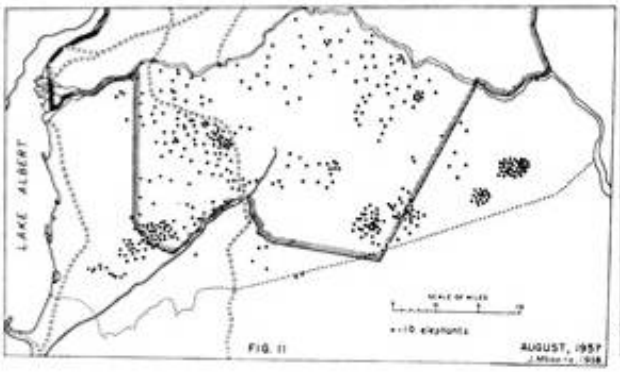
Presence of Giraffes or their signs were found only in the areas to the north of River Nile while most of the other mammals or their signs were found both to the north and south side of the river.

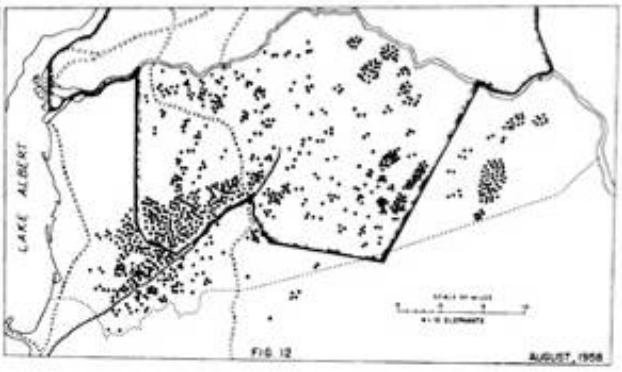
Fig 1 sourced from Buechner et al (1963) shows historical patterns of movement for elephants in the southern section of MFNP. In the 1960s,elephants occurred at much higher densities than is the case today and their movements were equally as significant because of the impacts they would have on the vegetation in the areas they ranged through.

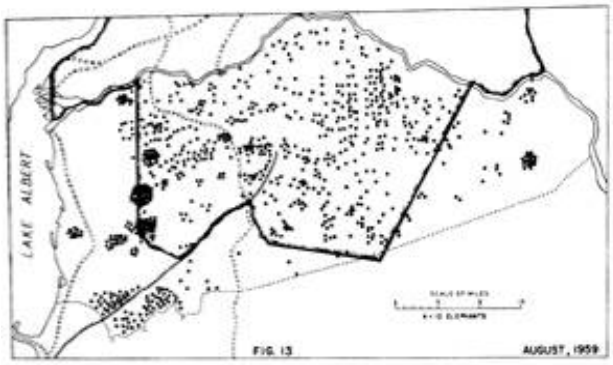
At the time the counts for the maps in Fig 1 were done, the elephants moved widely into and out of the park taking their impacts beyond the boundaries of Murchison FNP.

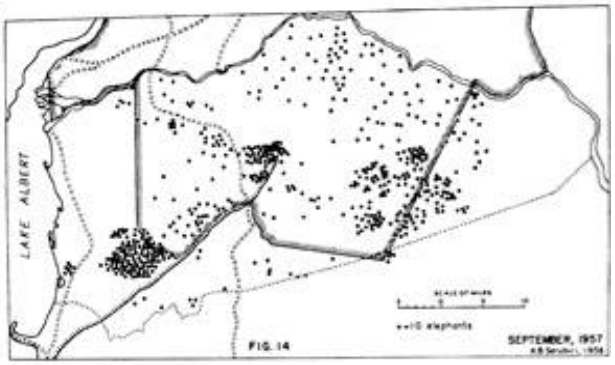

LAKE ALBERT
FIG. 9
MAY, 1959

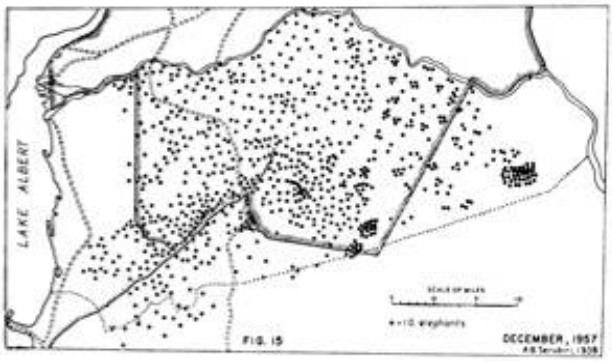

LAKE ALBERT
FIG. 10
JULY, 1957

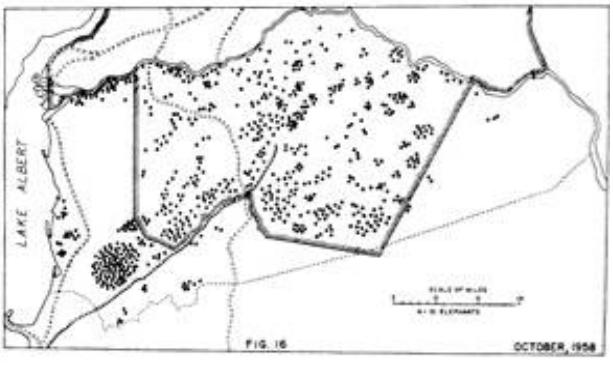

LAKE ALBERT
FIG. 11
AUGUST, 1957


LAKE ALBERT
FIG. 12
AUGUST, 1958


LAKE ALBERT
FIG. 13
AUGUST, 1959


LAKE ALBERT
FIG. 14
SEPTEMBER, 1957


LAKE ALBERT
FIG. 15
DECEMBER, 1957


LAKE ALBERT
FIG. 16
OCTOBER, 1958

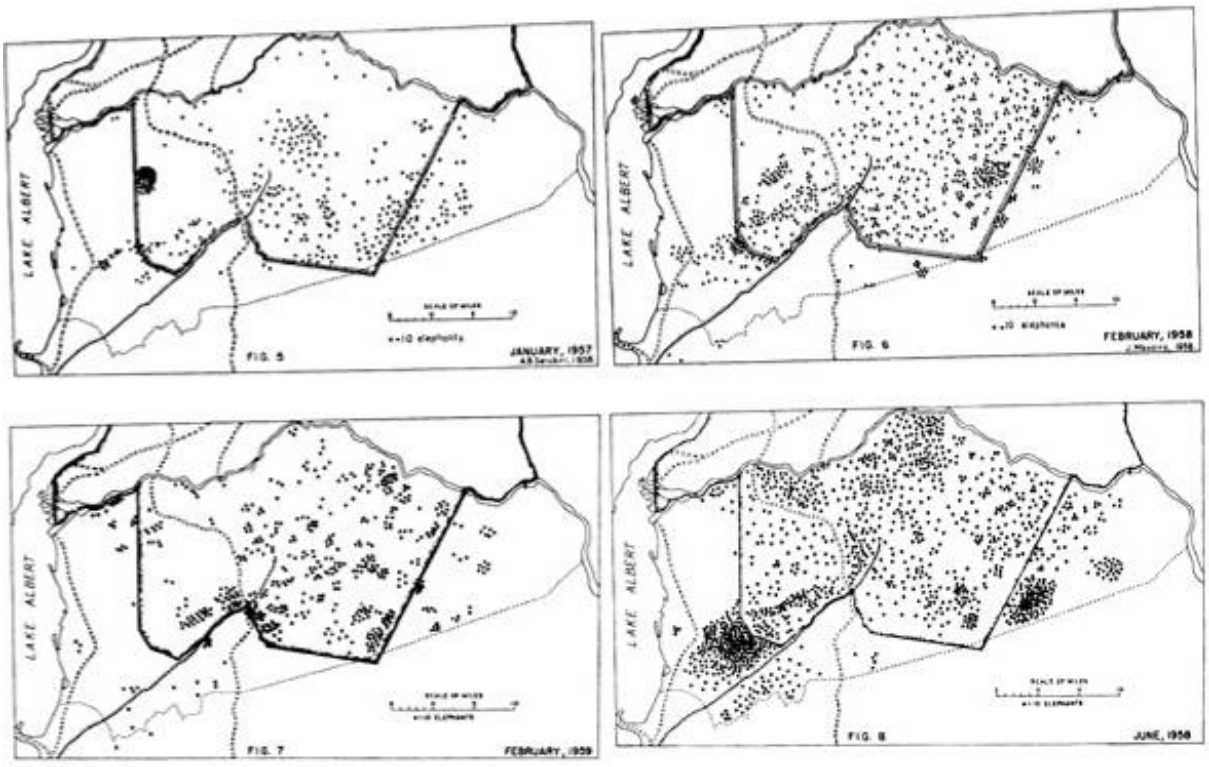


Figure 1 Historical patterns of movement for Elephants in the southern section of MFNP

Overall animal numbers for any species of mammals in MFNP are now possibly much lower than they were up to the early 1960s (see for example Lamprey et al (2003)).

Table 1 presents the species of medium to large sized mammals that were recorded in the project area. Of the mammals recorded, only two species Vervet monkeys and Leopard were not recorded in survey area B.

MFNP has as many as 109 species of mammals of which 48 species are in the medium to large sized categories (Wilson 1995 and Plumptre et al. 2003). It is possible therefore that several more of the known species for the Park could be recorded in the project area in extended surveys.

4.1.3 Field survey results

Figs 2 to 15 show combined records of occurrence (actual animals or their signs – dung, trucks, feeding or skeletons) of 10 species of medium to large sized mammals in MFNP.

Species that occur at relative to high abundances show wider occurrence than those occurring at lower abundances.

In all cases, the records represent only temporal situations/observations which if continued over several years could provide conclusive evidence of preferred areas for the different species.

Access to the proposed intake points for the dam on both north and south banks, crosses through areas of woodland with low grass cover. These are the areas that would be favored for grazing by ungulates. It is in these same areas where large carnivores such as Lions would be found, taking advantage of the prey animals.

Fig 2 - 15 shows where named species of mammals have been or were recorded by the surveys for this report. Surveys such as the one conducted for this report as well as data from UWA monitoring records only represent temporal situations in the occurrence of species. If such observations are repeated over a long period of time, they could form a strong basis for delimiting areas important for different species.

Table M1 Presence absence records of Mammals in the different survey areas

Family	English name	Scientific name	Survey area A	Survey area B
Cercopithecidae	Olive Baboon	*Papio anubis*	√	√
	Black & White Colobus	*Colobus guereza*	√	√
	Pata's Monkey	*Cercopithecus patas*	√	√
	Vervet Monkey	*Cercopithecus aethiops*		√
Felidae	Leopard	*Panthera pardus*		√
Herpestidae	Egyptian Mongoose	*Herpestes ichneumon*	√	√
Mustelidae	(African) Spot-necked Otter	*Lutra maculicollis*	√	√
Viveridae	East African Civet	*Civettictis civetta*		√
Hyenidae	Spotted Hyena	*Crocuta crocuta*	√	√
Hippopotamidae	Hippopotamus	*Hippopotamus amphibius*	√	√
Suidae	Bush Pig	*Potamochoerus porcus*	√	√
Suidae	Common Warthog	*Phacochoerus africanus*	√	√
Bovidae	African Buffalo	*Syncerus caffer*	√	√
	Bushbuck	*Tragelaphus scriptus*	√	√
	Common (Bush) Duiker	*Sylvicapra grimmia*	√	√
	Hartebeest	*Alcelaphus buselaphus*	√	√
	Uganda Kob	*Kobus kob*	√	√
	Oribi	*Ourebia ourebia*	√	√
	(Defassa) Waterbuck	*Kobus ellipsiprymnus*	√	√
Giraffidae	Giraffe	*Giraffa camelopardalis*	√	√
Elephantidae	African Elephant	*Loxodonta africana*	√	√
Manidae	Giant Pangolin	*Smutsia gigantea*	√	√
Hystricidae	Crested Porcupine	*Hystrix cristata*	√	√
Scuiridae	Striped Ground Squirrel	*Euxerus erythropus*	√	√
Thryonomidae	Savannah (Common) Cane Rat	*Thryonomys swinderianus*	√	√
Orycteropodidae	Aardvark (Ant Bear)	*Orycteropus afer*	√	√

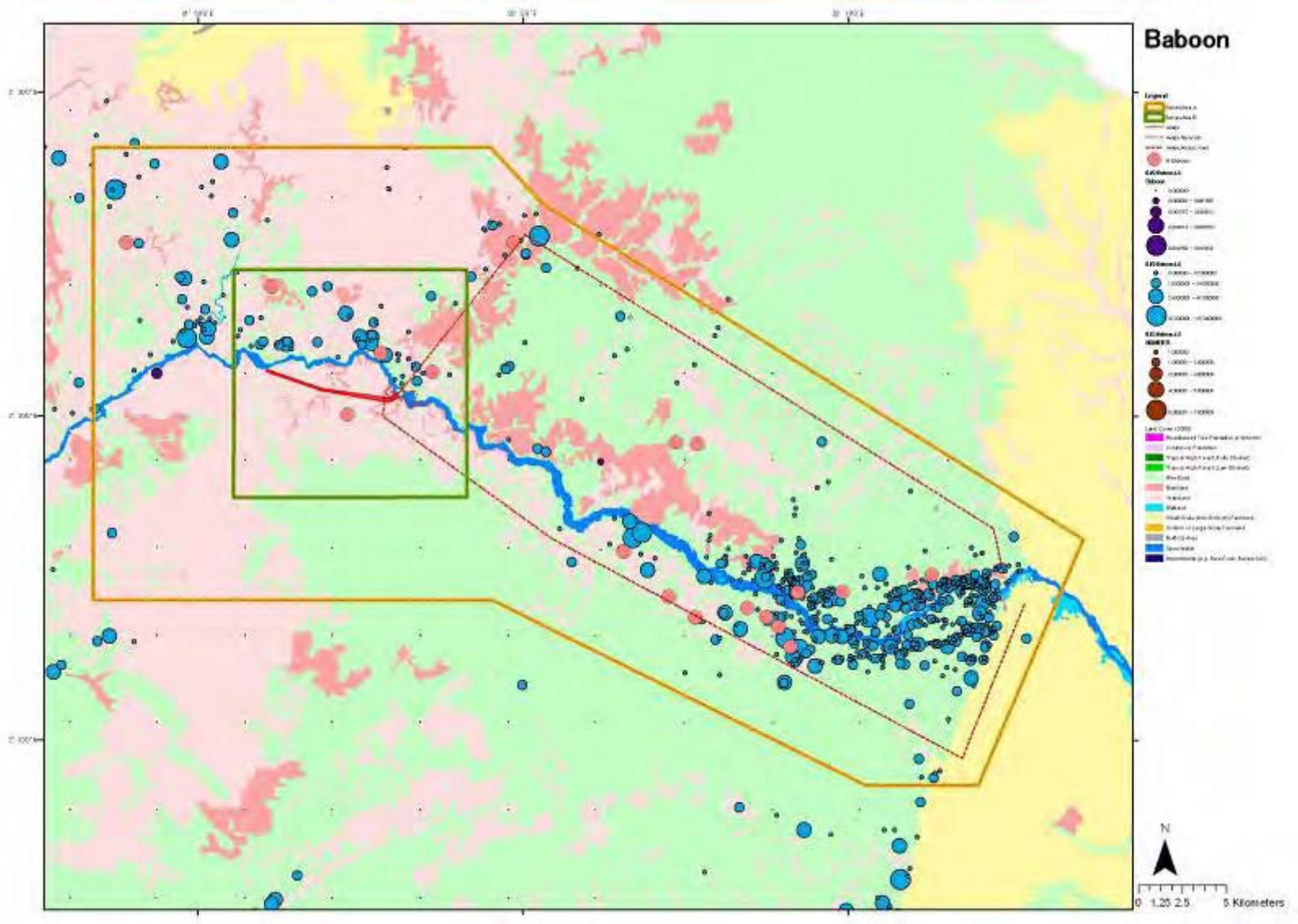


Figure 2 New and old records of presence or occurrence of Baboons in the Ayago project area

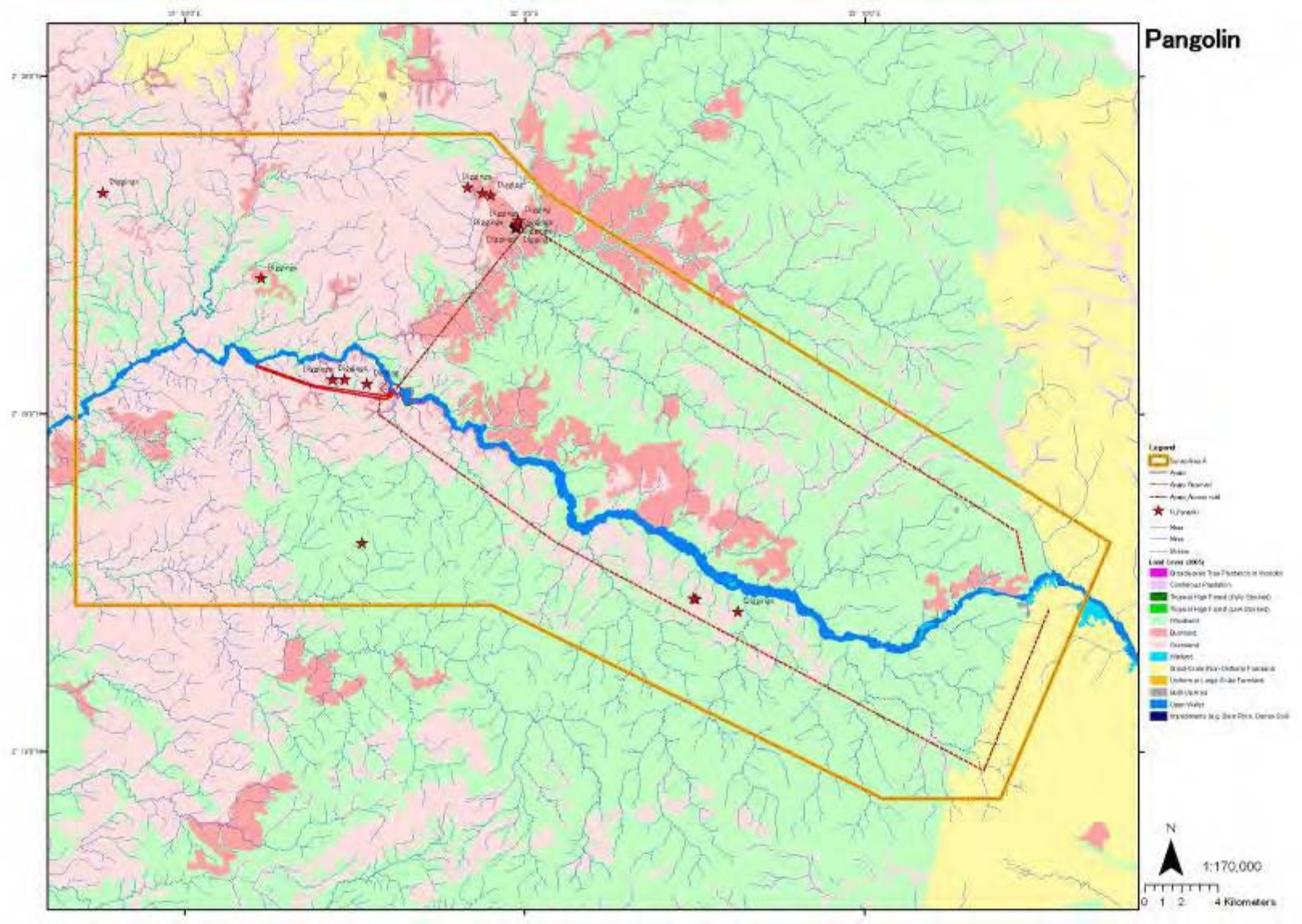


Figure 3 Records of occurrence of the Ground Pangolin in the Ayago project area

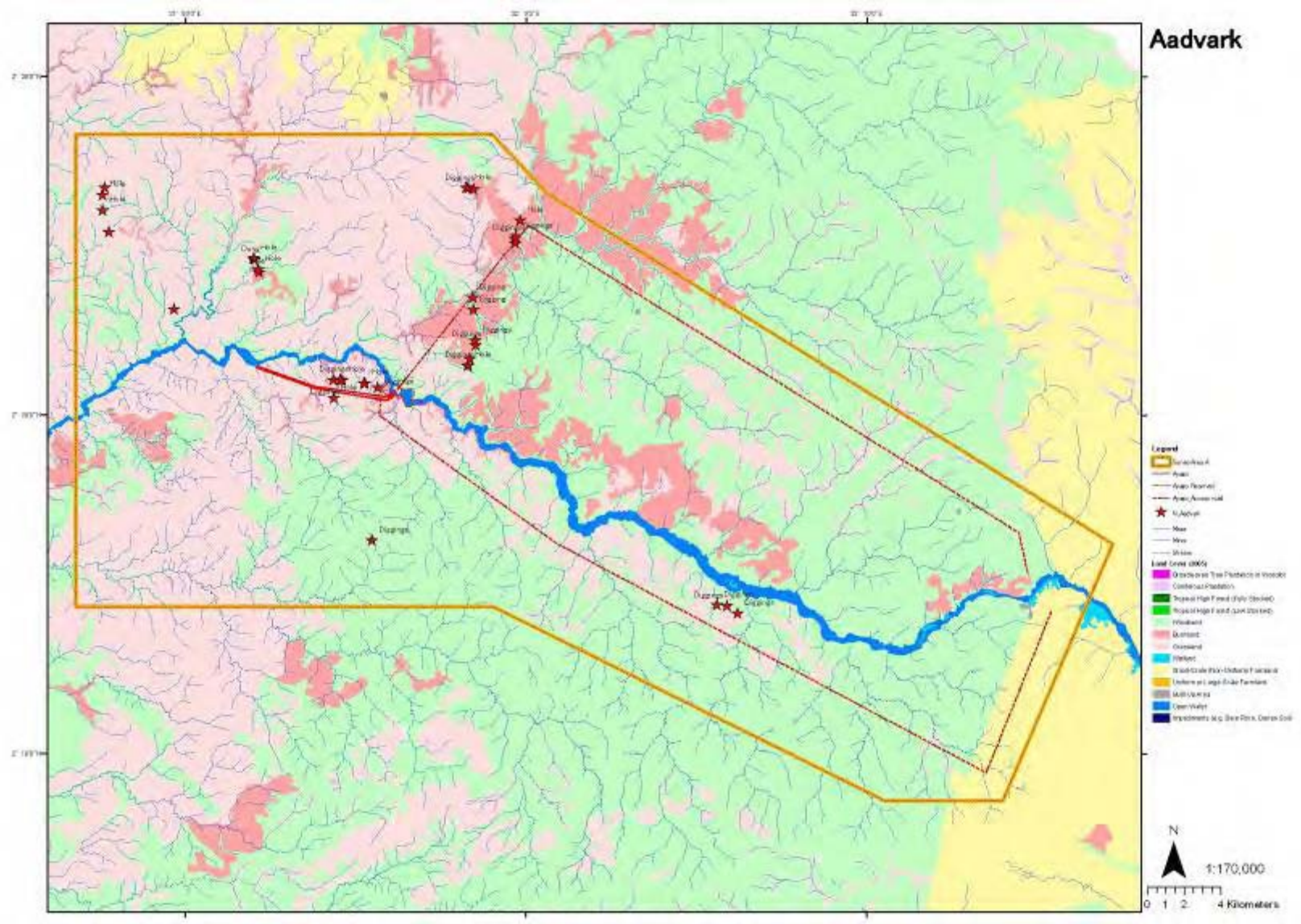


Figure 4 Records of presence or occurrence of the Aardvark in the Ayago project area

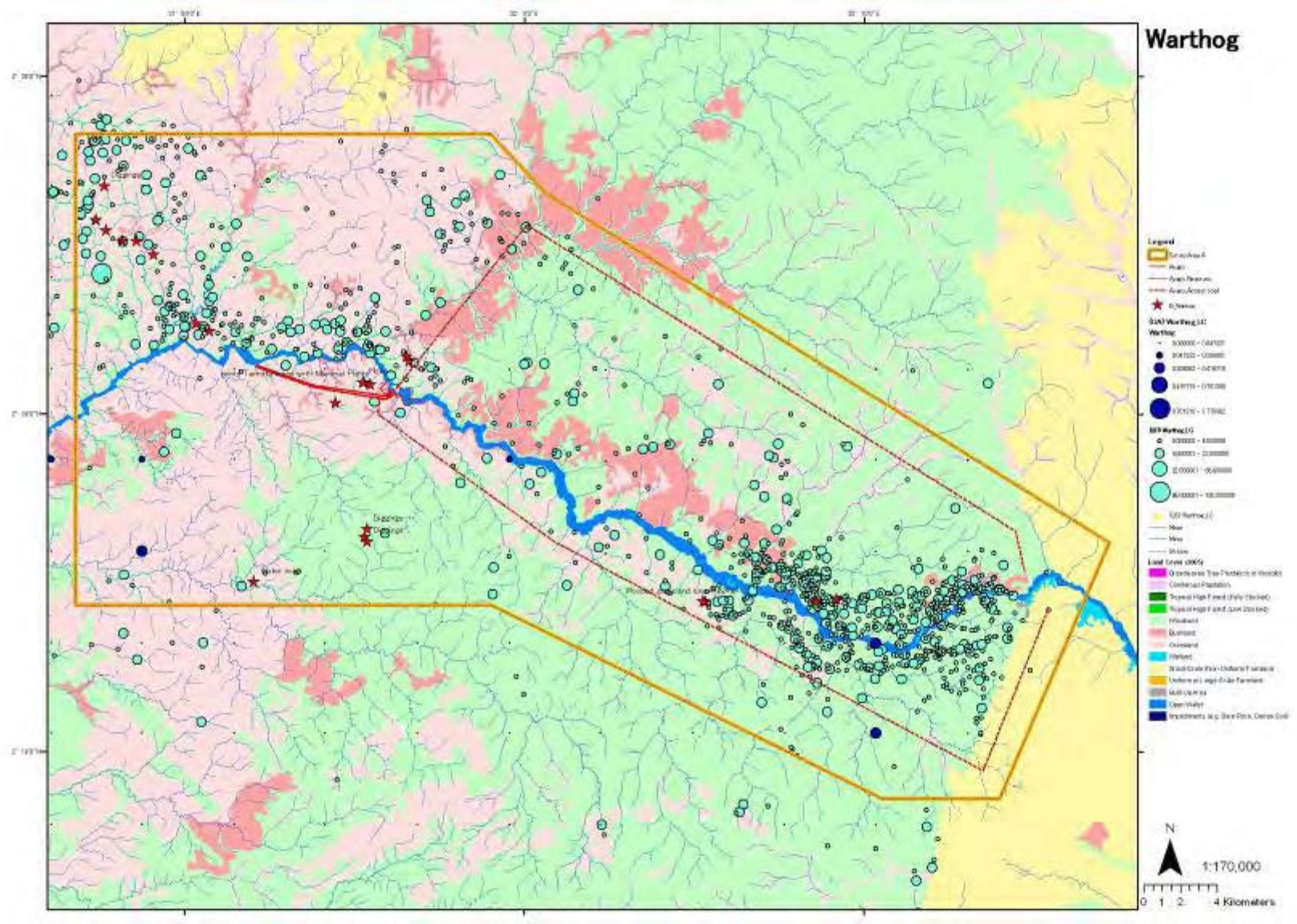


Figure 5 New and old records of presence or occurrence of Warthogs in the Ayago project area

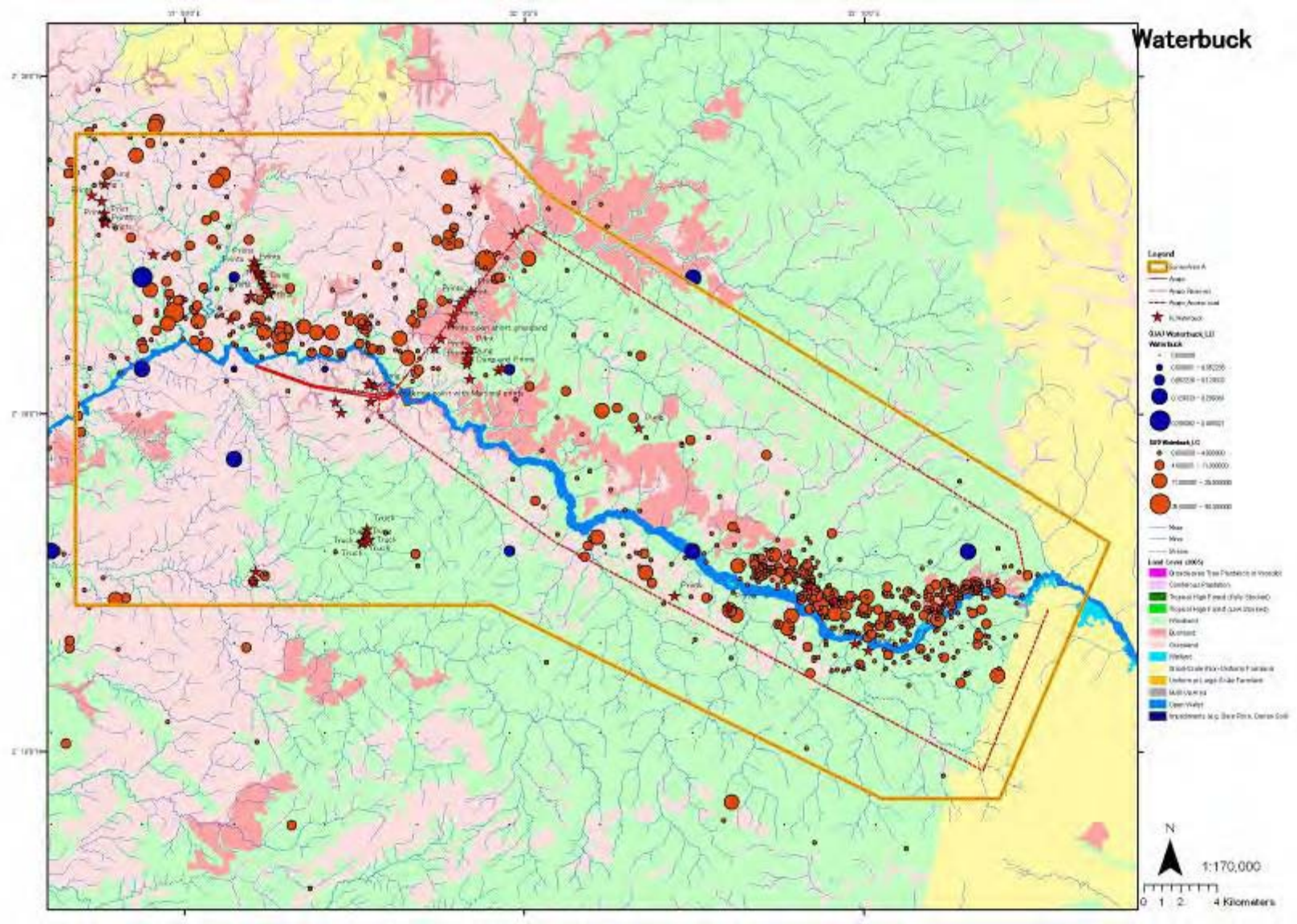


Figure 6 New and old records of presence or occurrence of Waterbucks in the Ayago project area

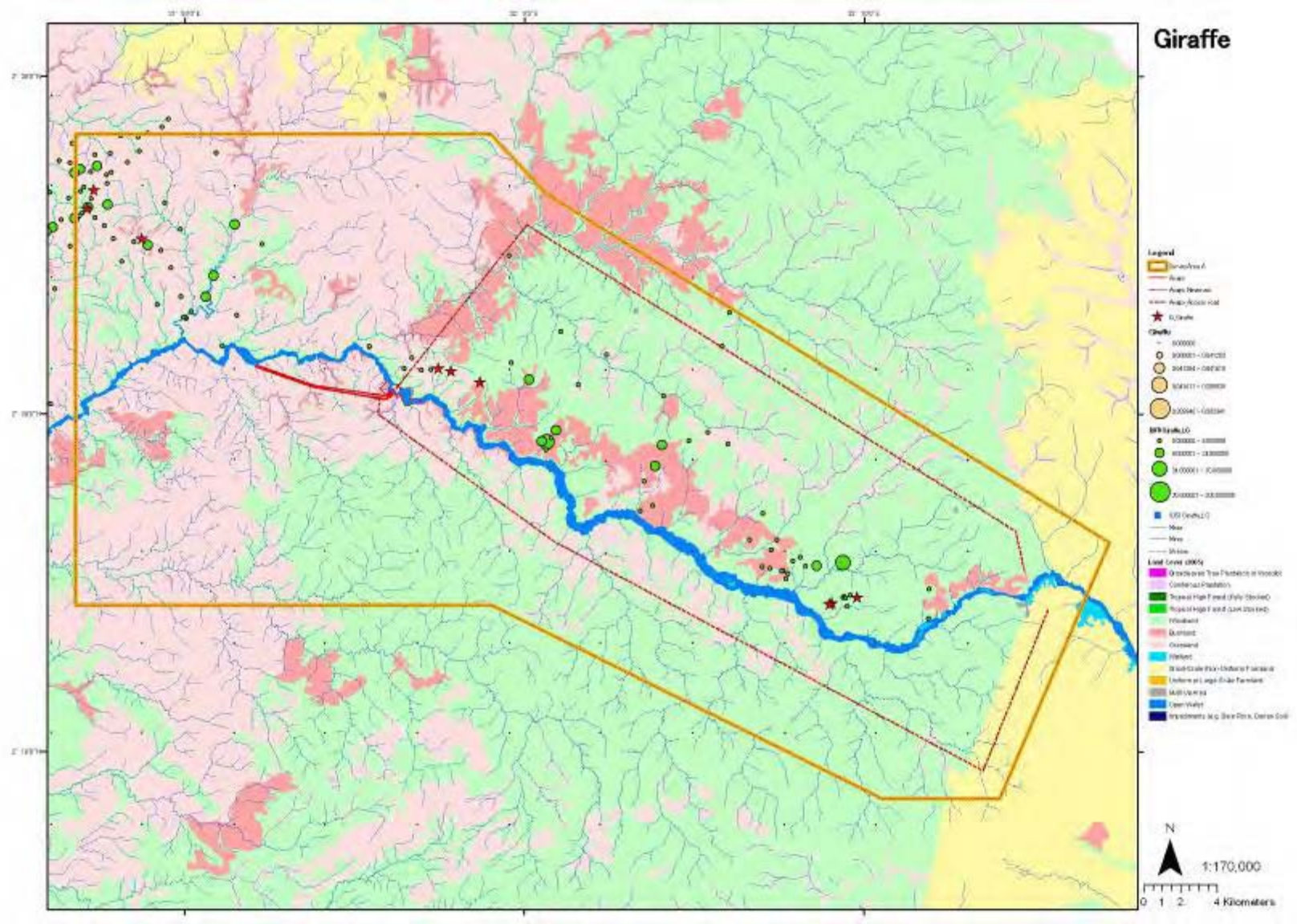


Figure 7 New and old records of presence or occurrence of Giraffe in the Ayago project area

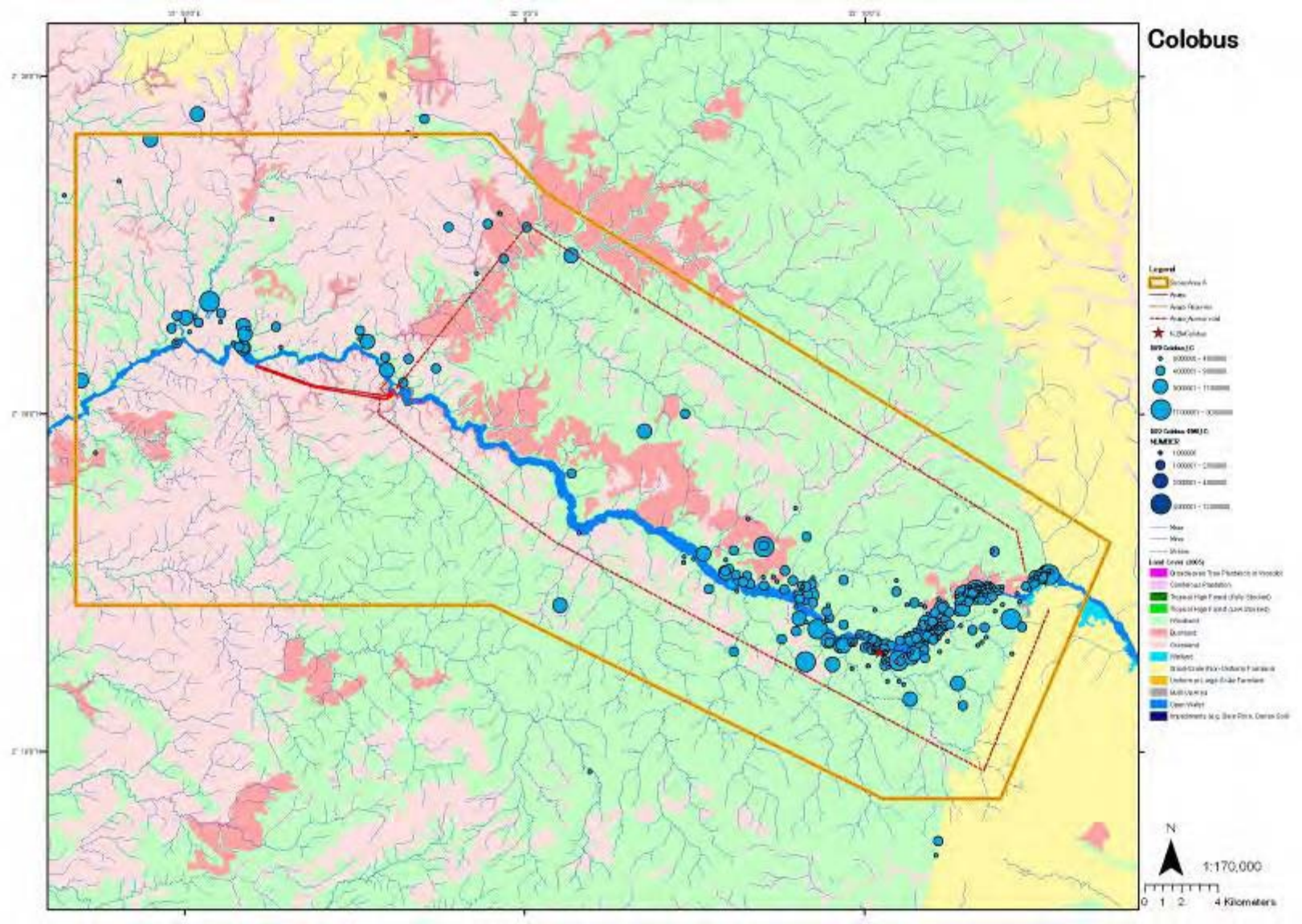


Figure 8 New and old records of occurrence of Black and White Colobus in the Ayago project area

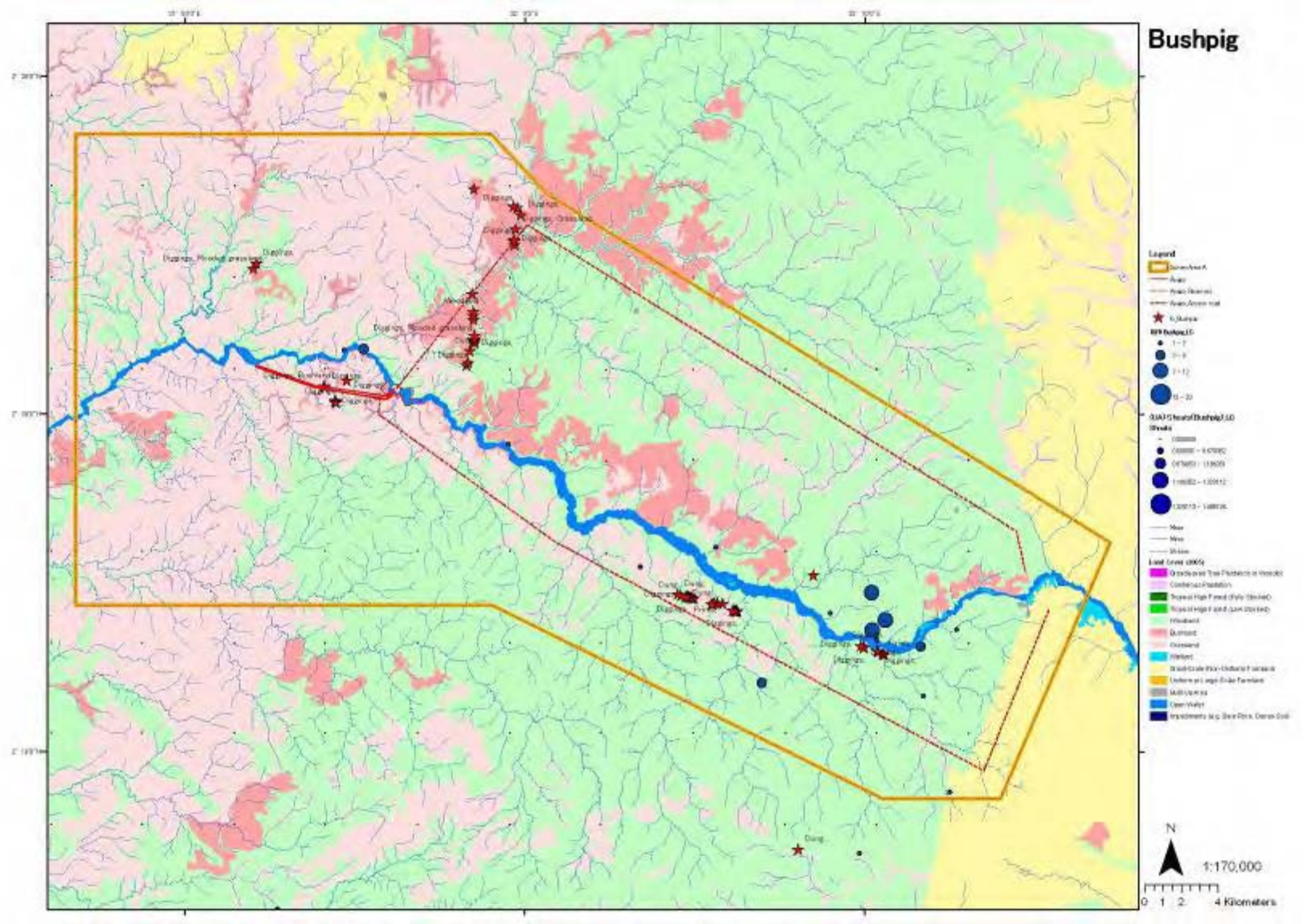


Figure 9 New and old records of occurrence of Bushpigs in the Ayago project area

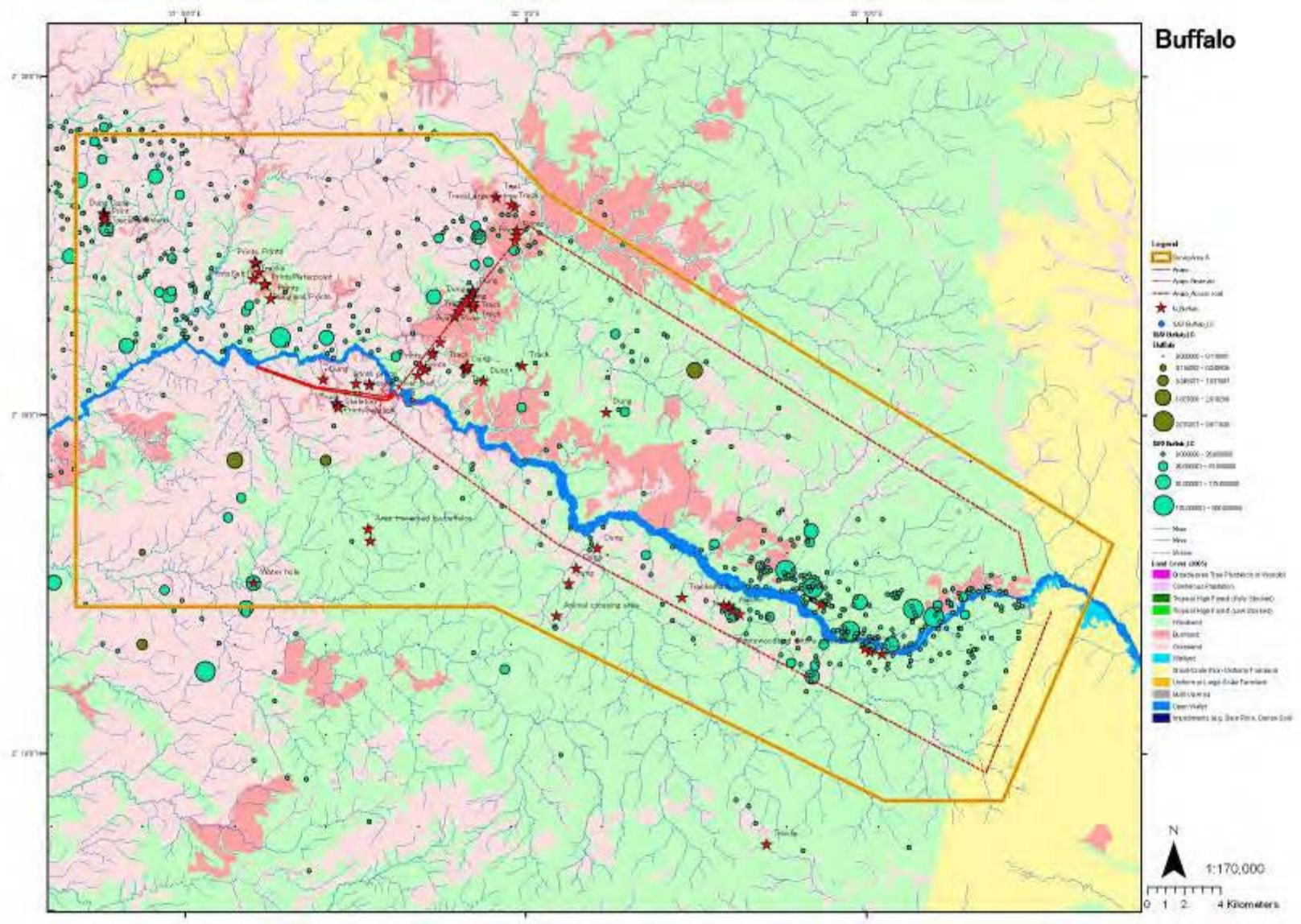


Figure 10 New and old records of presence or occurrence of Buffalo in the Ayago project area

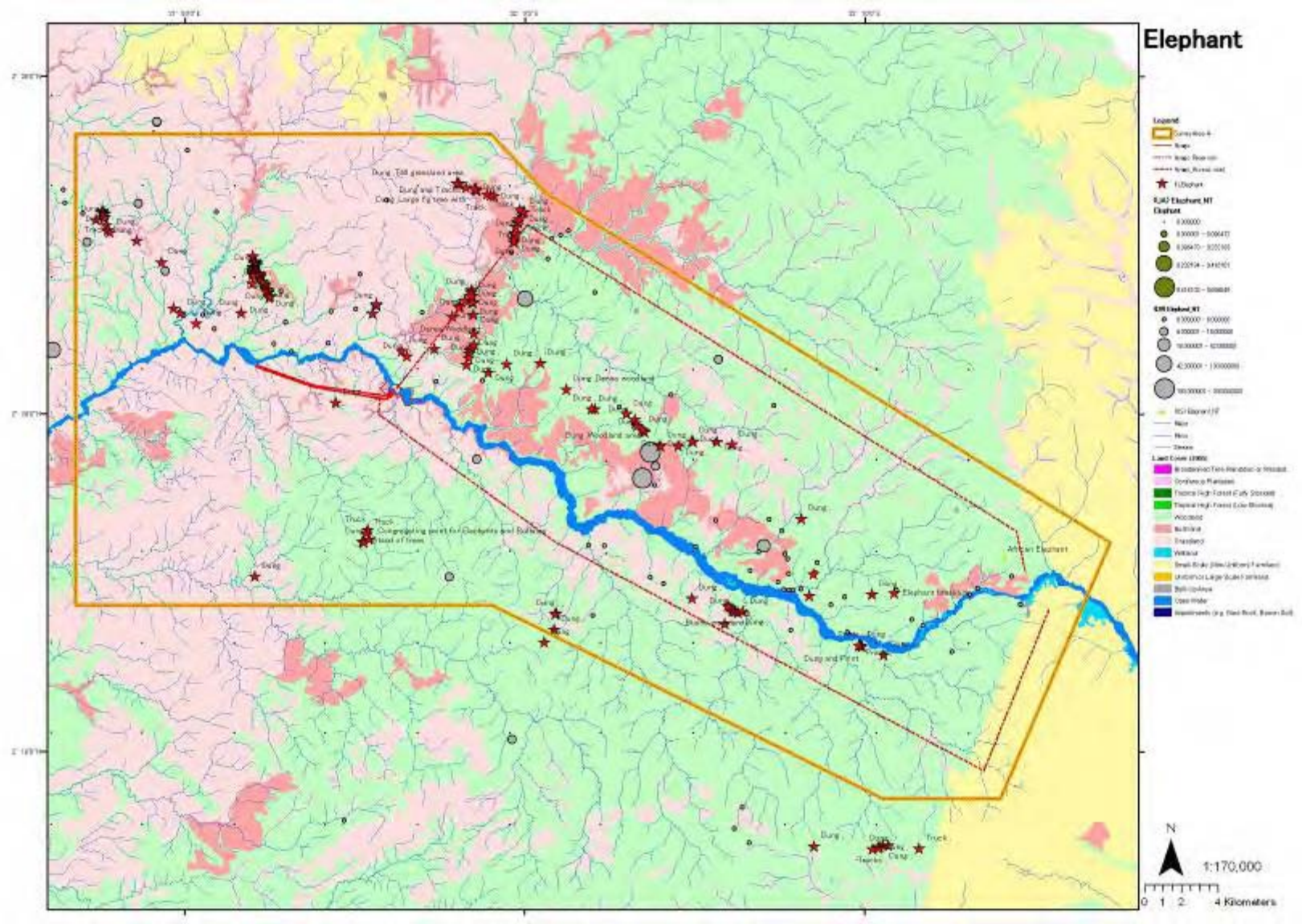


Figure 11 New and old records of presence or occurrence of Elephants in the Ayago project area

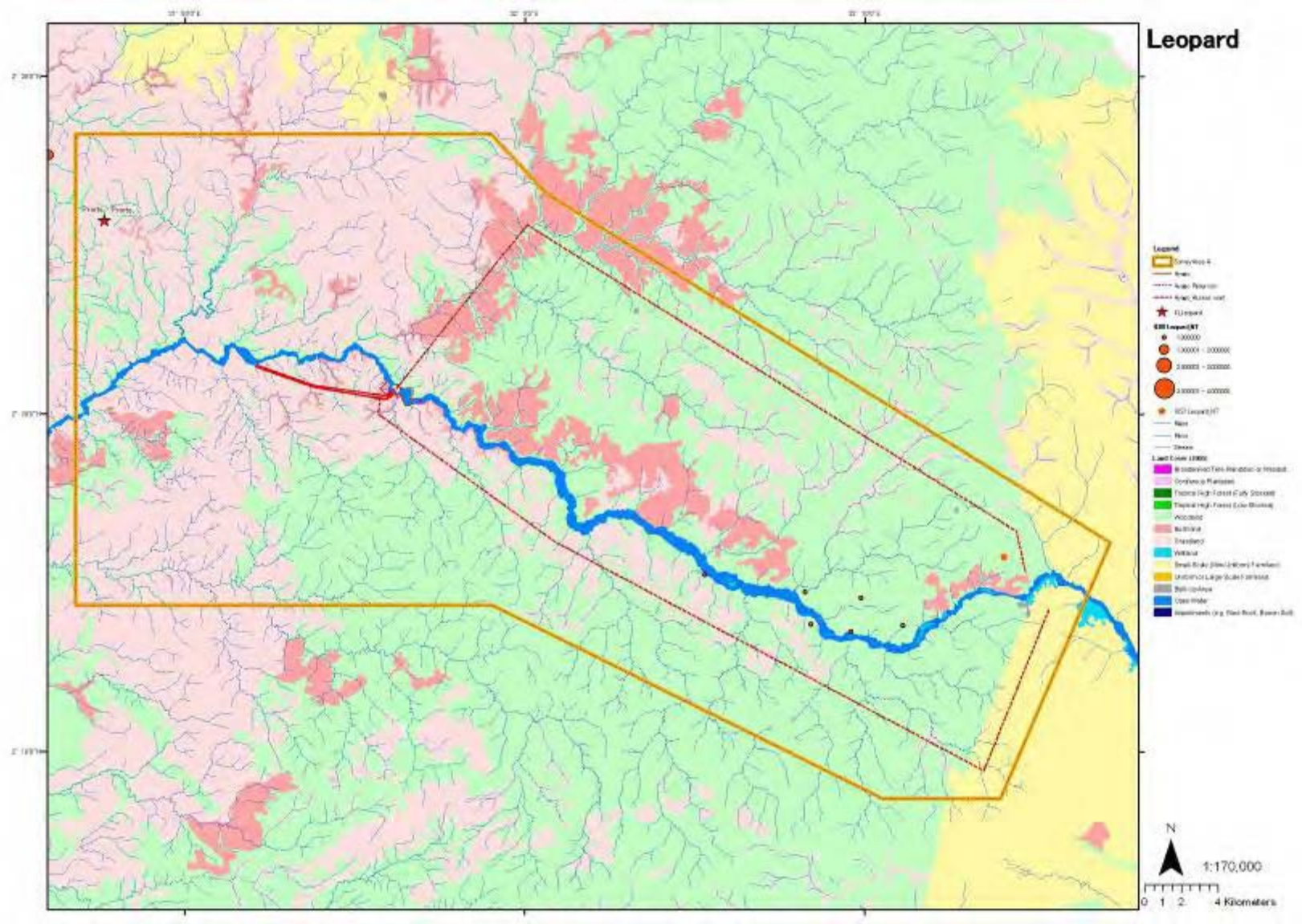


Figure 12 New and old records of occurrence of Leopard in the Ayago project area

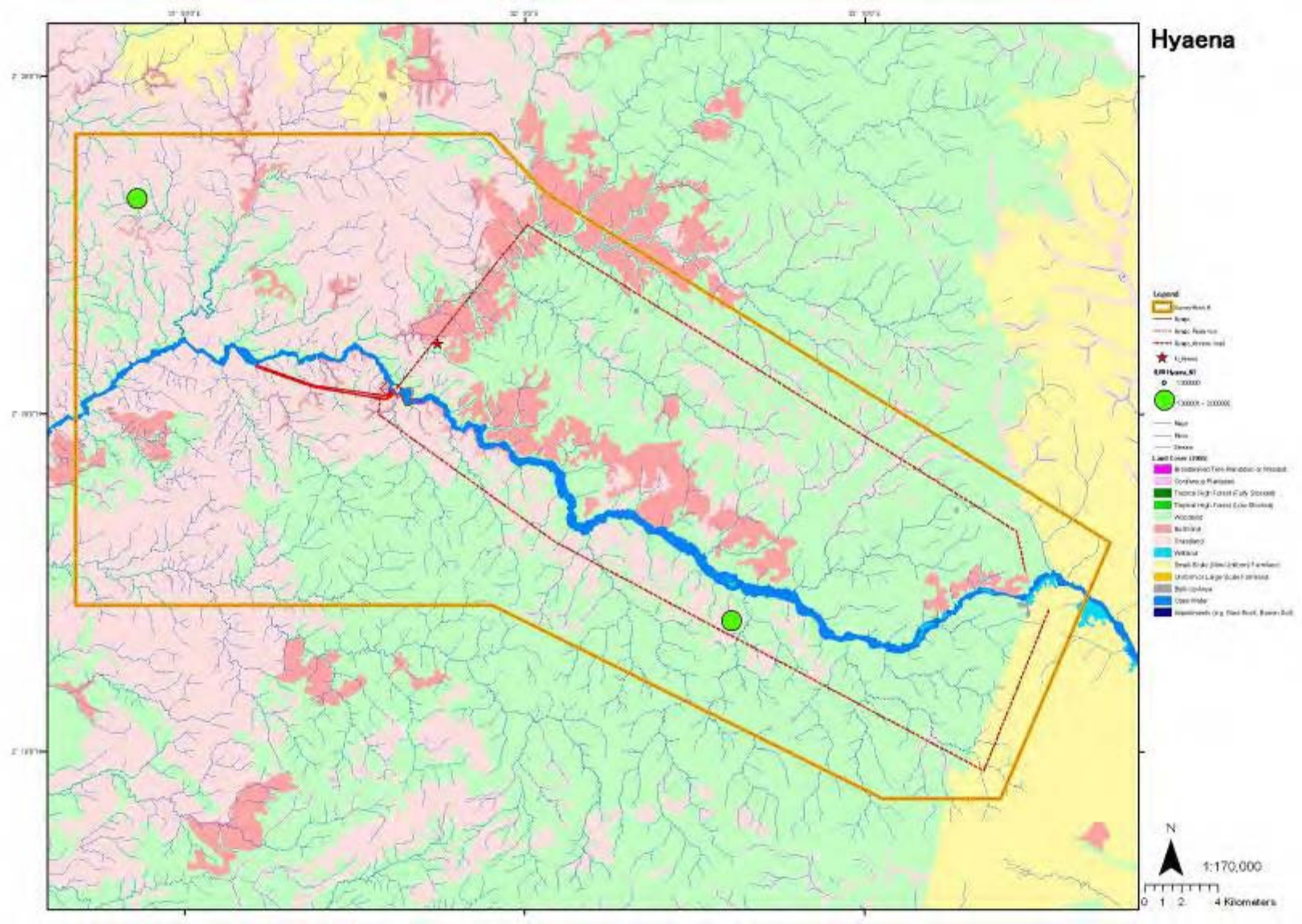


Figure 13 New and old records of occurrence of Hyenas in the Ayago project area

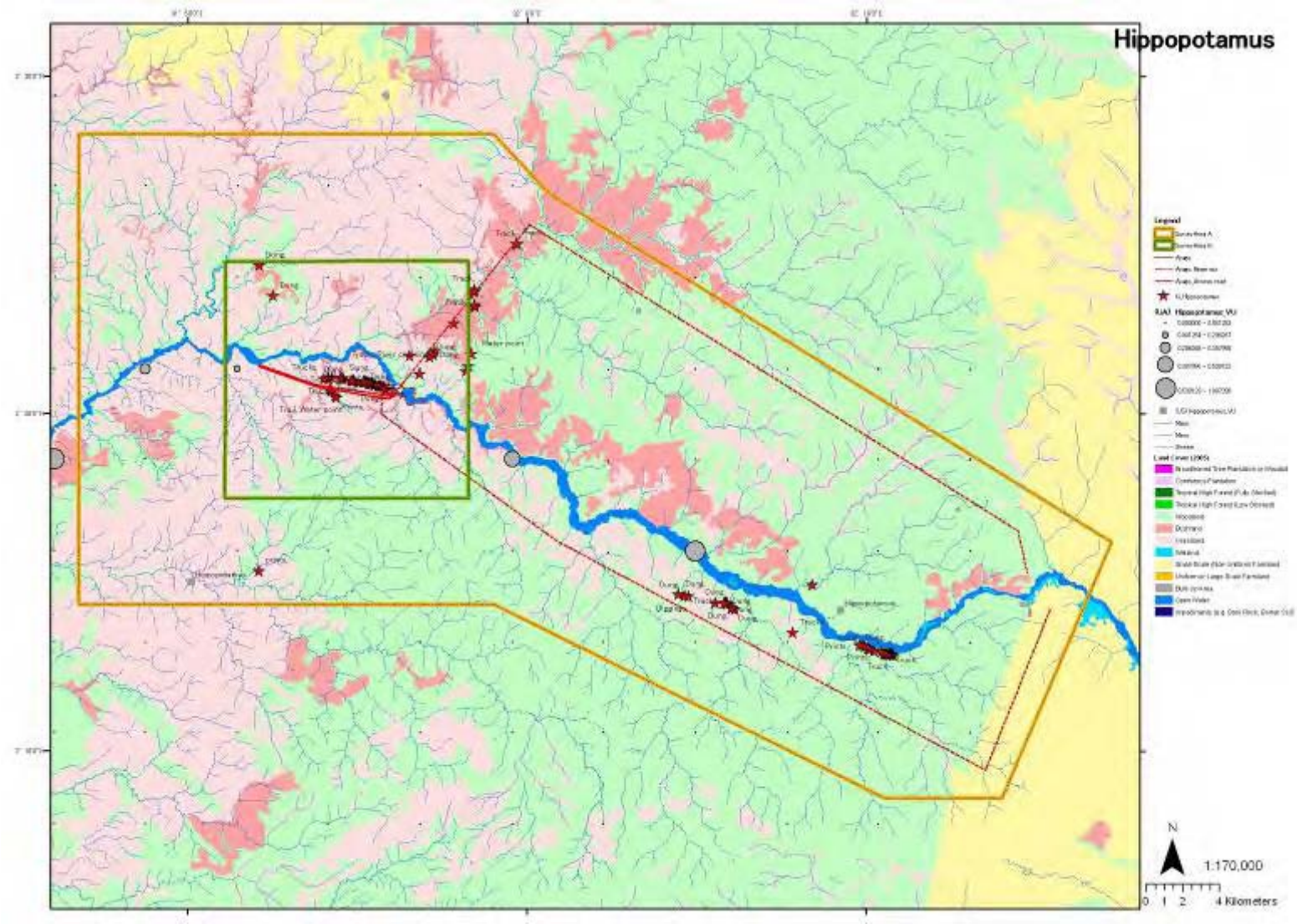


Figure 14 New and old records of presence or occurrence of Hippopotamus in the Ayago project area

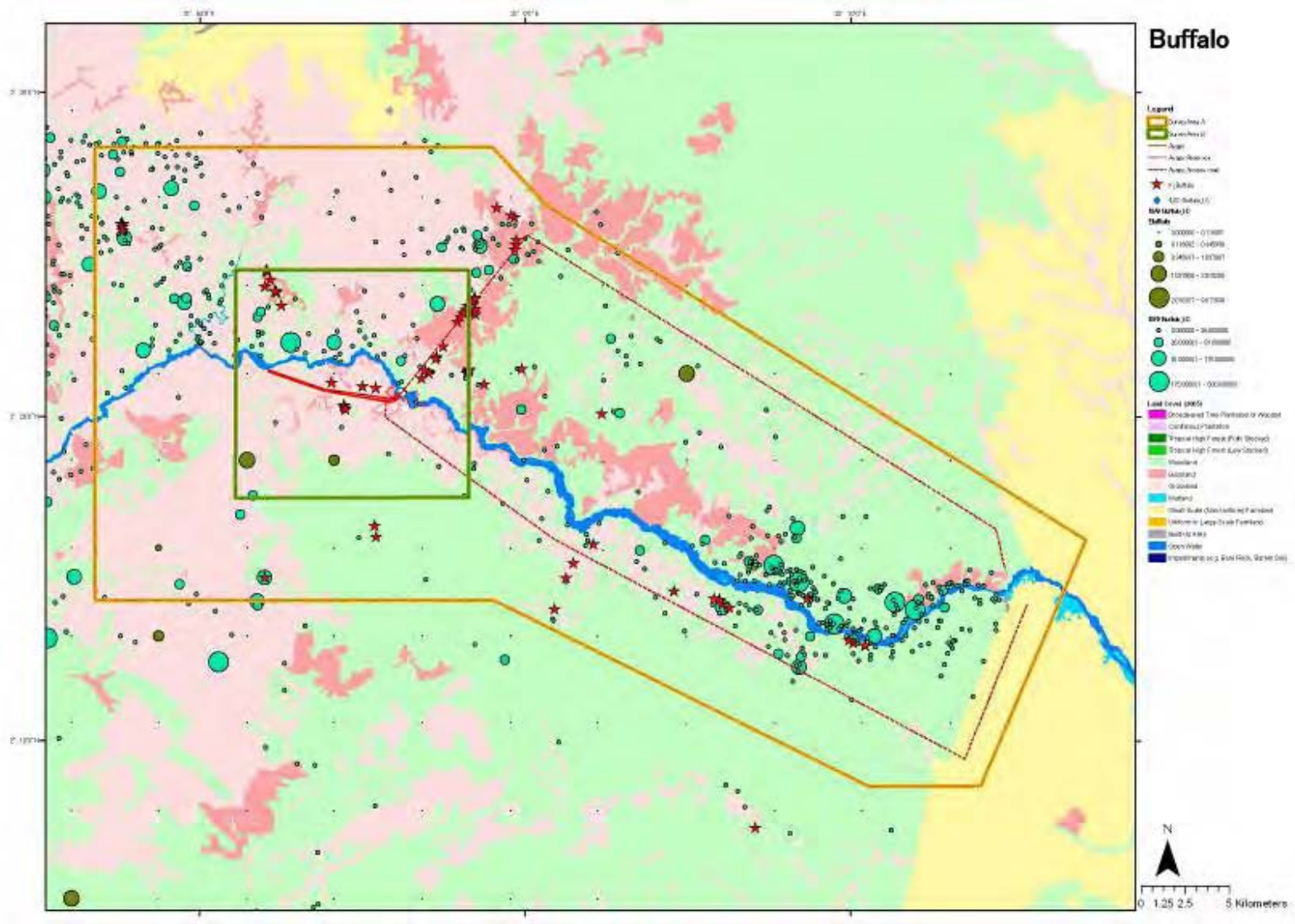


Figure 15 New and old records of presence or occurrence of Buffalos in the Ayago project area

4.1.4 Important habitats

It appears from the figures with many records that in all cases, the riverine situations within a stretch of about 4 kms, have higher levels of occurrence of the mammals or their signs implying that these may be preferred habitats.

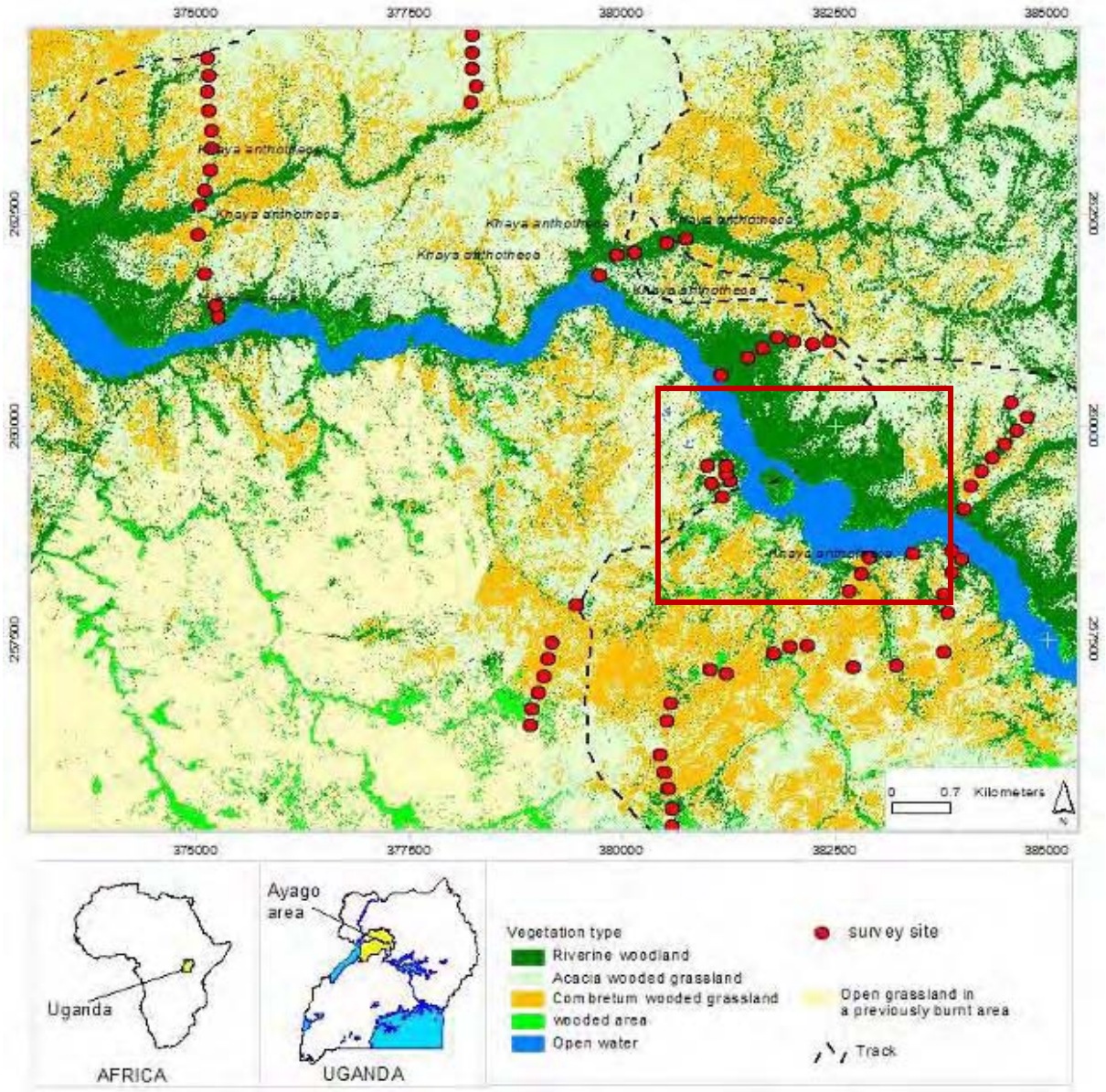


Figure 16 Detailed vegetation map for Survey area B

On the basis of the data accessed and the observations made, there is no basis to consider any of the mammal species recorded as restricted in the Ayago field project development area. Hippos would be the only mammal species that use the immediate riverside habitats on a daily basis as they move out and into the river to and from their foraging trips.

Open short grassland areas on the other hand would also provide the most suitable foraging grounds for the grazers. Fig 16 shows the concentration of these areas, which are classified as Acacia wooded and Combretum wooded grasslands.

The area enclosed by a red rectangle approximates largely the area of direct impact by the Ayago field project development area. In this, areas of Acacia wooded and Combretum wooded grasslands and Riverine woodland lie in the direct areas of impact.

4.1.5 Important species

Table M2 details the conservation status of the mammals of MFNP plus populations figures for 8 of the species. All together 5 species (Leopard (Panthera pardus- NT), Lion (Panthera leo – VU), Spotted Hyena (Crocuta crocuta – NT), Hippopotamus (Hippopotamus amphibious – VU), African Elephant (Loxodonta Africana – NT)) are considered of high conservation concern (NT – near threatened or VU- vulnerable).

For the species with some population trends data, it is evident that numbers have reduced from high figures in the 1970s to low population figures in the 2000s.

Table M2 IUCN listing status and population trends for important species of mammals in MFNP

Name			IUCN Red List status	Presence		Population in the MFNP							
Family	**English name**	**Scientific name**		**area A**	**area B**	**pre-1973a**	**1980b**	**1991c**	**April 1995d**	**Dec. 1995e**	**June 1999f**	**May 2002g**	**Jul-05**
Cercopithecidae	Olive Baboon	*Papio anubis*	LC	√	√								
	Black & White Colobus	*Colobus guereza*	LC	√	√								
	Red-tailed Monkey	*Cercopithecus ascanius*	LC										
Felidae	Leopard	*Panthera pardus*	NT		√								
	Lion	*Panthera leo*	VU										
Hyenidae	Spotted Hyena	*Crocuta crocuta*	NT	√	√								
Hippopotamidae	Hippopotamus	*Hippopotamus amphibius*	VU	√	√	12,000	7,565	-	1,498	1,238	1,792	-	2,104
Suidae	Bush Pig	*Potamochoerus porcus*	LC	√	√								
Suidae	Common Warthog	*Phacochoerus africanus*	LC	√	√	-	-	-	411	856	1,639	-	2,298
Bovidae	African Buffalo	*Syncerus caffer*	LC	√	√	30,000	15,250	1,610	1,087	2,477	3,889	8,200	11,004
	Bushbuck	*Tragelaphus scriptus*	LC	√	√								
	Sitatunga	*Tragelaphus spekii*	LC										
	Common (Bush) Duiker	*Sylvicapra grimmia*	LC	√	√								
	Hartebeest	*Alcelaphus buselaphus*	LC	√	√	-	14,000	-	3,068	2,431	2,903	-	4,101
	Uganda Kob	*Kobus kob*	LC	√	√	10,000	30,700	-	6,355	4,373	7,458	-	9,315
	Oribi	*Ourebia ourebia*	LC	√	√								
	(Defassa) Waterbuck	*Kobus ellipsiprymnus*	LC	√	√	-	5,500	-	539	566	792	-	1,441
Giraffidae	Giraffe	*Giraffa camelopardalis*	LC	√	√	150-200	-	78	100	153	347	229	245
Elephantidae	African Elephant	*Loxodonta africana*	NT	√	√	12,000	1,420	308	201	336	778	692	516

Note: Numbers in italics are from sample counts with standard errors omitted for clarity. Numbers in normal script are from aerial total counts. Sources: [a]UNP (1971), Laws et al (1976); [b]Malpas (1978), Douglas-Hamilton et al (1980); [c]Olivier (1991); [d]Sommerlatte & Williamson (1995); [e]Lamprey and Michelmore (1996); [f]Lamprey (2000); [g]Rwetsiba et al (2002).

VULNERABLE (VU) : considered to be facing a high risk of extinction in the wild, NEAR THREATENED (NT): close to qualifying for or is likely to qualify for a threatened category in the near future, LEAST CONCERN (LC): does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened

Table M3 Important mammals in the project area

Name	General Habitat	General Behavior	Estimated Distribution in Ayago Area
Leopard (Panthera pardus- NT)	An extremely wide habitat tolerance: from coastal plains to high altitude montains, from semi-desert areas to toropical rainforests.	Solitary with the exception of pairs coming together for mating, or when a female is accompanied by cubs. They are mainly active at night but in areas where they are not disturbed they can be observed moving during the cooler daylight hours. Most activity takes place on the ground but they are also capable climbers and swimmers. Adult males mark and defend a territory against other males, and a male's range may overlap those of several females. Territories are marked with urine scrapes, droppings, tree-scratching points and the deep 'sawing', or grunting, call. Females also call but this presumably serves no territorial function. Home ranges mey be as small as 10km2 in optimal habitat, to several hundred square kilometres where pray densities are low. They stalk and then pounce on their prey and do not rely on running at high speed like the cheetah.	Population in the park is unknown. The population in the Ayago project area, their range, and routes have not yet been clearly mapped..
Lion (Panthera leo – VU)	Very wide tolerance, from desert fringes to woodland and fairly open grasslands. Absent from true forest.	The most sociable larhe cat, living in prides ot between three and 30 individuals. Pride size is largely dictated by prey availability and various from region to region. The social groupings are complex, with each composed of a relatively stable core of related females, their dependent offspring, and usually a 'coalition' of two, or more, adult males. Most hunting takes place at night and during the cooler daylight hours. A pride territory is defended against strange lions by both males and females, but some prides and solitary males may be nomadic. Territories are marked with urine, droppings, earth-scratching and their distinctive roaring. These calls are audible over distances several kilometres. Pride home ranges vary from 26 to 220 km2 but in some cases may exceed 2000 km2.	There is no record yet near the project site, but the possibility of occurrence exists given the presence of suitable hunting grounds such as the lekking grounds and wallow areas. The population in the park is unknown but could be under 500 individuals. Population in the Ayago site, home range, moving route, and resting area has not been mapped yet.
Spotted Hyena (Crocuta crocuta – NT)	Open and lightly wooded savanna, dense woodland types, rugged, broken country; also penetrates drier areas	Solitary animals may be encountered, they usually live in family groups, or 'clans', led by an adult female. Clan size ranges from three to 15 or more individuals, with each clan defending a territory, which is marked with urine and anal gland secretions and the distinctive bright white droppings, usually deposited in latrine sites. They are both nocturnal and crepuscular, with more limited daytime activity. They frequently sunbask in the vicinity of their	Population in the park is unknown. Population in the Ayago site, home range, moving route, and resting area has not been mapped yet.

Name	General Habitat	General Behavior	Estimated Distribution in Ayago Area
	along vegetated water-courses.	daytime shelters. Countrary to popular opinion, they are not skulking scavengers, although they are not above driving other predators such asn lions from their kills.	
Hippopotamus (Hippopotamus amphibious – VU)	Sufficient water to allow for complete submergence is a requirement, and preference is shown for permanent waters with sandy substrates. Access to adequate grazing is also essential but these animals will move several kilometores away from water-bodies to reach suitable feeding areas.	Semi-aquatic, spending most of the daylight hours in water, but emerging frequently to bask on sand- and mudbanks and on occasion to feed, particularly on overcast, cool days and in areas where they are not disturbed. They emaerge at night to move to the grazing grounds, which may be a few 100 metres to several kilometres away (distances of up to 30km have been recorded), depending largely on the quantity and quality of grazing and the size of the population. They noemally live in heads, or schools, of between 10 and 15 individuals, although larger groups and solitary bulls are not uncommon. In areas of high density heads of 30 or more animals are common. Territories in the water are very narrow but broaden towards the grazing grounds. Territorial defence is greatedt in and close to the water but the little consequence in feeding areas. Herds disperse when feeding; only retaining their integrity when in the water. Fixed pathways to and from feeding grounds are used and these are characterized by a 'tram-line' trail, consisting of two pararell tracks separated by a slightly raise centre ridge. The hippopotamus is considered dangerous mammal, as attacks almost invariably result in death for the unfortunate who provokes, wittingly or unwittingly, on of these animals.	Around 2000 hippopotamus are living between Karuma to Murchison. Average population density is ***/km. High populated area is unknown. They disperse for grazing at least 1km away from the River Nile. Preffered grazing areas have not been identified.
African Elephant (Loxodonta Africana – NT)	Extremely wide habitat tolerance, including coastal, montane, forest, different savanna association, semi-desert and swamp, woth the only requirements being access to adequate food, water and usually shade.	Home range size varies considerably and usually relates to the abundance of food and accessto water, with matriarchal, or family, groups ranging over 15 to > 50 km2, but are frequently smaller. Ranges of the forest race are generally much smaller, primarily because of greater abundance of food. They are highly social, living in samall family herds consisting of an older cow and her offspring, with larger groups including other related cows and their calves of different ages. At certain times, usually at waterpoints or at abundant and localized food souces, several of these matriarchal groups may gather to form temporary 'herds', sometimes up to several hundred, but each family unit retains its integrity.	Around 500 elephants are living in the MFNP. High populated area, home range, number of the herds, migration routes has not been identified. Population in the northern bank seems higher than southern bank.

Source: Field guide to the larger Mammals of Africa (Chris & Tilde Stuart, 2006)

4.1.6 Potential impacts on mammals

- The large species including Elephants, Buffalo and Giraffe have quite large ranging grounds and it is not likely that a major proportion of their range and habitats will be significantly and negatively affected by operations of the Ayago field development project.
- The access route to the north bank starts in an area suitable for congregation of large numbers of particularly Uganda Kob but also other species. The grass in this area is quite low an evidence of heavy grazing pressures but in addition, the location also bears several fairly sizable wallows. The access to the operational area on the south bank also crosses through a fairly extensive area of wooded grassland with low short grasses, also very suitable grazing area for Buffalo, Kob, Waterbuck, Warthog and others. Operations and increased human presence in these areas are likely to result into disruption of the normal behavior of the wildlife in these areas.
- Any clearance of vegetation either for establishment of camps or for installing access routes would result into considerable vegetation clearance and loss of habitats. This will particularly have a larger impact on the closed vegetation in the Riverine woodland.
- Table M4 summarises other potential impacts on the mammals during construction or operational phases.

Table M4 Possible risk to mammals

	Possible Impact
Loss of Habitat	Feeding area, resting area, sleeping area will be reduced. Hippotamas might loose the swimming area caused by water recession.
Habitat alteration	Altered habitats may translate into reduced range or foraging areas for the mammals
Reduction of Home range	If the access road prevents moving of animals, it might reduce the home range.
Reduction in extent of feeding ground	Could result into increased pressure on other habitats resulting into adverse impacts on the vegetation through for example overgrazing which would reduce the overall suitability of the habitats for he mamals
Disruption of routes	If the access road or camps prevent movement of animals, it might block their routes
Reduction of lekking grounds	Lekking grounds/areas may be distryed or disturbed by continued presence of humans, increased traffic or construction of camps or roads.
Destruction of wallows	Wallows could be entirely lost, reduced or contaminated with engine oil from vehicles in the park
Introduction of invasive species	Invasive species such as *Lantana camara* could adversely change foraging and range areas for the species, reducing the extent or quality of such areas.
Introduction of hazardous materials	Introduction of plastics for example could pose harzards if ingested by wildlife
Risk of road kill	Construction vehicles might cause accidents. It might reduce the population.
Risk of poaching	Access roads make it easy to approach prohibited areas. It might cause poaching.

4.1.7 Recommendations

Niche breadth, distribution of suitable habitats types and correlation analyses of these will need to be done using historical data on species occurrence to enable a better understanding of actjal and potential distribution of mammal species in MFNP.

In order to identify the real home range, numbers of herds, migration routes, and prefered areas for different species,a telemetry survey stretching over four years might be needed for some important species.

Arial surveys done at least twice a year for two years would contribute to a better estimate of animal populations, distribution and trends.

Ground truthing surveys will be needed particularly in the areas of denser woodlands where arial counts may not be adequate for observing presence of mammals. This will be particularly usefull in the heavily wooded areas.

4.2 Birds

4.2.1 Methods

Surveys for birds were conducted along the same transects that were used for the other animal taxa. The approach used for these surveys did not follow the traditional use of timed species counts, point counts or mist netting.

Species seen or heard were recorded along the transects to compile checklists. Since the surveys for all terrestrial animal groups were done together, the bird surveys were also conducted walking at a speed of 1 km per hour.

4.2.2 Literature survey results

A total of at least 491 species of birds are known to occur in MFNP (Wilson 1995). Appendix 1 presents a list of these species that include at least 53 species of small, medium to large sized species of birds of prey 15 species o which are considered to be either globally or regionally of conservation interest. . Altogether, as many as 64 species of birds from MFNP are categorized as either of global conservation concern or of relatively local (Eastern Africa) conservation concern (Table B1 and details in Appendix 1).

The species list of birds for the park comprises a total of 116 migrants species (Wilson 1995) of both the intra African and inter continental migrants.

Table B1 Distribution of species of birds of MFNP by threat categories

Threat Category	Number per category
G-DD	1
G-LR/nt	2
G-LR/nt R-NT/RR	1
G-LR/nt R-VU	1
G-LR/nt, R-EN	1
G-LR/nt, R-NT	2
G-LR/nt, R-VU/RR	1
G-NT/RR, R-NT/RR	1
G-VU, R-NT	1
G-VU, R-VU	1
R-NT	28
R-RR	12
R-VU	12
R-VU/RR	1

Key to threat categories (these follow IUCN categories also adopted for Uganda by Wilson (1995) and Carswell et at (2005))

- G-CR - globally critical, G-EN - globally endangered, G-VU - globally vulnerable, G-LR/nt - globally lower-risk, near threatened, G-DD - globally data deficient, G-RR - globally range-restricted,
- R-CR - regionally critical, R-EN - regionally endangered, R-VU - regionally vulnerable R-NT - regionally near-threatened R-RR - species of regional responsibility

4.2.3 Field survey results

The bird species in the categories F and f would be more likely to be affected than any of the others due to habitat loss particularly in the riverine wooded vegetation. Other species with high likelihood to be affected would include the ground nesting birds such as Plovers. We don't see much likelihood of major negative impacts on the water birds resulting from the project.

The ecological walk over surveys in the Ayago project area recorded a total of 112 species of birds (Appendix 2). These represent a little over 20% of the avifauna of the Park. Since birds unlike the mammals are able to fly it is unlikely that certain species will be strictly restricted in one section of the park and not others. The only species that might have a restricted occurrence within the park are the Shoebill stork for which known records in the park are so far from the Delta area.

4.2.4 Important habitats

Over 53% of the known avifauna of MFNP has recognized habitat preferences (Wilson 1995), Table B2 presents a summary for the species of birds of MFNP that have known specific habitat preferences. 47% of the bird species of MFNP are on the other hand generalist species not tied to a particular habitat. Of the species with a particular habitat preference, the species are split nearly half and half between species with affinity to forested areas or areas with a considerable amount of woody vegetation and those associated with water..

Table B2 Distribution of the birds of MFNP by habitat preferences

Habitat preference	Number per category
Af/FF	1
AW	1
F	103
f/F	1
FF	9
fW	9
FWW	6
W	41
WW	90
Grand Total	261

Key to habitat preference categories

W - always resident in or near water (WW refers to a species strictly tied to a water habitat), w - often resident or observed in or near water, F -Forest resident (FF- refers to species of strictly forested habitats), f - resident in and near forests, Af - intra-African migrant,

Table B4 summarizes the habitat preferences for those species recorded in the project area that are not generalists. Species with preference for forested habitats dominated the species with particular habitat preferences.

Table B4 Summary of habitat preferences for species recorded in the project area

Habitat preference	Number per category
f	26
FF	2
fW	2
FWW	1
W	8
WW	8
Grand Total	47

4.2.5 Important Species

Of the bird species recorded 9 species are considered of conservation concern at the regional Eastern Africa level (Table B3). Survey area B had only six of these species while all 9 species were recorded in Survey Area A. Also of relative importance is the presence of as many as 10 species of birds of prey (Osprey -, *Pandion haliaetus*, Palm-nut Vulture - *Gypohierax angolensis*, Brown Snake Eagle - *Circaetus cinereus*, Western Banded Snake Eagle - *Circaetus cinerascens*, Bateleur - *Terathopius ecaudatus*, African Harrier Hawk - *Polyboroides typus*, Shikra - *Accipiter badius*, Lizard Buzzard - *Kaupifalco monogrammicus*, Tawny Eagle - *Aquila rapax*, and the Long-crested Eagle - *Lophaetus occipitalis*) in the project area. These are of importance since; the presence of a rich diversity of top predators is a reflection of the health of an ecosystem in more ways than one.

Table B3 Species of birds of conservation concern recorded in the project area

Briton Number	Common name Scientific name	Threat	Habitat preference	Survey area A	Survey area B
B36	Purple Heron *Ardea purpurea*	R-NT	WW	√	√
B178	Brown Snake Eagle *Circaetus cinereus*	R-NT		√	√
B180	Western Banded Snake Eagle *Circaetus cinerascens*	R-VU	F	√	√
B324	Ring-necked Francolin *Francolinus streptophorus*	R-VU/RR		√	√
B468	Rock Pratincole *Glareola nuchalis*	R-VU	WW	√	
B876	Swallow-tailed Bee-eater *Merops hirundineus*	R-NT		√	
B984	Spot-flanked Barbet *Tricholaema lacrymosa*	R-RR		√	√
B1120	White-headed Saw-wing *Psalidoprocne albiceps*	R-RR	f	√	√
B1949	Sharpe's Starling *Cinnyricinclus sharpii*	R-NT	FF	√	

(Acronyms used in the table are similar to those for Table 1)

4.2.6 Potential impacts on birds

i. Clearance of woody vegetation in the immediate riverside habitats could potentially destroy prime nesting sites for large birds of prey such as Fish Eagles as well as large Storks which require large trees for nesting or roosting.

ii. Fish Eagles could also potentially loose staging posts where they rest to feed on their catch in the woodland areas in the immediate riverside woodland areas.

iii. Ground nesting birds such as Plovers, Ducks, Frankolins face the risk of nest destruction and clutch failure due to ground level vegetation clearance for making access roads and camps.

Nests of these kinds of birds are usually not quite conspicuous that it may be difficult to avoid them many of the times.

iv. The small wier at the dam intake although not expected to result into a major pondage, could potentially create a habitat suitable for several species of water birds.

v. The risk of road kills of birds such as Doves, Guinnea Fowls, Francolins and Spurfolws that commonly forage or rest on roads and such open grounds, and Raptors that may swoop down to pick dead animals on the road, could be enhanced if speed limits are not instituted on access and operational routes.

4.2.7 Recommendations

Although the avifauna of MFNP is fairly well known, detailed distribution maps for the species in the Park are lacking. Except for the Shoebill Stork with a very particular niche requirement, it is likely that many of the other species will be fairly widespread in the Park. For purposes of guiding the EIA study it will be usefull to conduct niche breadth assessments as well as assessments for occurrence of suitable habitats for species of:-

i. conservation concern,
ii. species of restricted range,
iii. top predators
iv. species with particular habitat requirements

This coupled with the vegetation map of MFNP produced for this report could enable a better understanding of potential distribution of these species in the park. Such an understanding would enable predictions of the potential range of these species in the Park upon which directed mitigation actions need to be considered.

Surveys conducted every quarter would make it possible to understand the trends and turn over of species composition in the Ayago field project area in the park.

4.3 Herpetofauna (amphibians and Reptiles including Crocodiles)

The herpetofauna surveys covered selected representative sites in survey areas A and B as specified in the technical specifications.

The main aim of the study was to asses the impact the construction and accessory activities of the dam would have on herpetofauna in the project area.

The objectives of the study were to:-

- Document amphibian and reptilian species in survey areas A and B.
- Identify the important habitats of amphibian and reptilian species in survey areas A and B.

- Assess the conservation status of the recorded species
- Assess generally the impact the hydropower activities would have on amphibian and reptilian fauna and their habitats
- Make preliminary recommendations on how to mitigate the negative impacts the activities might have

4.3.1 Methods

Line census and Visual Encounter Surveys

Line transects were placed randomly in the survey areas A and B, in the main vegetation zones as indicated on the vegetation map, to cover as many amphibian and reptilian habitats as possible and Visual Encounter Surveys employed to document the species. Visual Encounter Survey is a time-honoured technique and is similar to the Timed Constrained Count (TCC) method described by Heyer et al., (1994). The transect length was usually between 1-10km depending on the vegetation zones targeted or even more if road drives were considered.

For the Nile crocodile, point counts were made from the river banks since the motor boat or low-lying aeroplane was not used. Although Nile crocodile is listed as "Least Concern" on the IUCN Red List, since "the stretch of river between Murchison Fall and the delta has one of the biggest concentrations of the species of the world" (Hutton, 1991), careful attention was therefore to be given to this species.

Identification of the herpetofauna followed Channing and Howell (2006) and Spawls et al., (2002, 2006).

4.3.2 Leterature survey results

There is only a scanty amount of published literature on amphibian and reptilian fauna of Murchison Falls National Part. Parker (1969) reported on the crocodile numbers and distribution using diurnal aerial counting and nocturnal ground counts methods. Hutton (1991) reported that the stretch of river between Murchison Falls and the delta was one of the biggest concentrations of crocodiles in the world. Behangana (1999) reported on the herpotafauna of Karuma Hydropower Project. Other studies in the 1990's by Kaija Baguma on the distribution of crocodiles in the Murchison Falls and by Behangana on reptiles and amphibian fauna of Kanio-Pabidi and Murchison Falls, were never published.

4.3.3 Field survey results

A total of 11 amphibian species belonging to three families were documented during the study. The most important habitats for the amphibians were mostly wetlands and river valleys.

A total of 16 reptiles belonging to two orders (the true reptiles and turtles and tortoises) and 12 families were recorded during the study. The reptiles – other than the Nile Crocodile which is a resident of the rivers, were randomly distributed throughout the habitats sampled. However, tortoises were only encountered in the wooded grassland while the Pelomedusids were only recorded in rain pools of water or wetlands/marshes.

Table H 1 Amphibians and Reptiles of Ayago

Name			IUCN Red List status	Survey area A			Survey area B	
	Family name	Scientific name		I. Habitats Adjacent to the Nile River Banks near the point of dam placement	II. Woodlands and Bushlands on the northern bank	III. The areas along the Karuma-Rabongo Forest	IV. Woodlands and Bushlands on the southern bank	V. Grassy Plains on the southern bank
Amphibians	Family Bufonidae	*Amietophrynus maculatus*	*Least Concern (LC)*	1	0	0	1	0
		Amietophrynus regularis	*LC*	1	0	1	1	1
		Amietophrynus vittatus	*Data deficient (DD)*	1	0	0	0	0
	Family Hyperoliidae	*Afrixalus osorioi*	*LC*	1	1	0	0	0
		Hyperolius viridiflavus	*LC*	1	0	0	1	1
		Kassina senegalensis	*LC*	1	0	1	1	1
	Family Ranidae	*Amietia angolensis*	*LC*	1	0	1	1	0
		Phrynobatrachus acridoides	*LC*	1	0	1	1	1
		Phrynobatrachus natalensis	*LC*	1	0	1	1	1
		Ptychadena anchiateae	*LC*	0	1	1	0	1
		Ptychadena chrysogaster	*LC*	0	1	0	0	0
		Ptychadena mascareniensis	*LC*	1	1	1	1	1
Reptiles	Family Gecknoniidae	*Hemidactylus brookii*	*Not evaluated*	0	1	0	0	0
	Family Scincidae	*Mabuya maculilabris*	*Not evaluated*	0	1	1	1	1
		Mabuya megarula	*Not evaluated*	0	0	0	0	1
	Family		*Not*	0	1	1	0	0

	Chamaelionidae		*evaluated*					
		Chamaeleo laevigatus	*Not evaluated*	0	0	1	0	1
	Family Agamidae	*Agama agama*	*Not evaluated*	0	1	1	1	0
	Family Varanidae	*Varanus niloticus*	*Not evaluated*	1	1	1	1	0
	Family Crocodilydae	*Crocodylus niloticus*	*Least Concern*	1	0	0	0	0
	Family Typhlopidae	*Typhlops sp.*	*Not evaluated*	0	1	0	0	0
	Family Colubridae	*Dasypeltis scabra*	*Not evaluated*	0	0	0	0	1
		Philopthamnus sp	*Not evaluated*	0	1	0	1	1
	Family Elapidae	*Naja melanoleuca*	*Not evaluated*	1	1	0	1	1
	Family Viperidae	*Bitis arietans*	*Not evaluated*	0	0	0	0	1
	Family Pelomedusidae	*Pelomedusa subrufa*	*Not evaluated*	0	1	0	0	1
	Family Testudinidae	*Geochelone pardalis*	*Not evaluated*	0	1	1	1	1
		Kinixys belliana	*Not evaluated*	0	1	0	0	1

Where 1= Presence and 0 = Absence

4.3.3.1 Conservation Status of the herpetofauna recorded

All the amphibian and reptilian species recorded according to the IUCN (2010) Red listing are in the Least Concern (LC) category because they either have a very wide distribution, tolerant to a broad range of habitats or presumed to have large populations.

4.3.4 Important habitats

4.3.4.1 Survey area B:

The coordinate values of the corners of Survey area B are 31°51'6.000"E 2°24'31.000N, 31°51"6.000"E 2°17'30.000"N, 31°58'15.00E 2°17'30.000"N, 31°58'15.000" 2°24'31.000"N. Coordination system is WGS_1984_UTM_Zone_36N.

I. Habitats Adjacent to the Nile River Banks near the point of dam placement

The most important habitats in Survey Area B were those along the Nile River banks

- These are import in that the Crocodiles were seen especially in the temporary pools of water and in the slow moving water.
- The islands and the river-banks with sand and short vegetation are also important basking and breeding areas for the crocodiles.
- The wetland vegetation comprising of the water hyacinth is also important for amphibian fauna

II. Woodlands and Bushlands on the northern bank

- The woodlands and bushlands on the northern bank, particularly to the right of the road from Chobe Lodge sand-witched between N2° 21.043 E31° 58.391, N2° 24.000 E31° 58.495 and N2° 21.564 E31° 56.623 yielded the highest number of reptilian. The wetlands also recorded a good number of amphibian fauna. The amphibians recorded here included;

  Amietophrynus regularis

  Phrynobatrachus natalensis

  Ptychadena mascareniensis

  Hyperolius viridiflavus

  The reptiles included:

  Python sebae – *African Rock Python*

  Geochelone pardalis – *Leopard Tortoise*

  Naja melanoleuca – *Forest Cobra*

  Pelomedusa subrufa – *Pond Terrapin*

Mabuya maculilabris – *Speckle-lipped Skink*

Agama agama – *Orange-headed Agama*

III. The areas along the Karuma-Rabongo Forest

- The road from the Karuma-Rabongo Forest road to the fig tree passes through several valleys interspersed with river streams that are good for various amphibian species. Noteworthy was the seasonal wetland area with 1st order streams (N2° 20.905 E31° 55.336) that was a home to breeding Cricket Frogs (Phrynobatrachus spp) and Toads (Amietia spp) whose chorus could be heard from a kilometre or so away.
- The undulating grassy plains to the left of this road had also the Puff-adder recorded-Bitis arietans (N2° 20.001 E31° 54.644)

4.3.4.2 Survey area A:

I. Woodlands and Bushlands on the northern bank

- The woodlands along were also important habitat to the African Rock Python (N2 25.091 E31 59.693), the seasonal wetlands home to the water cobra (N2 26.681 E31 58.480) while the grassy plains were important for the egg-eater snake (N2 26.681 E31 58.480). The wetlands were also important to several common amphibian species.

II. assy Plains on the southern bank

- The grassy plains yielded Chamaeleo laevigatus (N2 15.372 E31 52.132) and Mabuya megalura (N2 15.422 E31 52.168). Several common amphibian species were also recorded

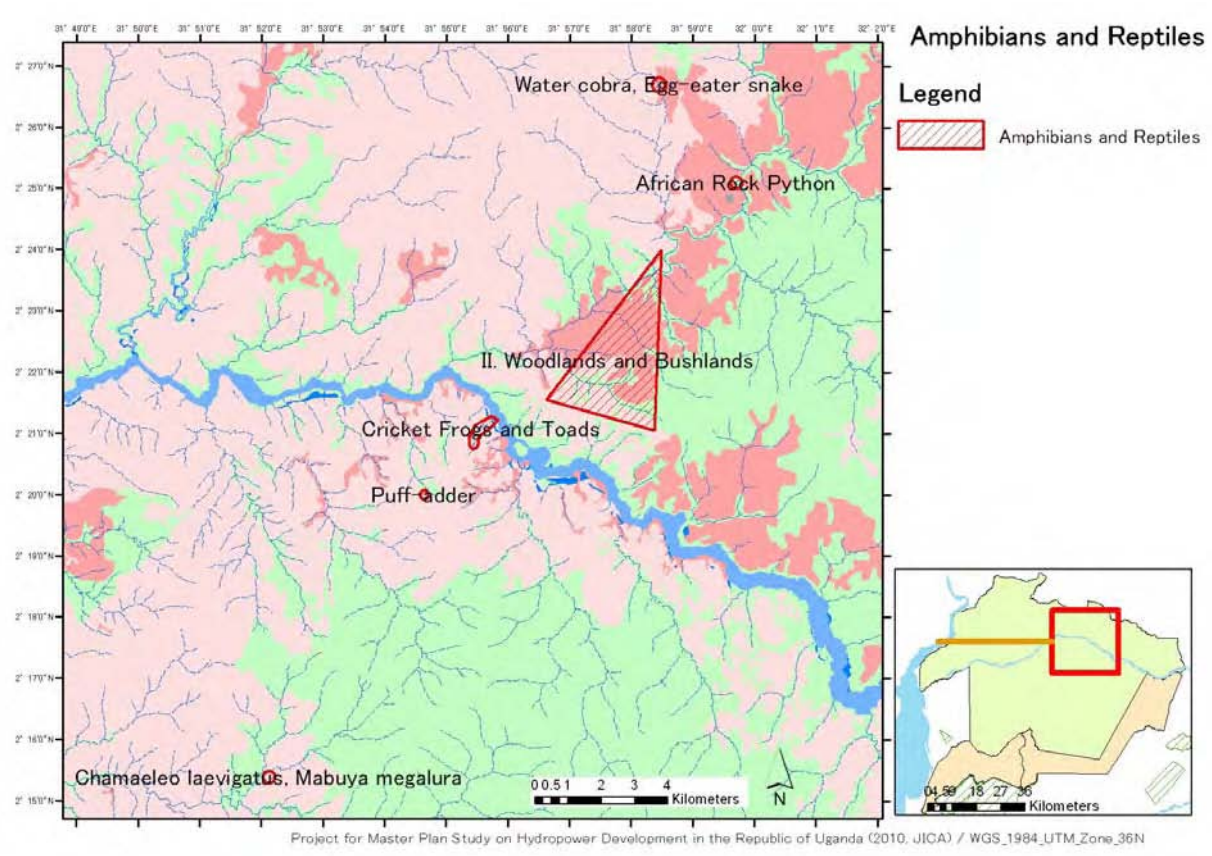


Figure 17 Recorded points and Woodlands and Bushlands

4.3.5 Important Species

The important species of the Murchison Falls were the toad – *Amietophrynus vittatus* and the Nile Crocodile – *Crocodylus niloticus*.

4.3.6 Potential impact on herpetofauna and their habitats

- The most significant impact the hydropower project activities might have on the herpetofauna and their habitats could be on the Nile Crocodile (Crocodylus niloticus). This is because although Nile crocodile is listed as "Least Concern" on the IUCN Red List, the stretch of river between Murchison Falls and the delta has one of the biggest concentrations of the species of the world (Hutton, 1991) and hence needs special attention.
- Note that the habitats in which the other amphibian and reptilian fauna were recorded are not restricted to Survey area B, this implies therefore that such species may not be restricted in this area. It is therefore not very likely that they would be adversely affected by the project's operations

4.3.7 Recommendations

- Attention should be placed on the survey of the Nile Crocodile since there seems to be no readily available obtains as observed in Hutton (1991).
  - Its home range, breeding ground, feeding grounds, resting areas and its daily activities need to be studied.
  - The recognised survey techniques for crocodiles, including spotlight and day Boat Surveys, Foot Surveys, Aerial Surveys and Nest Surveys as explained by Aust (2009) and Shacks (2006) should be employed.
    - Note that 3-4 areal surveys would provide some indicator as to the status and distribution of the Nile Crocodile in the shortest time possible; while Boat Surveys and Foot Surveys could be rather cumbersome and expensive because of the nature of the terrain along which the Nile River flows, and the danger posed by the rapids and the hippopotamus.
    - Sites where further intensive sampling for amphibian species using pitfall traps in addition to VES, and for future monitoring should be established.

4.4 Invertebrates

4.4.1 Introduction

The project area is composed of various habitat types ranging from woodlands, bush land, open grasslands and wooded grasslands. Within a number of sites are riverrines and streams with their accompanying vegetations.

Generally the Ayago project area is composed of a heterogeneous structure making it an ecologically important area for reproduction, survival and dispersal of the butterfly fauna. The high stock woodlands along the River Nile and Ayago River are specifically good habitats for survival of forest dependent as well as wetland specific species. Minimal or no disturbances in these critical areas will be paramount to the maintenance of the butterfly fauna and the invertebrate fauna as a whole.

Scoping is a critical, early step in the preparation of an Environment Impact Assessment (EIA). This process identifies the issues that are likely to be of most importance during the EIA and eliminates those that are of little concern. Typically, this process concludes with the establishment of Terms of Reference for the preparation of an EIA. In this way, scoping ensures that EIA studies are focused on the significant effects and time and money are not wasted on unnecessary investigations. Scoping refers to the early, open and interactive process of determining the major issues and impacts that will be important in decision-making on the proposal, and need to be addressed in an EIA.

The purpose of this scoping was to identify:

- the important ecological issues on butterflies to be considered in an EIA;
- to identify important areas for butterflies in the proposed project areas
- the appropriate time and space boundaries of the EIA study;
- the information necessary for decision-making; and
- the significant effects and factors to be studied in detail.

4.4.2 Methods

4.4.2.1 Study sites

The scoping surveys were carried out along transects located both within the larger Survey Area A and the rather smaller Survey Area B.

4.4.2.2 Field methods

Transects were systematically selected to cover both locations with Survey Area A and Survey Area B as much as possible. Transects that covered all representative habitat types found within the two project areas were established. Detailed walks along a given transect were carried out to assess current condition of the environment, identifying habitats that are critical for the survival of the insect fauna using butterflies as model indicators, and assessed what impacts the two layouts would have on the butterfly fauna of;

- how much of critical habitat would be reduced by either layout of the project
- how much of the general habitat would be reduced by each layout
- by what amount would each layout influence/increase extinction rates in butterflies

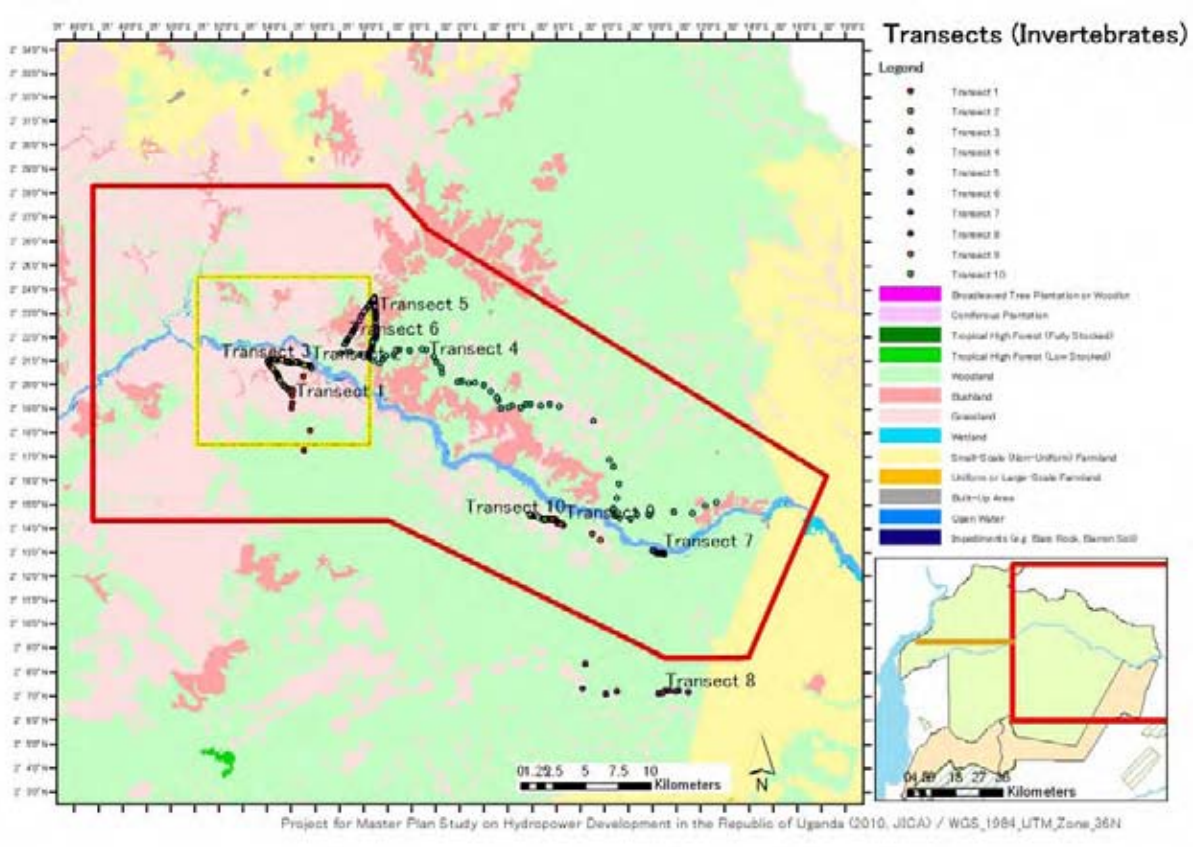


Figure 18 Transects of Invertebrates survey

Transect 1.

This was located on the southern side of the River Nile. The transect start point was just immediately after the road junction to the camp. The area covered is represented by GPS log points 054-064 (Akite log points).

This area that is located within Survey Area A is relatively uniform dense woodland with few areas of open grassland enclaves. The woodland has relatively good under storey vegetation that is very critical for survival of certain shade loving butterfly species and also the forest edge/woodland species. Some forest dependent species were noted along this transect.

Transect 2.

This was also located in the southern bank of the river Nile. This line is represented by the GPS log points 067-077 (Akite log points).

The area covered by this transect is mainly an open grassland area especially at the edge of river Mupina and its tributaries. The riverrine vegetation is quite good, with dense woodlands. The northern side of River Mupina is gently sloping, making it more prone to negative impact of

erosion when the wood vegetation is removed. There was also a seasonally flooded wetland within this area and this may be critical to survival of wetland/ swamp dependent butterfly species

Transect 3 (Channel bend route).

This transect was along the river on the southern bank. Areas covered are represented by log points 078-0118 (first line) and 020-203 (diagonal line).

This area is mainly dense bush land dominated by Acacia spp. The first line mainly went through areas of bush lands, open grasslands with few scattered trees and thickets. This area also had many small stream crossings and valleys with riverrine vegetation. From point 0118, it opens up into more open grassland with few scattered trees. The diagonal line mainly passed through an area of open grassland with few dry stream crossings. The riverrine had dense woodland along river banks.

Transect 4 (along the Chobe- Paraa road).

This transect was on the northern side of the river Nile. It is represented by log points 204-245.

This transect went through several habitats from dense Acacia woodland and combretum woodland, occasionally intercepted by open wooded grasslands that are rather more open. River crossings have dense riverrine vegetation. The areas along this line would be critical in maintaining habitat specific butterfly species.

Transect 5 (off Chobe-Paraa road and a diagonal line back to road).

This is represented by log points 247-296 (first line) and 298-321 (diagonal line) respectively.

Areas covered by these two line are basically a mix of dense woodland intermixed with tall open grasslands. The woodland areas have under storey vegetation important for maintaining shade loving butterfly species such as Gnophodes betsimena, Bicyclus funebris and Tagiades flesus (forest dependent species) and Amauris niavius, Nepheronia argia (typical forest edge species) among others that were quite common. The two lines transected several river crossing and dry streams that had good riverrine vegetation.

Transect 6 (Along the river starting at the drill site).

This is marked by the log points 325-330. This is a uniformly wooded area with high wood stock, almost tending to forest. The trees were rather tall ~15-20m forming good canopy cover. The under storey vegetation are quite low providing large areas of bare ground. Point 329 had lots of the fruit feeding butterflies; Euphaedra alacris and Bicyclus auricrudus feeding on figs. These are typical forest under storey species. Several other none fruit feeding but forest species were recorded along this transect including not so common Mesoxantha ethosea.

Transect 7

This was located on the southern bank of the river marked by log points 373-402. The area covered is mainly Acacia woodland, with dense bush land scattered in the entire area. Closed woodland areas had some forest dependent butterfly species including the fruit feeding Euphaedra medon. Such areas are thus important to the maintenance of these species.

Transect 8

This was located on the drive way towards Olwio, marked by log points 407-431.This area is mainly open grassland area with pockets of dense woodland areas especially along the river crossings. This also included the area crossed by Ayago River and Kiba bridge.

Transect 9

This is marked by log points 433-444 (first line) and log points 447-465 (second line). This transect was located along Olwio-Paraa road. This is mainly open grassland area with few scattered trees. Only the stream and riverrine had fair dense wood vegetation.

Transect 10

This was located along the Arua road just after the Ayago bridge. It's marked by log points 468-479 (line 1) and 480-495 (line 2).The area along this transect was basically tall grassland with scattered areas of woodland. The grasses were too tall and almost no butterflies were seen flying around except in the short grass areas with scattered trees.

In summary, the impacts on butterfly fauna can be categorized as as in table I1:

Table I1 Summary potential impacts on butterflies

Item	Survey Area A	Survey Area B
Reduction on place used by butterflies	>50%	<50%
Reduction rate of habitat used by butterflies	>50%	<50%
Increased extinction rate	<5%	<1%

4.4.3 Field survey result

No IUCN threatened or endangered species would be impacted by the proposed action because none of them is present in the areas covered by this project. However, some sensitive butterfly species could be disturbed especially those that are habitat specific. None of the swamp/wetland species that have limited continental distribution were recorded by this study. 14 forest specialists (F and FL-ecotypes) butterfly species were recorded in the areas surveyed and one swamp species (S) as well. These rather habitat specific species are often vulnerable to any form of habitat

alterations. Areas around transects 5, 6 and 7 are such examples of the critical habitats for these species.

However, there are always some complex and often unexpected effects of ecological disturbances. Such disturbances including flooding that may arise from the proposed dam. Such dramatically sudden disturbance can change even tiny components of a once-integrated ecosystem.

Table I2 Species of butterflies recorded in the Ayago project area

Species	Ecotype	IUCN Red list status	Transect									
			1	2	3	4	5	6	7	8	9	10
Acleros ploetzi	f.	NE	1					1				
Acraea acerata	W	NE			1							
Acraea egina	W	NE			1					1		
Acraea encedon	W	NE		1								
Acraea eponina	W	NE						1	1			
Acraea pharsalus	f.	NE	1					1	1			
Acraea zetes	W	NE			1							1
Amauris niavius	W	NE					1	1				
Andronymus neander	M	NE			1							
Ariadne enotrea	F	NE				1						
Aterica galene	F	NE	1									
Belenois aurota	M	NE		1						1		
Belenois creona	M	NE	1		1				1		1	1
Belenois solilucis	f.	NE				1		1				
Belenois thysa	f.	NE	1	1	1	1		1				
Bicyclus funebris	F	NE	1				1					
Bicyclus mandanes	F	NE					1	1				
Bicyclus safitza	W	NE				1				1	1	1
Bicyclus vulgaris	W	NE	1		1							1
Borbo borbonica	M	NE		1								
Borbo fallax	O	NE									1	
Byblia anvatara	M	NE			1				1			
Catopsilia florella	M	NE			1							
Charaxes etesipe	f.	NE				1						1
Charaxes varanes	W	NE				1				1	1	
Coeliades forestan	W	NE						1				
Colotis danae	W	NE			1							
Colotis protomedia	O	NE							1			
Danaus chrysippus	M	NE								1	1	1
Dixeia charina	O	NE							1			
Dixeia orbona	W	NE	1		1							
Eicochrysops hippocrates	W	NE							1			

Species	Ecotype	IUCN Red list status	Transect									
			1	2	3	4	5	6	7	8	9	10
Eronia cleodora	O	NE							1			
Euphaedra alacris	FL	NE						1				
Euphaedra medon	F	NE							1			
Eurema brigitta	M	NE		1						1	1	
Eurema hecabe	M	NE		1						1	1	
Eurytela dryope	W	NE								1		
Gegenes hottentota	O	NE		1					1	1		
Gnophodes betsimena	F	NE	1			1						
Henotesia perspicua	O	NE								1	1	
Hypolimnas misippus	M	NE								1	1	
Junonia oenone	W	NE								1		
Leptosia nupta	F	NE	1					1				
Leptosia wigginsi	F	NE						1				
Melanitis leda	W	NE	1			1	1					1
Mesoxantha ethosea	F	NE						1				
Metisella midas	S	NE		1								
Nepheronia argia	F	NE					1	1				
Papilio bromius	f.	NE	1			1	1	1				
Papilio cynorta	FL	NE						1				
Papilio dardanus	W	NE	1	1		1	1		1			1
Papilio demodocus	M	NE						1				1
Papilio nireus	f.	NE						1				
Papilio phorcas	F	NE					1	1				
Pentila pauli	f.	NE						1				
Phalanta phalanta	M	NE									1	
Sarangesa phidyle	O	NE								1		
Spialia spio	O	NE		1						1	1	
Tagiades flesus	F	NE	1				1					
Tirumala formosa	f.	NE				1						
Tirumala petiverana	M	NE				1				1		
Ypthima albida	f.	NE	1			1						
Ypthima asterope	O	NE									1	
Zizeeria knysna	W	NE								1		
Zizina antanossa	W	NE							1			

Note the acronym NE is for not evaluated

4.4.4 Important habitats

A number of sites located within the two layouts can be considered critical for the survival and maintenance of the butterfly fauna and other insects as well. Such habitats include the dense woodlands, riverrines, wetlands and seasonally flooded swamps; all of which were encountered in

different project areas. Areas around transects 5 & 6 are particularly of interest and can be considered as offset areas for the project activities in the other areas.

4.4.5 Important Species

So far no species of conservation concer have been recorded in the project area.

4.4.6 Recommendations

In developing future EIA study for butterflies therefore the following has to be considered in order to minimize impacts

4.4.6.1 Baseline surveys and investigations which should be carried out

A detailed study of the butterfly fauna should be carried out. Standard sampling methods that include transect sweep netting and baited traps should be employed especially in the dense woodland areas. These surveys will help to achieve the following;

- Establish baseline information on butterflies richness and diversity for the two survey areas.
- Identify indicator species (if any) that can be used for future biodiversity monitoring.
- Identify any IUCN species that may be present in project areas
- Make field observations and descriptions especially on the distributions of species in different locations
- Produce a comprehensive report on the butterfly diversity with the project areas.

4.4.6.2 Expected Output

- A species list of the butterfly taxa encountered from the areas
- A description of the ecological preferences of species recorded. This is important in planning for conservation of either target taxa or habitat
- An evaluation of the relative importance of the areas in terms of their butterfly fauna
- Any IUCN species records and locations

4.4.6.3 Methods and criteria to be used for prediction and evaluation of effects

Butterflies respond quickly to environmental changes and there is now considerable data on how particular species contend with alterations in land-use, and thus may play a valuable role in ecological monitoring (Daily and Ehrlich, 1995). The influence of seasonality on the presence or absence of adults of certain species, and on their morphology, as well as knowledge of species ecology must always be considered. However, the compilation of species lists may be used both qualitatively and quantitatively, to comment on a habitat (its condition and vegetation) and to

identify conservation and monitoring needs. Increasingly, therefore, butterflies are being used as tools in ecological monitoring strategies (Pollard and Yates, 1993; Sparrow et al., 1994).

4.4.6.4 Why monitor?

Uganda is one of the countries that has ratified the Convention on Biological Diversity and as such is required to inventory and monitor its own biodiversity. This is an onerous task, given that only a small fraction of the organisms living within the boundaries of most countries have so far been discovered, identified, scientifically named and classified (Groombridge, 1992). Regular monitoring of species' occurrences in a given habitat/site is a necessary component of biodiversity monitoring. The database increases in value with each subsequent monitoring event, and repeated censusing will ensure that any change in biodiversity can be detected.

According to Sparrow et al. (1994), no matter how well documented population trends in a single taxonomic group such as butterflies are, they are likely to provide only a partial picture of overall biological diversity. Long-term monitoring is most effective when they include diverse taxa and accompanied by research into abiotic factors such as macro and microclimate and habitat condition. A focused, multidisciplinary approach to monitoring offers the best opportunity for obtaining biological information that is truly useful in making informed management decisions for example gazetting an ecosystem as a result of well noted declines in populations due to certain human activities.

4.4.6.5 Mitigation measures which should be considered

On the basis of field observations and the biological environment described, the following options would help in minimizing and mitigating the losses in insects and general biodiversity during and after the construction of the Ayago Hydro power dam and as well as during maintenance activities.

- habitat specific species and restricted range species and their preferred habitats need special attention since they are the main contributors to diversity and conservation strategies and thus should be protected.
- Sites that are relatively more degraded are more vulnerable to further degradation as a result of access due to development of infrastructure particularly within the Karuma Wildlife reserve (along the channel bend) as well as in some parts of Murchison falls national park. These areas would be best maintained in their natural status as offset areas for activities in the other parts of the project area.
- Corridors of vegetation should be maintained along the rivers and large streams and vegetation along these should be left intact. These would enable udder storey forest butterflies and other animals to maintain population link.
- As much as possible, the location of the infrastructures should be placed further landward to minimize impacts on the mail river.

- Continued monitoring of the butterfly fauna is strongly recommended.

4.5 Environment and Natural Resource Issues

Understanding the existing and potential consequences of hydropower development for environmental sustainability is one of the main purposes of the SEA. There are a wide range of complex interactions between different environmental parameters that take place with hydropower development. Any major level of hydropower investments will inevitably have an effect on ecological processes and on other aspects of natural resource management. This can lead to trade-offs, where some level of environmental modification is an accepted price for the benefits that hydropower brings.

In analyzing environment and natural resources management in the Baseline Assessment, the acceptable level of change to ecological processes and natural resource values should be considered. Two criteria that can be applied when making such an analysis are;

- The first and bottom line criterion is that hydropower development should not compromise the integrity of the ecosystems involved to a level where their existence is jeopardized. This means in practice that minimum environmental flows must be maintained in the river network and that land use changes consequent from hydropower development do not severely disrupt habitats or the continuity of ecosystem areas to an extent that their existence is threatened.
- The second criterion is that hydropower development should maintain or enhance the overall flow of environmental services and natural resource availability and maintain or enhance biodiversity and other measures of ecological integrity.

The maintenance of ecosystems integrity, both around the hydropower development site and downstream and recognizing the cumulative impact of multiple hydropower schemes within a Nile river basin should be considered.

5 Impact assessments for the three dam options

5.1 During construction and Construction impacts

Except perhaps for Poaching activities, the Ayago field development project area is in one of the least impacted parts of the Park. The area is little traversed for tourism especially on the south side of the River Nile. The North side of the river has Chobe Safari lodge as a major development project and is working with the park management to rehabilitate the Chobe sector for Tourism.

These facts together will mean that the wildlife in the Ayago field development project area has experienced lesser anthropogenic influences until now in comparison for example to the Delta area of the Park.

It is likely therefore that animals and especially the larger mammals will be wearier of people in the Ayago field development project area than in the areas actively and continuously traversed by humans in the Park.

The Ayago hydropower scheme currently under considerations involves an intake upstream of the Ayago river inflow into the Nile, a head of 81 m; a weir and underground tail race of 9km (Project brief 2010). It is the understanding that there won't be a significance pondage created behind the weir and that therefore no significant extent of riverside habitats would be lost through submersion.

Given the nature of the proposed project development, it is not likely that many very major and negative impacts will be exerted on the wildlife by activities directly resulting from the operations of the project. That notwithstanding, it is envisaged that some impacts of both positive and negative nature may be realised from the operations of the field development project.

The following list identifies positive and negative impacts that may result due to implementation of the Ayago field development project.

5.1.1 Negative impacts

- Vegetation clearance and habitat alteration due to construction of access roads and camps.
  - This would result into a much larger area opened up on the south side of the river, a distance of about 12 km for access road to the river as well as an access road the full length of the tunnel.
  - To the north side of the river the access road to the river would be much shorter although requiring clearance along the length of the tunnel.
  - The access road to the north side of the river would have to open up more closed stands of woodland for a longer distance than on the south side where it is largely routed through more open wooded grassland.
- Home ranges could be affected by area lost due to habitat clearance and alteration.
- Possibility of negative impacts on species of global or regional conservation concern.
- Reduction of extent of foraging grounds
- Interference with movement patterns of animals
- Disruption of normal behaviour of species of animals in the park (due to movement of humans, machines etc)
- Accidental animal kills from operations in the project area from machinery or vehicles
- Introduction of hazardous materials to animals into the park
- Clearance or destruction of major animal resources (e.g. Salt lick areas, Lekking, preferred foraging and breeding grounds etc).

- Introduction of invasive species of plants that could alter the ecology the animals' range and forage areas
- Increased incidents of poaching due to increased human presence in the Park
- Soil compaction in camps sites, construction areas and roads leading to increased runoff and flooding of prime foraging, lekking (or otherwise) areas
- Increased human presence in the park significantly affecting the normal behaviour of species of conservation concern.
- Increased incidences of illegal activities such as poaching due to increased presence of humans in the park
- Significant reduction in population and home range of species of conservation concern.

5.1.2 Positive impacts

- Improved access to much of this sector of MFNP to ease monitoring in the park
- Increased monitoring of illegal activities in the park due to increased presence of human activity within the park.
- Improved access to the section of the park that could result into development of tourism in this section of the reserve

5.2 Impact assessments for the three dam options

Table 5-1 Criteria for rating of severity of impacts of animal groups

Negligible Impacts (score of 1)	No noticeable or limited local effect upon the environment, rapidly returning to original state by natural action Unlikely to affect animal home ranges to a noticeable degree No noticeable effects on globally or regionally endangered species No significant impact on grazing grounds No significant interference with movement patterns Disruption of normal behaviour of the protected species in the park (due to movement of humans, machines etc)
Minor Impacts (score of 2)	Noticeable effects on the animal habitats, but with capacity to recover naturally to original state in the medium term Low level impact on animal habitats but not limiting continued use of area by animals Disruption/disturbance to normal behaviour of a globally or regionally endangered species but with potential to quickly reverting to normal in the short term Accidental animal kills from operations in the project area from machinery or vehicles Introduction of hazardous materials to animals into the park
Moderate Impacts (score of 3)	Clearance of a major section of animal's range but with possibility of recovery in the long term Clearance of major animal resources (e.g. Lekking, preferred foraging and breeding grounds etc) but with capacity of recovery in the long term. Introduction of invasive species of plants that could alter the ecology the animals' range and forage areas

	Increased incidents of poaching due to increased human presence in the Park
Major Impacts (score of 4)	Highly noticeable effects on the environment, difficult to reverse Soil compaction in camps sites, construction areas and roads leading to increased runoff and flooding of prime foraging, lekking (or otherwise) areas Increased human presence in the park significantly affecting the normal behaviour of species of conservation concern. Increased monitoring of illegal activities in the park due to increased presence of human activity within the park Large scale and permanent destruction of preferred habitats for animals Significant reduction in population and home range of species of conservation concern.

These criteria are used in tables Table 5-2 - Table 5-7 to assess the potential impacts for Large and Medium sized mammals, Birds, Herpetiles and Buterflies.

5.2.1 Large and Medium Mammals

Table 5-1 presents habitat level impact assessments while table 5-3 presents a species specific impact assessment. At the species level, only Leopard, Lion, Hippopotamus, Giraffe and the African Elephant are the only species that are considered as potentially likely to be impacted to any notable level.

Table 5-2 Impact assessment on Large and medium mammals

Name			**Relative Impact Assessment**		
Family	**English name**	**Scientific name**	**Dam Waterway**	**Left Bank**	**Right Bank**
Cercopithecidae	Olive Baboon	*Papio anubis*	1	1	1
	Black & White Colobus	*Colobus guereza*	3	2	3
	Pata's Monkey	*Cercopithecus patas*	1	1	1
	Vervet Monkey	*Cercopithecus aethiops*	1	1	1
	Red-tailed Monkey	*Cercopithecus ascanius*	2	1	2
Felidae	Leopard	*Panthera pardus*	3	2	2
	Lion	*Panthera leo*	1	2	2
Herpestidae	Egyptian Mongoose	*Herpestes ichneumon*	1	1	1
Mustelidae	(African) Spot-necked Otter	*Lutra maculicollis*	2	1	1
Viveridae	East African Civet	*Civettictis civetta*	1	1	1
Hyenidae	Spotted Hyena	*Crocuta crocuta*	1	1	1
Hippopotamidae	Hippopotamus	*Hippopotamus amphibius*	4	3	3
Suidae	Bush Pig	*Potamochoerus porcus*	2	1	2
Suidae	Common Warthog	*Phacochoerus africanus*	2	1	1
Bovidae	African Buffalo	*Syncerus caffer*	2	2	2
	Bushbuck	*Tragelaphus scriptus*	1	1	1

Name			Relative Impact Assessment		
Family	**English name**	**Scientific name**	**Dam Waterway**	**Left Bank**	**Right Bank**
	Sitatunga	*Tragelaphus spekii*	1	1	1
	Common (Bush) Duiker	*Sylvicapra grimmia*	1	1	1
	Hartebeest	*Alcelaphus buselaphus*	1	1	1
	Uganda Kob	*Kobus kob*	1	1	2
	Oribi	*Ourebia ourebia*	1	1	1
	(Defassa) Waterbuck	*Kobus ellipsiprymnus*	1	1	1
Giraffidae	Giraffe	*Giraffa camelopardalis*	1	2	2
Elephantidae	African Elephant	*Loxodonta africana*	2	2	2
Manidae	Giant Pangolin	*Smutsia gigantea*	1	1	1
Hystricidae	Crested Porcupine	*Hystrix cristata*	1	1	1
Scuiridae	Striped Ground Squirrel	*Euxerus erythropus*	1	1	1
Thryonomidae	Savannah (Common) Cane Rat	*Thryonomys swinderianus*	1	1	1
Orycteropodidae	Aardvark (Ant Bear)	*Orycteropus afer*	1	1	1
Rating			C	B	C

A: Smaller impact B: Middle impact C: Bigger impact

Table 5-3 Potential Species specific Impacts due to the different option

Items	Dam Waterway	Left Bank	Right Bank
CONSTRUCTION IMPACTS			
Loss of Habitat	4	3	3
Habitat alteration	4	3	3
Reduction of Home range	2	2	2
Reduction extent of feeding ground	2	3 (for Hippos)	3
Disruption of routes	3	3 (for Hippos)	3 (for Hippos)
Reduction of lekking grounds	1	1	3
Destruction of wallows	2	1	3
Introduction of invasive species	2	2	2
Introduction of hazardous materials	3	2	2
Increasing Extinct risk	1	1	1
OPERATION IMPACTS			
Loss of Habitat	4	3	3
Habitat alteration	4	3	3
Reduction of Home range	4	2	3
Reduction extent of feeding ground	3	3	3
Reduction of lekking grounds	1	2	3
Destruction of wallows	1	1	3
Introduction of invasive plant species	2	2	2
Introduction of hazardous materials	2	2	2
Increasing Extinct risk	1	1	1
Total Points	**46**	**40**	**45**
Rating	**C**	**B**	**C**

A: Smaller impact B: Middle impact C: Bigger impact

5.2.2 Birds

Table 5-4 Impact assessment on Birds

Items	Dam Waterway	Left Bank	Right Bank
CONSTRUCTION IMPACTS			
Loss of Habitat	3	2	2
Habitat alteration	3	2	3
Reduction of Home range	2	1	1
Destruction of nesting grounds	3	2	2
Introduction of invasive plant species	2	2	2
Introduction of hazardous materials	2	2	2
Increasing Extinction risk	1	1	1
OPERATION IMPACTS			
Loss of Habitat	3	2	2
Habitat alteration	3	2	2
Reduction of Home range	2	1	1
Introduction of hazardous materials	1	1	1
Increasing Extinction risk	1	1	1
Total Score	**26**	**19**	**20**
Rating	**C**	**B**	**B**

A: Smaller impact B: Middle impact C: Bigger impact

5.2.3 Reptiles and amphibians

Table 5-5 Impact assessment on Reptiles and amphibians

Items	Dam Waterway	Left Bank	Right Bank
CONSTRUCTION IMPACTS			
Loss of Habitat	1	1	1
Habitat alteration	3(for crocodiles)	2(for crocodiles)	2(for crocodiles)
Reduction of Home range	1	1	1
Destruction of breeding grounds	3	1	1
Introduction of invasive plants and microbe species	3(for amphibians)	3(for amphibians)	3(for amphibians)
Introduction of hazardous materials	1	1	1
Increasing local Extinction risk	2	2	2
OPERATION IMPACTS			
Loss of Habitat	1	1	1
Habitat alteration	3(for crocodiles)	2(for crocodiles)	2(for crocodiles)
Reduction of Home range	1	1	1
Reduction extent of breeding ground	3	1	1
Introduction of invasive plants and microbe species	3(for amphibians)	3(for amphibians)	3(for amphibians)
Increasing local Extinction risk	2	2	2
Total	**27**	**21**	**21**
Rating	**C**	**B**	**B**

A: Smaller impact B: Middle impact C: Bigger impact

5.2.4 Insects (Butterfly)

Table 5-6 Impact assessment on Butterfly

Items	Dam waterway	Left Bank	Roght bank
CONSTRUCTION IMPACTS			
Loss of Habitat	3	2	3
Habitat alteration	3	2	3
Reduction of Home range	2	1	2
Reduction extent of foraging ground	2	1	1
Introduction of invasive species	2	2	2
Increasing Extinction risk	1	1	1
OPERATION IMPACTS			
Loss of Habitat	3	2	2
Habitat alteration	3	2	2
Reduction of Home range	2	1	1
Reduction extent of foraging ground	2	2	2
Introduction of invasive species	1	2	2
Increasing Extinction risk	1	1	1
Total Score	**25**	**19**	**22**
Rating	**C**	**B**	**B**

A: Smaller impact B: Middle impact C: Bigger impact

6 Mitigation measures

- Vegetation clearance should only be done where it is absolutely necessary and also driving should be restricted to the roads constructed so that off-road driving is minimized or not practiced at all
- An environment Action Plan will have to be developed and strictly enforced
- Speed limits should be instituted to ensure no cases of road kills ever happen or that the risk of their occurrence is reduced
- Night driving should strictly be disallowed to allow animals continue with their normal activity and also reduce the risk of road kills.
- Any hazardous materials introduced in the park must be properly managed and also removed on completion of its usefulness to the implementation of the project.
- A plan for restoration should be drawn

7 References

Aust, P.W. (2009). The ecology, conservation and management of Nile crocodiles *Crocodylus niloticus* in a human dominated landscape. Ph.D. Thesis. Imperial College London

Behangana, M. (1999) Karuma Hydropower Project: Study of the herpetofauna. Report to Norplan (U) Ltd.

Buechner H. K, Buss I. O., Longhurst W. M., BrooksSource A. C. 1963:Numbers and Migration of Elephants in Murchison Falls National Park, Uganda Author(s):. The Journal of Wildlife Management, Vol. 27, pp. 36-53Published

Carswell, M., Pomeroy, D.E., Reynolds, J. and Tushabe, H. 2005. *Bird atlas of Uganda*. British Ornithologists' Union, London.

Channing, A. and Howell, K.M. 2006. *Amphibians of East Africa.* Edition Chimaira. Cornell University Press, New York.

Daily, G.C. & Ehrlich, P.R (1995). Preservation of biodiversity in small rain forest patches: rapid evaluations using butterfly trapping. *Biodiversity and Conservation*, **4**, 35-55.

Environmental Survey for Project Master Plan Study on Hydropower Development in Uganda: Technical Specifications

Groombridge, B. (1992) *Global Biodiversity – Status of the Earth's Living Resources*. IUCN Publishing Unit, Cambridge, UK.

Heyer, W.R., Donnely, M.A., Mc Diarmid, R.W., Hayek L.C., and Foster M.S. (Eds.). (1994). *Measuring and Monitoring Biological Diversity*: Standard Methods for Reptiles and Amphibians. Smithsonian Institution Press, Washington.

Hutton, J.M. (1991) Crocodiles and their management in the Murchison Falls National Park of Uganda. Agriconsulting/Uganda Institute of Ecology.

IUCN (2010). *IUCN Red List of Threatened Species.* Version 2010.3. <http://www.iucnredlist.org>. Downloaded on 28 September 2010

Parker I. S. C. (1970). Crocodile Distribution and Status in the Major Waters of Western and Central Uganda. *Afr. J. Ecol*. 8(1): 85-103

Plumptre A.J. Behangana M., Davenport T., Kahindo C., **Kityo R,** Ndomba E., Nkuutu D., Owiunji I., Ssegawa P., Eilu G. 2003 **The Biodiversity of Albertine Rift**. Albertine Rift Technical Reports No. 3.

Pollard, E., and T. J. Yates (1993). Monitoring butterflies for ecology and conservation. Chapman & Hall, London.

Project Brief March 2010: The Republic of Uganda the Ministry of Energy & Mineral Development - Project Brief of Pre-Feasibility Study of Ayago Hydro Electric Power Project Hydropower Development in Uganda

Shacks, V. (2006). Habitat Vulnerability for the Nile Crocodyle (Crocodilus niloticus) in the Okavango Delta, Botswana. M.A. University of Stellenbosch

Sir Alexander Gibb & Partners and Kennedy & Donkin 1986 Power Development study of the Uganda Electricity System *Draft Final Report*

Smart N.O.E., Hatton J.C. and Spencer D.H.N. 1985 The effect of long-term exclusion of large herbivores on vegetation in Murchison Falls National Park, Uganda Biological Conservation 33 (3) 229-245

SNC LAVALIN International 2007 Strategic/Sectoral, Social and Environmental Assessment of Power Development Options in the Nile Equatorial Lakes Region: *Final Report Volume 1 Main Report*

Sparrow, H., Sisk, T., Ehrlich, P. and Murphy, D (1994). Techniques and guidelines for monitoring Neotropical butterflies. *Conservation Biology*, **8**, 800-809.

Spawl, S.; Howell, K. and Drewes, R. (2006) Pocket Guide to the Reptiles and Amphibians of East Africa. A & C Black Publishers, London.

Spawl, S.; Howell, K., R. Drewes and Ashe, J. (2006). A Field Guide to the Reptiles of East Africa. A & C Black Publishers, London.

Wilson S.E. 1995 (ed). Bird and Mammal checklists for ten National Parks MUIENR, Kampala.

Annex 1 Known Bird species for Murchison Falls National Park

Number	Common name	Scientific name	Threat
B5	Greater Cormorant	*Phalacrocorax carbo*	
B6	Long-tailed Cormorant	*Phalacrocorax africanus*	
B7	African Darter	*Anhinga rufa*	R-VU
B8	Great White Pelican	*Pelecanus onocrotalus*	R-RR
B10	Pink-backed Pelican	*Pelecanus rufescens*	
B12	Little Bittern	*Ixobrychus minutus*	
B13	Dwarf Bittern	*Ixobrychus sturmii*	
B14	White-backed Night Heron	*Gorsachius leuconotus*	R-NT
B15	Black-crowned Night Heron	*Nycticorax nycticorax*	
B16	Common Squacco Heron	*Ardeola ralloides*	
B22	Cattle Egret	*Bubulcus ibis*	
B24	Striated Heron	*Butorides striatus*	R-NT
B26	Black Egret	*Egretta ardesiaca*	R-NT
B30	Little Egret	*Egretta garzetta*	
B32	Intermediate Egret	*Mesophoyx intermedia*	
B34	Great Egret	*Casmerodius albus*	R-VU
B36	Purple Heron	*Ardea purpurea*	R-NT
B38	Grey Heron	*Ardea cinerea*	R-NT
B40	Black-headed Heron	*Ardea melanocephala*	
B42	Goliath Heron	*Ardea goliath*	R-NT
B46	Hamerkop	*Scopus umbretta*	
B50	Yellow-billed Stork	*Mycteria ibis*	
B52	African Open-billed Stork	*Anastomus lamelligerus*	
B56	Abdim's Stork	*Ciconia abdimii*	
B58	Woolly-necked Stork	*Ciconia episcopus*	R-NT
B60	White Stork	*Ciconia ciconia*	
B62	Saddle-billed Stork	*Ephippiorhynchus senegalensis*	R-VU
B64	Marabou Stork	*Leptoptilos crumeniferus*	
B68	Shoebill	*Balaeniceps rex*	G-LR/nt R-VU
B72	Glossy Ibis	*Plegadis falcinellus*	
B74	Hadada Ibis	*Bostrychia hagedash*	
B80	Sacred Ibis	*Threskiornis aethiopica*	
B82	Eurasian Spoonbill	*Platalea leucorodia*	
B84	African Spoonbill	*Platalea alba*	
B90	Lesser Flamingo	*Phoeniconaias minor*	G-LR/nt R-NT/RR
B94	Fulvous Whistling Duck	*Dendrocygna bicolor*	
B96	White-faced Whistling Duck	*Dendrocygna viduata*	
B100	Egyptian Goose	*Alopochen aegyptiacus*	
B102	Spur-winged Goose	*Plectropterus gambensis*	
B106	Knob-billed Duck	*Sarkidiornis melanotos*	
B108	African Pygmy Goose	*Nettapus auritus*	

Number	Common name	Scientific name	Threat
B112	Common Teal	*Anas crecca*	
B120	Northern Pintail	*Anas acuta*	
B126	Garganey	*Anas querquedula*	
B130	Southern Pochard	*Netta erythrophthalma*	
B136	Tufted Duck	*Aythya fuligula*	
B142	Osprey	*Pandion haliaetus*	
B148	European Honey Buzzard	*Pernis apivorus*	
B150	Bat Hawk	*Macheirhamphus alcinus*	R-NT
B152	Black-shouldered Kite	*Elanus caeruleus*	
B154	African Swallow-tailed Kite	*Chelictinia riocourii*	
B156	Black Kite	*Milvus migrans*	
B158	African Fish Eagle	*Haliaeetus vocifer*	
B160	Palm-nut Vulture	*Gypohierax angolensis*	
B164	Egyptian Vulture	*Neophron percnopterus*	R-NT
B166	Hooded Vulture	*Necrosyrtes monachus*	
B168	African White-backed Vulture	*Gyps africanus*	R-NT
B170	Rüppell's Griffon Vulture	*Gyps rueppellii*	R-NT
B172	Lappet-faced Vulture	*Torgos tracheliotus*	G-VU, R-NT
B174	White-headed Vulture	*Trigonoceps occipitalis*	R-VU
B176	Short-toed Snake Eagle	*Circaetus gallicus*	
B178	Brown Snake Eagle	*Circaetus cinereus*	R-NT
B180	Western Banded Snake Eagle	*Circaetus cinerascens*	R-VU
B182	Bateleur	*Terathopius ecaudatus*	
B186	African Harrier Hawk	*Polyboroides typus*	
B188	Pallid Harrier	*Circus macrourus*	G-LR/nt, R-NT
B190	Montagu's Harrier	*Circus pygargus*	R-NT
B192	African Marsh Harrier	*Circus ranivorus*	R-NT
B194	Eurasian Marsh Harrier	*Circus aeruginosus*	
B196	Gabar Goshawk	*Micronisus gabar*	
B198	Dark Chanting Goshawk	*Melierax metabates*	
B200	Eastern Chanting Goshawk	*Melierax poliopterus*	
B202	African Goshawk	*Accipiter tachiro*	
B206	Shikra	*Accipiter badius*	
B212	Little Sparrowhawk	*Accipiter minullus*	
B224	Grasshopper Buzzard	*Butastur rufipennis*	
B226	Lizard Buzzard	*Kaupifalco monogrammicus*	
B228	Common Buzzard	*Buteo buteo*	
B232	Long-legged Buzzard	*Buteo rufinus*	
B234	Red-necked Buzzard	*Buteo auguralis*	
B236	Augur Buzzard	*Buteo augur*	
B240	[Greater Spotted Eagle]	*Aquila clanga*	
B242	Tawny Eagle	*Aquila rapax*	
B244	Wahlberg's Eagle	*Aquila wahlbergi*	
B246	Verreaux's Eagle	*Aquila verreauxi*	

Number	Common name	Scientific name	Threat
B248	African Hawk Eagle	*Hieraaetus spilogaster*	
B252	Ayres's Hawk Eagle	*Hieraaetus ayersii*	R-VU
B254	Long-crested Eagle	*Lophaetus occipitalis*	
B260	Martial Eagle	*Polemaetus bellicosus*	R-VU
B264	Secretary Bird	*Sagittarius serpentarius*	
B270	Lesser Kestrel	*Falco naumanni*	G-VU, R-VU
B272	Common Kestrel	*Falco tinnunculus*	
B278	Grey Kestrel	*Falco ardosiaceus*	
B280	Red-necked Falcon	*Falco chicquera*	R-NT
B282	[Red-footed Falcon]	*Falco vespertinus*	
B288	Sooty Falcon	*Falco concolor*	
B290	Eurasian Hobby	*Falco subbuteo*	
B292	African Hobby	*Falco cuvieri*	
B294	Lanner Falcon	*Falco biarmicus*	
B298	Peregrine Falcon	*Falco peregrinus*	
B304	Crested Guineafowl	*Guttera pucherani*	
B308	Helmeted Guineafowl	*Numida meleagris*	
B312	Common Quail	*Coturnix coturnix*	
B314	Blue Quail	*Coturnix adansonii*	R-VU
B316	Harlequin Quail	*Coturnix delegorguei*	
B324	Ring-necked Francolin	*Francolinus streptophorus*	R-VU/RR
B334	Crested Francolin	*Francolinus sephaena*	
B340	Heuglin's Francolin	*Francolinus icterorhynchus*	
B356	Common Button Quail	*Turnix sylvatica*	
B368	Buff-spotted Flufftail	*Sarothrura elegans*	
B374	African Crake	*Crex egregia*	R-NT
B378	African Water Rail	*Rallus caerulescens*	
B388	Black Crake	*Amaurornis flavirostris*	
B392	Purple Swamphen	*Porphyrio porphyrio*	
B398	Red-knobbed Coot	*Fulica cristata*	
B402	Black-crowned Crane	*Balearica pavonina*	G-LR/nt
B404	Grey Crowned Crane	*Balearica regulorum*	R-NT
B408	African Finfoot	*Podica senegalensis*	R-VU
B412	Denham's Bustard	*Neotis denhami*	G-LR/nt, R-EN
B420	Black-bellied Bustard	*Eupodotis melanogaster*	
B426	African Jacana	*Actophilornis africana*	
B428	Lesser Jacana	*Microparra capensis*	R-NT
B432	Greater Painted Snipe	*Rostratula benghalensis*	
B440	Black-winged Stilt	*Himantopus himantopus*	
B442	Pied Avocet	*Recurvirostra avosetta*	
B446	Eurasian Thick-knee	*Burhinus oedicnemus*	
B448	Senegal Thick-knee	*Burhinus senegalensis*	
B450	Water Thick-knee	*Burhinus vermiculatus*	
B452	Spotted Thick-knee	*Burhinus capensis*	

Number	Common name	Scientific name	Threat
B456	Egyptian Plover	*Pluvianus aegyptius*	
B458	Temminck's Courser	*Cursorius temminckii*	
B464	Collared Pratincole	*Glareola pratincola*	
B466	Black-winged Pratincole	*Glareola nordmanni*	G-DD
B468	Rock Pratincole	*Glareola nuchalis*	R-VU
B472	Little Ringed Plover	*Charadrius dubius*	
B474	Common Ringed Plover	*Charadrius hiaticula*	
B476	Kittlitz's Plover	*Charadrius pecuarius*	
B484	White-fronted Plover	*Charadrius marginatus*	
B490	Caspian Plover	*Charadrius asiaticus*	
B494	African Wattled Plover	*Vanellus sengallus*	
B496	Black-headed Lapwing	*Vanellus tectus*	
B498	Spur-winged Lapwing	*Vanellus spinosus*	
B500	Brown-chested Lapwing	*Vanellus superciliosus*	R-NT
B502	Senegal Lapwing	*Vanellus lugubris*	
B506	Long-toed Lapwing	*Vanellus crassirostris*	
B512	Little Stint	*Calidris minuta*	
B522	Ruff	*Philomachus pugnax*	
B526	Common Snipe	*Gallinago gallinago*	
B530	Great Snipe	*Gallinago media*	G-LR/nt, R-NT
B532	Black-tailed Godwit	*Limosa limosa*	
B536	Whimbrel	*Numenius phaeopus*	
B538	Eurasian Curlew	*Numenius arquata*	
B540	Spotted Redshank	*Tringa erythropus*	
B544	Marsh Sandpiper	*Tringa stagnatilis*	
B546	Common Greenshank	*Tringa nebularia*	
B548	Green Sandpiper	*Tringa ochropus*	
B550	Wood Sandpiper	*Tringa glareola*	
B552	Terek Sandpiper	*Xenus cinereus*	
B554	Common Sandpiper	*Actitis hypoleucos*	
B556	Ruddy Turnstone	*Arenaria interpres*	
B572	Lesser Black-backed Gull	*Larus fuscus*	
B578	Gull-billed Tern	*Sterna nilotica*	
B588	White-winged Tern	*Chlidonias leucopterus*	
B592	African Skimmer	*Rynchops flavirostris*	G-LR/nt, R-VU/RR
B600	Four-banded Sandgrouse	*Pterocles quadricinctus*	
B604	African Green Pigeon	*Treron calva*	
B606	Bruce's Green Pigeon	*Treron waalia*	
B608	Tambourine Dove	*Turtur tympanistria*	
B610	Blue-spotted Wood Dove	*Turtur afer*	
B612	Black-billed Wood Dove	*Turtur abyssinicus*	
B616	Namaqua Dove	*Oena capensis*	
B628	Afep Pigeon	*Columba unicincta*	

Number	Common name	Scientific name	Threat
B630	Speckled Pigeon	*Columba guinea*	
B634	Red-eyed Dove	*Streptopelia semitorquata*	
B636	African Mourning Dove	*Streptopelia decipiens*	
B638	Vinaceous Dove	*Streptopelia vinacea*	
B640	Ring-necked Dove	*Streptopelia capicola*	
B646	Laughing Dove	*Streptopelia senegalensis*	
B656	Brown Parrot	*Poicephalus meyeri*	
B658	Red-headed Lovebird	*Agapornis pullarius*	
B670	White-crested Turaco	*Tauraco leucolophus*	
B672	Hartlaub's Turaco	*Tauraco hartlaubi*	R-RR
B684	Eastern Grey Plantain Eater	*Crinifer zonurus*	
B688	Black and White Cuckoo	*Oxylophus jacobinus*	
B690	Levaillant's Cuckoo	*Oxylophus levaillantii*	
B694	[Thick-billed Cuckoo]	*Pachycoccyx audeberti*	
B696	Red-chested Cuckoo	*Cuculus solitarius*	
B698	Black Cuckoo	*Cuculus clamosus*	
B700	Common Cuckoo	*Cuculus canorus*	
B702	African Cuckoo	*Cuculus gularis*	
B712	African Emerald Cuckoo	*Chrysococcyx cupreus*	
B716	Klaas's Cuckoo	*Chrysococcyx klaas*	
B718	Diederik Cuckoo	*Chrysococcyx caprius*	
B720	Yellowbill	*Ceuthmochares aereus*	
B724	White-browed Coucal	*Centropus superciliosus*	
B726	Black Coucal	*Centropus grillii*	R-NT
B728	Senegal Coucal	*Centropus senegalensis*	
B730	Blue-headed Coucal	*Centropus monachus*	
B736	Barn Owl	*Tyto alba*	
B740	Scops Owl	*Otus scops*	
B746	Spotted Eagle Owl	*Bubo africanus*	
B750	Verreaux's Eagle Owl	*Bubo lacteus*	
B752	Pel's Fishing Owl	*Scotopelia peli*	R-VU
B754	Pearl-spotted Owlet	*Glaucidium perlatum*	
B760	African Wood Owl	*Strix woodfordii*	
B766	Marsh Owl	*Asio capensis*	R-NT
B774	Long-tailed Nightjar	*Caprimulgus climacurus*	
B778	Square-tailed Nightjar	*Caprimulgus fossii*	
B780	Black-shouldered Nightjar	*Caprimulgus nigriscapularis*	
B786	Plain Nightjar	*Caprimulgus inornatus*	
B792	Eurasian Nightjar	*Caprimulgus europaeus*	
B794	Standard-winged Nightjar	*Macrodipteryx longipennis*	
B796	Pennant-winged Nightjar	*Macrodipteryx vexillarius*	
B798	Sabine's Spinetail	*Rhaphidura sabini*	R-NT
B804	Scarce Swift	*Schoutedenapus myoptilus*	
B806	African Palm Swift	*Cypsiurus parvus*	

Number	Common name	Scientific name	Threat
B814	Eurasian Swift	*Apus apus*	
B816	White-rumped Swift	*Apus caffer*	
B818	Horus Swift	*Apus horus*	
B820	Little Swift	*Apus affinis*	
B824	Alpine Swift	*Apus melba*	
B828	Blue-naped Mousebird	*Urocolius macrourus*	
B830	Speckled Mousebird	*Colius striatus*	
B842	Grey-headed Kingfisher	*Halcyon leucocephala*	
B844	Blue-breasted Kingfisher	*Halcyon malimbica*	
B846	Woodland Kingfisher	*Halcyon senegalensis*	
B848	Striped Kingfisher	*Halcyon chelicuti*	
B852	African Pygmy Kingfisher	*Ispidina picta*	
B856	Malachite Kingfisher	*Alcedo cristata*	
B860	Giant Kingfisher	*Megaceryle maxima*	R-NT
B862	Pied Kingfisher	*Ceryle rudis*	
B870	Little Bee-eater	*Merops pusillus*	
B872	Blue-breasted Bee-eater	*Merops variegatus*	
B874	Cinnamon-chested Bee-eater	*Merops oreobates*	R-RR
B876	Swallow-tailed Bee-eater	*Merops hirundineus*	R-NT
B878	Red-throated Bee-eater	*Merops bulocki*	
B880	White-throated Bee-eater	*Merops albicollis*	
B884	Blue-cheeked Bee-eater	*Merops persicus*	
B886	Madagascar Bee-eater	*Merops superciliosus*	
B888	Eurasian Bee-eater	*Merops apiaster*	
B890	Carmine Bee-eater	*Merops nubicus*	
B894	Rufous-crowned Roller	*Coracias naevia*	
B896	Abyssinian Roller	*Coracias abyssinica*	
B898	Eurasian Roller	*Coracias garrulus*	
B900	Lilac-breasted Roller	*Coracius caudata*	
B904	Broad-billed Roller	*Eurystomus glaucurus*	
B912	Green Wood Hoopoe	*Phoeniculus purpureus*	
B916	Black Scimitarbill	*Rhinopomastus aterrimus*	
B922	Hoopoe	*Upupa epops*	
B926	Abyssinian Ground Hornbill	*Bucorvus abyssinicus*	
B944	African Pied Hornbill	*Tockus fasciatus*	
B946	Crowned Hornbill	*Tockus alboterminatus*	
B948	African Grey Hornbill	*Tockus nasutus*	
B952	Black and White Casqued Hornbill	*Bycanistes subcylindricus*	
B954	White-thighed Hornbill	*Bycanistes cylindricus*	G-LR/nt
B960	Grey-throated Barbet	*Gymnobucco bonapartei*	
B972	Yellow-rumped Tinkerbird	*Pogoniulus bilineatus*	
B976	Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*	
B984	Spot-flanked Barbet	*Tricholaema lacrymosa*	R-RR
B988	White-headed Barbet	*Lybius leucocephalus*	

Number	Common name	Scientific name	Threat
B992	Black-billed Barbet	*Lybius guifsobalito*	
B996	Double-toothed Barbet	*Lybius bidentatus*	
B1020	Scaly-throated Honeyguide	*Indicator variegatus*	
B1022	Greater Honeyguide	*Indicator indicator*	
B1024	Lesser Honeyguide	*Indicator minor*	
B1044	Nubian Woodpecker	*Campethera nubica*	
B1062	Cardinal Woodpecker	*Dendropicos fuscescens*	
B1070	Grey Woodpecker	*Dendropicos goertae*	
B1074	Brown-backed Woodpecker	*Picoides obsoletus*	
B1094	White-tailed Lark	*Mirafra albicauda*	R-RR
B1100	Flappet Lark	*Mirafra rufocinnamomea*	
B1106	Rufous-rumped Lark	*Pinarocorys erythropygia*	
B1120	White-headed Saw-wing	*Psalidoprocne albiceps*	R-RR
B1122	Plain Martin	*Riparia paludicola*	
B1124	Sand Martin	*Riparia riparia*	
B1130	Rufous-chested Swallow	*Hirundo semirufa*	
B1132	Mosque Swallow	*Hirundo senegalensis*	
B1134	Lesser Striped Swallow	*Hirundo abyssinica*	
B1136	Red-rumped Swallow	*Hirundo daurica*	
B1138	Rock Martin	*Hirundo fuligula*	
B1142	Wire-tailed Swallow	*Hirundo smithii*	
B1146	Ethiopian Swallow	*Hirundo aethiopica*	
B1148	Angola Swallow	*Hirundo angolensis*	
B1150	Barn Swallow	*Hirundo rustica*	
B1152	Common House Martin	*Delichon urbica*	
B1156	Yellow Wagtail	*Motacilla flava*	
B1160	Grey Wagtail	*Motacilla cinerea*	
B1164	White Wagtail	*Motacilla alba*	
B1166	African Pied Wagtail	*Motacilla aguimp*	
B1170	Grassland Pipit	*Anthus cinnamomeus*	
B1176	Plain-backed Pipit	*Anthus leucophrys*	
B1180	Tree Pipit	*Anthus trivialis*	
B1182	Red-throated Pipit	*Anthus cervinus*	
B1184	Yellow-throated Longclaw	*Macronyx croceus*	
B1188	Red-shouldered Cuckoo-shrike	*Campephaga phoenicea*	
B1190	Black Cuckoo-shrike	*Campephaga flava*	
B1198	White-breasted Cuckoo-shrike	*Coracina pectoralis*	
B1208	Little Greenbul	*Andropadus virens*	
B1214	Cameroon Sombre Greenbul	*Andropadus curvirostris*	
B1228	Yellow-throated Greenbul	*Chlorocichla flavicollis*	
B1258	Common Bulbul	*Pycnonotus barbatus*	
B1276	Nightingale	*Luscinia megarhynchos*	
B1288	White-browed Robin Chat	*Cossypha heuglini*	
B1290	Red-capped Robin Chat	*Cossypha natalensis*	

Number	Common name	Scientific name	Threat
B1292	Snowy-headed Robin Chat	*Cossypha niveicapilla*	
B1308	Spotted Morning Thrush	*Cichladusa guttata*	
B1314	White-browed Scrub Robin	*Cercotrichas leucophrys*	
B1318	Common Redstart	*Phoenicurus phoenicurus*	
B1322	Whinchat	*Saxicola rubetra*	
B1324	Northern Wheatear	*Oenanthe oenanthe*	
B1326	Pied Wheatear	*Oenanthe pleschanka*	
B1332	Isabelline Wheatear	*Oenanthe isabellina*	
B1340	Sooty Chat	*Myrmecocichla nigra*	
B1342	White-fronted Black Chat	*Myrmecocichla albifrons*	
B1350	Common Rock Thrush	*Monticola saxatilis*	
B1366	African Thrush	*Turdus pelios*	
B1386	African Moustached Warbler	*Melocichla mentalis*	
B1392	Sedge Warbler	*Acrocephalus schoenobaenus*	
B1394	Eurasian Reed Warbler	*Acrocephalus scirpaceus*	
B1400	Great Reed Warbler	*Acrocephalus arundinaceus*	
B1406	Lesser Swamp Warbler	*Acrocephalus gracilirostris*	
B1408	Dark-capped Yellow Warbler	*Chloropeta natalensis*	
B1414	Olivaceous Warbler	*Hippolais pallida*	
B1418	Icterine Warbler	*Hippolais icterina*	
B1420	Red-faced Cisticola	*Cisticola erythrops*	
B1422	Singing Cisticola	*Cisticola cantans*	
B1424	Whistling Cisticola	*Cisticola lateralis*	
B1426	Trilling Cisticola	*Cisticola woosnami*	
B1434	Rattling Cisticola	*Cisticola chiniana*	
B1440	Winding Cisticola	*Cisticola galactotes*	
B1446	Croaking Cisticola	*Cisticola natalensis*	
B1452	Siffling Cisticola	*Cisticola brachypterus*	
B1454	Foxy Cisticola	*Cisticola troglodytes*	
B1458	Zitting Cisticola	*Cisticola juncidis*	
B1460	Black-backed Cisticola	*Cisticola eximius*	
B1462	Wing-snapping Cisticola	*Cisticola ayresii*	
B1464	Tawny-flanked Prinia	*Prinia subflava*	
B1472	Red-winged Warbler	*Heliolais erythroptera*	
B1474	Red-winged Grey Warbler	*Drymocichla incana*	R-NT
B1476	Buff-bellied Warbler	*Phyllolais pulchella*	
B1482	Yellow-breasted Apalis	*Apalis flavida*	
B1502	Grey-backed Camaroptera	*Camaroptera brachyura*	
B1522	Green-backed Eremomela	*Eremomela pusilla*	
B1530	Northern Crombec	*Sylvietta brachyura*	
B1532	Red-faced Crombec	*Sylvietta whytii*	
B1534	Green Crombec	*Sylvietta virens*	
B1540	Willow Warbler	*Phylloscopus trochilus*	
B1552	Grey-capped Warbler	*Eminia lepida*	R-RR

Number	Common name	Scientific name	Threat
B1554	Barred Warbler	*Sylvia nisoria*	
B1556	Garden Warbler	*Sylvia borin*	
B1560	Common Whitethroat	*Sylvia communis*	
B1564	Yellow-bellied Hyliota	*Hyliota flavigaster*	
B1578	Northern Black Flycatcher	*Melaenornis edolioides*	
B1580	Pale Flycatcher	*Bradornis pallidus*	
B1584	Silverbird	*Empidornis semipartitus*	
B1586	Spotted Flycatcher	*Muscicapa striata*	
B1590	Ashy Flycatcher	*Muscicapa caerulescens*	
B1592	Swamp Flycatcher	*Muscicapa aquatica*	
B1598	African Dusky Flycatcher	*Muscicapa adusta*	
B1608	Lead-coloured Flycatcher	*Myioparus plumbeus*	
B1614	Semi-collared Flycatcher	*Ficedula semitorquata*	
B1620	African Blue Flycatcher	*Elminia longicauda*	
B1634	African Paradise Flycatcher	*Terpsiphone viridis*	
B1650	Brown-throated Wattle-eye	*Platysteira cyanea*	
B1652	Black-throated Wattle-eye	*Platysteira peltata*	
B1660	Black-headed Batis	*Batis minor*	
B1682	Brown Babbler	*Turdoides plebejus*	
B1684	Arrow-marked Babbler	*Turdoides jardineii*	
B1688	Black-lored Babbler	*Turdoides sharpei*	R-RR
B1704	Black Tit	*Parus leucomelas*	
B1710	African Penduline Tit	*Anthoscopus caroli*	
B1721	Western Violet-backed Sunbird	*Anthreptes longuemarei*	R-NT
B1723	Eastern Violet-backed Sunbird	*Anthreptes orientalis*	
B1729	Grey-headed Sunbird	*Delornis axillaris*	
B1731	Green-headed Sunbird	*Cyanomitra verticalis*	
B1739	Green-throated Sunbird	*Chalcomitra rubescens*	
B1743	Scarlet-chested Sunbird	*Chalcomitra senegalensis*	
B1759	Collared Sunbird	*Hedydipna collaris*	
B1761	Pygmy Sunbird	*Hedydipna platura*	
B1763	Olive-bellied Sunbird	*Cinnyris chloropygia*	
B1775	Beautiful Sunbird	*Cinnyris pulchella*	
B1777	Marico Sunbird	*Cinnyris mariquensis*	
B1779	Red-chested Sunbird	*Cinnyris erythroceria*	R-RR
B1781	Purple-banded Sunbird	*Cinnyris bifasciata*	
B1789	Variable Sunbird	*Cinnyris venusta*	
B1791	Superb Sunbird	*Cinnyris superba*	
B1795	Copper Sunbird	*Cinnyris cuprea*	
B1799	Yellow White-eye	*Zosterops senegalensis*	
B1803	Common Fiscal	*Lanius collaris*	
B1807	Mackinnon's Fiscal	*Lanius mackinnoni*	
B1809	Grey-backed Fiscal	*Lanius excubitoroides*	
B1811	Lesser Grey Shrike	*Lanius minor*	

Number	Common name	Scientific name	Threat
B1813	Isabelline Shrike	*Lanius isabellinus*	
B1815	Red-backed Shrike	*Lanius collurio*	
B1817	Emin's Shrike	*Lanius gubernator*	R-NT
B1819	Woodchat Shrike	*Lanius senator*	
B1823	Yellow-billed Shrike	*Corvinella corvina*	
B1831	Grey-headed Bush Shrike	*Malaconotus blanchoti*	
B1839	Sulphur-breasted Bush Shrike	*Malaconotus sulphureopectus*	
B1843	Marsh Tchagra	*Tchagra minuta*	
B1845	Brown-crowned Tchagra	*Tchagra australis*	
B1849	Black-crowned Tchagra	*Tchagra senegala*	
B1855	Northern Puffback	*Dryoscopus gambensis*	
B1865	Tropical Boubou	*Laniarius aethiopicus*	
B1869	Black-headed Gonolek	*Laniarius erythrogaster*	
B1871	Brubru	*Nilaus afer*	
B1875	White-crested Helmet Shrike	*Prionops plumatus*	
B1891	African Golden Oriole	*Oriolus auratus*	
B1893	Eurasian Golden Oriole	*Oriolus oriolus*	
B1899	Fork-tailed Drongo	*Dicrurus adsimilis*	
B1907	Pied Crow	*Corvus albus*	
B1913	Piapiac	*Ptilostomus afer*	
B1933	Purple Starling	*Lamprotornis purpureus*	
B1935	Bronze-tailed Starling	*Lamprotornis chalcurus*	
B1937	Greater Blue-eared Starling	*Lamprotornis chalybaeus*	
B1939	Lesser Blue-eared Starling	*Lamprotornis chloropterus*	
B1941	Splendid Starling	*Lamprotornis splendidus*	
B1943	Rüppell's Long-tailed Starling	*Lamprotornis purpuropterus*	
B1947	Magpie Starling	*Speculipastor bicolor*	
B1949	Sharpe's Starling	*Cinnyricinclus sharpii*	R-NT
B1951	Violet-backed Starling	*Cinnyricinclus leucogaster*	
B1953	Wattled Starling	*Creatophora cinerea*	
B1957	Yellow-billed Oxpecker	*Buphagus africanus*	R-VU
B1963	Rufous Sparrow	*Passer rufocinctus*	R-RR
B1965	Grey-headed Sparrow	*Passer griseus*	
B1969	Chestnut Sparrow	*Passer eminibey*	
B1983	Speckle-fronted Weaver	*Sporopipes frontalis*	
B1985	White-browed Sparrow Weaver	*Plocepasser mahali*	
B1987	Chestnut-crowned Sparrow Weaver	*Plocepasser superciliosus*	
B1991	Baglafecht Weaver	*Ploceus baglafecht*	
B1993	Slender-billed Weaver	*Ploceus pelzelni*	
B1995	Little Weaver	*Ploceus luteolus*	
B1997	Black-necked Weaver	*Ploceus nigricollis*	
B1999	Spectacled Weaver	*Ploceus ocularis*	
B2005	Holub's Golden Weaver	*Ploceus xanthops*	
B2015	Lesser Masked Weaver	*Ploceus intermedius*	

Number	Common name	Scientific name	Threat
B2017	Vitelline Masked Weaver	*Ploceus velatus*	
B2021	Fox's Weaver	*Ploceus spekeoides*	G-NT/RR, R-NT/RR
B2023	Vieillot's Black Weaver	*Ploceus nigerrimus*	
B2025	Black-headed Weaver	*Ploceus cucullatus*	
B2029	Yellow-backed Weaver	*Ploceus melanocephalus*	
B2031	Golden-backed Weaver	*Ploceus jacksoni*	R-RR
B2039	Compact Weaver	*Ploceus superciliosus*	
B2049	Red-headed Malimbe	*Malimbus rubricollis*	
B2053	Red-headed Weaver	*Anaplectes rubriceps*	
B2055	Cardinal Quelea	*Quelea cardinalis*	R-RR
B2057	Red-headed Quelea	*Quelea erythrops*	
B2059	Red-billed Quelea	*Quelea quelea*	
B2063	Black Bishop	*Euplectes gierowii*	
B2065	Black-winged Red Bishop	*Euplectes hordeaceus*	
B2069	Northern Red Bishop	*Euplectes franciscanus*	
B2071	Yellow Bishop	*Euplectes capensis*	
B2073	Fan-tailed Widowbird	*Euplectes axillaris*	
B2075	Yellow-mantled Widowbird	*Euplectus macrourus*	
B2077	White-winged Widowbird	*Euplectes albonotatus*	
B2079	Red-collared Widowbird	*Euplectes ardens*	
B2083	Grosbeak Weaver	*Amblyospiza albifrons*	
B2089	Grey-headed Negrofinch	*Nigrita canicapilla*	
B2099	Grey-headed Oliveback	*Nesocharis capistrata*	
B2101	Green-winged Pytilia	*Pytilia melba*	
B2103	Orange-winged Pytilia	*Pytilia afra*	
B2105	Red-winged Pytilia	*Pytilia phoenicoptera*	
B2115	Black-bellied Seedcracker	*Pyrenestes ostrinus*	
B2123	Brown Twinspot	*Clytospiza monteiri*	
B2129	Red-billed Firefinch	*Lagonosticta senegala*	
B2131	Bar-breasted Firefinch	*Lagonosticta rufopicta*	
B2135	Black-bellied Firefinch	*Lagonosticta rara*	
B2137	African Firefinch	*Lagonosticta rubricata*	
B2143	Fawn-breasted Waxbill	*Estrilda paludicola*	
B2145	Crimson-rumped Waxbill	*Estrilda rhodopyga*	
B2147	Black-rumped Waxbill	*Estrilda troglodytes*	
B2149	Common Waxbill	*Estrilda astrild*	
B2151	Black-crowned Waxbill	*Estrilda nonnula*	
B2159	Red-cheeked Cordon Bleu	*Uraeginthus bengalus*	
B2163	Zebra Waxbill	*Amandava subflava*	
B2165	African Quail-Finch	*Ortygospiza atricollis*	
B2173	Bronze Mannikin	*Lonchura cucullata*	
B2175	Black and White Mannikin	*Lonchura bicolor*	
B2179	Cut-throat Finch	*Amadina fasciata*	

Number	Common name	Scientific name	Threat
B2183	Village Indigobird	*Vidua chalybeata*	
B2185	Pin-tailed Whydah	*Vidua macroura*	
B2191	Eastern Paradise-Whydah	*Vidua paradisaea*	
B2195	Parasitic Weaver	*Anomalospiza imberbis*	
B2201	African Citril	*Serinus citrinelloides*	
B2205	White-rumped Seedeater	*Serinus leucopygius*	
B2209	Yellow-fronted Canary	*Serinus mozambicus*	
B2215	Streaky-headed Seedeater	*Serinus gularis*	
B2227	Cinnamon-breasted Rock Bunting	*Emberiza tahapisi*	
B2231	African Golden-breasted Bunting	*Emberiza flaviventris*	
B2233	Brown-rumped Bunting	*Emberiza affinis*	
B2235	Cabanis's Bunting	*Emberiza cabanisi*	

7.1 Annex 2 Species of birds recorded in the different sample areas for the present study

Brit number	Common name	Scientific name	Threat	Sample area A	Sample area B
B6	Long-tailed Cormorant	*Phalacrocorax africanus*		√	√
B30	Little Egret	*Egretta garzetta*			√
B36	Purple Heron	*Ardea purpurea*	R-NT	√	√
B46	Hamerkop	*Scopus umbretta*		√	√
B52	African Open-billed Stork	*Anastomus lamelligerus*		√	√
B64	Marabou Stork	*Leptoptilos crumeniferus*		√	√
B74	Hadada Ibis	*Bostrychia hagedash*		√	√
B80	Sacred Ibis	*Threskiornis aethiopica*		√	√
B142	Osprey	*Pandion haliaetus*		√	√
B160	Palm-nut Vulture	*Gypohierax angolensis*		√	
B178	Brown Snake Eagle	*Circaetus cinereus*	R-NT	√	√
B180	Western Banded Snake Eagle	*Circaetus cinerascens*	R-VU	√	√
B182	Bateleur	*Terathopius ecaudatus*		√	√
B186	African Harrier Hawk	*Polyboroides typus*		√	√
B206	Shikra	*Accipiter badius*		√	
B226	Lizard Buzzard	*Kaupifalco monogrammicus*		√	√
B242	Tawny Eagle	*Aquila rapax*		√	√
B254	Long-crested Eagle	*Lophaetus occipitalis*		√	√
B308	Helmeted Guineafowl	*Numida meleagris*		√	√
B324	Ring-necked Francolin	*Francolinus streptophorus*	R-VU/RR	√	√
B334	Crested Francolin	*Francolinus sephaena*		√	√
B420	Black-bellied Bustard	*Eupodotis melanogaster*		√	√
B468	Rock Pratincole	*Glareola nuchalis*	R-VU	√	
B498	Spur-winged Lapwing	*Vanellus spinosus*		√	
B502	Senegal Lapwing	*Vanellus lugubris*		√	√
B608	Tambourine Dove	*Turtur tympanistria*		√	√
B610	Blue-spotted Wood Dove	*Turtur afer*		√	√
B616	Namaqua Dove	*Oena capensis*		√	√
B630	Speckled Pigeon	*Columba guinea*		√	
B634	Red-eyed Dove	*Streptopelia semitorquata*		√	
B636	African Mourning Dove	*Streptopelia decipiens*		√	√
B638	Vinaceous Dove	*Streptopelia vinacea*		√	
B646	Laughing Dove	*Streptopelia senegalensis*		√	√
B658	Red-headed Lovebird	*Agapornis pullarius*		√	
B670	White-crested Turaco	*Tauraco leucolophus*		√	√
B696	Red-chested Cuckoo	*Cuculus solitarius*		√	√
B716	Klaas's Cuckoo	*Chrysococcyx klaas*		√	√
B724	White-browed Coucal	*Centropus superciliosus*		√	√
B728	Senegal Coucal	*Centropus senegalensis*		√	
B774	Long-tailed Nightjar	*Caprimulgus climacurus*		√	√
B778	Square-tailed Nightjar	*Caprimulgus fossii*		√	√

Brit number	Common name	Scientific name	Threat	Sample area A	Sample area B
B794	Standard-winged Nightjar	*Macrodipteryx longipennis*		√	√
B820	Little Swift	*Apus affinis*		√	√
B824	Alpine Swift	*Apus melba*		√	√
B830	Speckled Mousebird	*Colius striatus*		√	√
B846	Woodland Kingfisher	*Halcyon senegalensis*		√	√
B848	Striped Kingfisher	*Halcyon chelicuti*		√	√
B862	Pied Kingfisher	*Ceryle rudis*		√	√
B870	Little Bee-eater	*Merops pusillus*		√	√
B876	Swallow-tailed Bee-eater	*Merops hirundineus*	R-NT	√	
B878	Red-throated Bee-eater	*Merops bulocki*		√	
B880	White-throated Bee-eater	*Merops albicollis*		√	√
B886	Madagascar Bee-eater	*Merops superciliosus*		√	
B922	Hoopoe	*Upupa epops*		√	√
B926	Abyssinian Ground Hornbill	*Bucorvus abyssinicus*		√	√
B944	African Pied Hornbill	*Tockus fasciatus*		√	
B948	African Grey Hornbill	*Tockus nasutus*		√	√
B972	Yellow-rumped Tinkerbird	*Pogoniulus bilineatus*		√	√
B984	Spot-flanked Barbet	*Tricholaema lacrymosa*	R-RR	√	√
B988	White-headed Barbet	*Lybius leucocephalus*		√	√
B1022	Greater Honeyguide	*Indicator indicator*		√	√
B1120	White-headed Saw-wing	*Psalidoprocne albiceps*	R-RR	√	√
B1124	Sand Martin	*Riparia riparia*		√	√
B1134	Lesser Striped Swallow	*Hirundo abyssinica*		√	√
B1138	Rock Martin	*Hirundo fuligula*		√	
B1142	Wire-tailed Swallow	*Hirundo smithii*		√	
B1176	Plain-backed Pipit	*Anthus leucophrys*		√	√
B1184	Yellow-throated Longclaw	*Macronyx croceus*		√	√
B1258	Common Bulbul	*Pycnonotus barbatus*		√	√
B1288	White-browed Robin Chat	*Cossypha heuglini*		√	
B1292	Snowy-headed Robin Chat	*Cossypha niveicapilla*		√	
B1314	White-browed Scrub Robin	*Cercotrichas leucophrys*		√	√
B1322	Whinchat	*Saxicola rubetra*		√	√
B1340	Sooty Chat	*Myrmecocichla nigra*		√	√
B1426	Trilling Cisticola	*Cisticola woosnami*		√	√
B1434	Rattling Cisticola	*Cisticola chiniana*		√	√
B1440	Winding Cisticola	*Cisticola galactotes*		√	√
B1462	Wing-snapping Cisticola	*Cisticola ayresii*		√	√
B1464	Tawny-flanked Prinia	*Prinia subflava*		√	√
B1532	Red-faced Crombec	*Sylvietta whytii*		√	√
B1578	Northern Black Flycatcher	*Melaenornis edolioides*		√	√
B1743	Scarlet-chested Sunbird	*Chalcomitra senegalensis*		√	√
B1789	Variable Sunbird	*Cinnyris venusta*		√	√
B1809	Grey-backed Fiscal	*Lanius excubitoroides*		√	√

Brit number	Common name	Scientific name	Threat	Sample area A	Sample area B
B1839	Sulphur-breasted Bush Shrike	*Malaconotus sulphureopectus*		√	
B1843	Marsh Tchagra	*Tchagra minuta*		√	
B1849	Black-crowned Tchagra	*Tchagra senegala*		√	√
B1855	Northern Puffback	*Dryoscopus gambensis*		√	√
B1865	Tropical Boubou	*Laniarius aethiopicus*		√	
B1875	White-crested Helmet Shrike	*Prionops plumatus*		√	√
B1907	Pied Crow	*Corvus albus*			
B1913	Piapiac	*Ptilostomus afer*		√	√
B1943	Rüppell's Long-tailed Starling	*Lamprotornis purpuropterus*		√	√
B1949	Sharpe's Starling	*Cinnyricinclus sharpii*	R-NT	√	
B1951	Violet-backed Starling	*Cinnyricinclus leucogaster*		√	
B1999	Spectacled Weaver	*Ploceus ocularis*		√	
B2015	Lesser Masked Weaver	*Ploceus intermedius*		√	√
B2017	Vitelline Masked Weaver	*Ploceus velatus*		√	
B2023	Vieillot's Black Weaver	*Ploceus nigerrimus*		√	√
B2049	Red-headed Malimbe	*Malimbus rubricollis*		√	√
B2059	Red-billed Quelea	*Quelea quelea*		√	√
B2063	Black Bishop	*Euplectes gierowii*		√	√
B2069	Northern Red Bishop	*Euplectes franciscanus*		√	√
B2071	Yellow Bishop	*Euplectes capensis*		√	√
B2075	Yellow-mantled Widowbird	*Euplectus macrourus*		√	√
B2103	Orange-winged Pytilia	*Pytilia afra*		√	
B2105	Red-winged Pytilia	*Pytilia phoenicoptera*		√	√
B2129	Red-billed Firefinch	*Lagonosticta senegala*		√	√
B2159	Red-cheeked Cordon Bleu	*Uraeginthus bengalus*		√	√
B2183	Village Indigobird	*Vidua chalybeata*		√	√
B2185	Pin-tailed Whydah	*Vidua macroura*		√	
B2209	Yellow-fronted Canary	*Serinus mozambicus*		√	√