7.6.4 Evaluation from Economical and Technical Aspects

(1) Approximate Construction Cost

Approximate cost of the construction for the alternatives are estimated based on the principal feature, as shown in Table 7.6.4-1, and typical layout drawings, as shown in Figures 7.6.3-1 to 7.6.3-3 respectively.

As a result, the waterway type of left bank route proved to be most economical among the alternatives.

Table 7.6.4-1 Cost Summary of Layout Alternatives at Ayago Site

Unit: (x10^3US$)

Item	Dam and Waterway Type	Waterway 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	100x10^3US$/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)

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 is 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 is estimated considering the overbreak due to excavation work and increasing of the muck in volume. Required aggregate volume is estimated under the assumption of typical concrete mix proportion and specific weight. Beak down of the estimation is shown in following table.

Table 7.6.4-2 Disposal Volume of Layout Alternatives

Item	Dam-Waterway Type		Left Bank Route		Right Bank Route		Note
	Excavation (m^3)	Concrete (m^3)	Excavation (m^3)	Concrete (m^3)	Excavation (m^3)	Concrete (m^3)	
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 (m^3)	6,116,319		7,132,769		8,833,809		(a) = Excavation Volume x 1.5
(b) Concrete Aggregate (m^3)	864,183		842,086		1,104,043		(b) =Conc. Volume x 2.046/2.6x1.125
(c) Subbase (m^3)	150,000		150,000		150,000		(c) =0.3m×5m×100km
(d) Disposal Volume (m^3)	**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.

(3) Volume of Aggregate Mining from Quarry Site

Since concrete volume of the dam & waterway type is about 270,000m^3. 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 7.6.4-2, 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 7.6.4-3.

Table 7.6.4-3 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)

(4) Geology along the Waterway Route

Rock classification along the waterway for the alternatives is assumed based on the area photograph & topographic analysis, site investigation, and core drilling results at the site. Results of the rock classification are shown in Table 7.6.4-4.

Table 7.6.4-4 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) Peak Duration Time

Since waterway type is often called “run of river type”, peak power regulation cannot be carried out (or only slightly). On the other hand, the dam & waterway type has 20miliion m3 of regulating pond and the maximum plant discharge is 840m^3/s. Hence 6-hours peak regulation can be carried out as a result of following calculation.

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

Table 7.6.4-5 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)

(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 7.6.4-6.

Table 7.6.4-6 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)

(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 uncertainty in the construction work will mostly be derived from underground work which could have unexpected geological conditions. Major underground works of the Project are powerhouse and tunnel works and the powerhouse works for all the alternatives are assumed to have similar conditions. Hence, construction risk was estimated based on the tunnel length as shown in Table 7.6.4-7.

Table 7.6.4-7 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)

7.6.5 Evaluation from Environmental aspect

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

Table 7.6.5-1 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 7.6.5-2 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.

(1) 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 7.6.5-3 Assessment of significance of impacts on flora and vegetation (without mitigation)

	Dam-Waterway Type	Left Bank Route	Right Bank Route
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

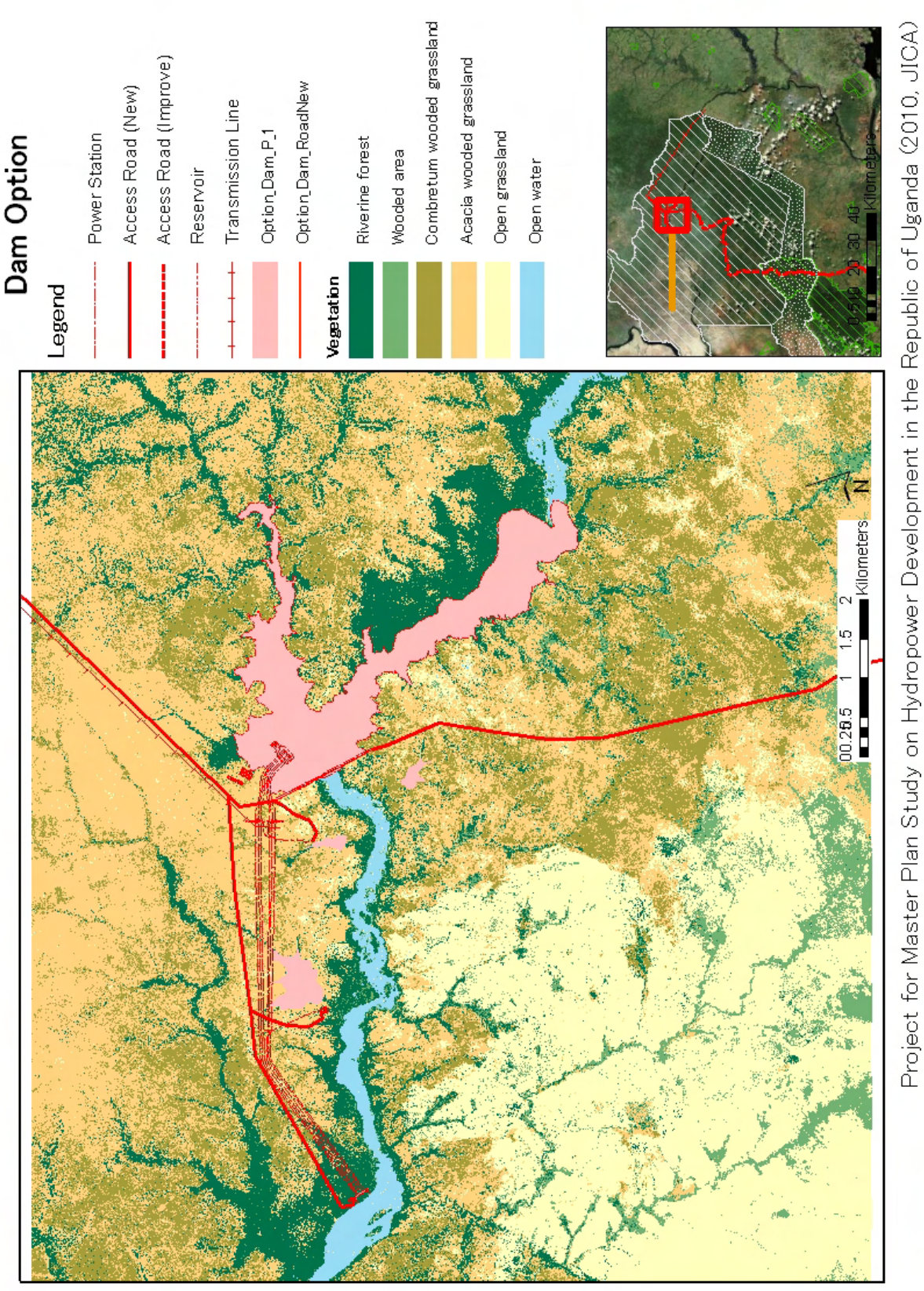

Figure 7.6.5-1 Dam Waterway Type and Vegetation (WGS_1984_UTM_Zone_36N)

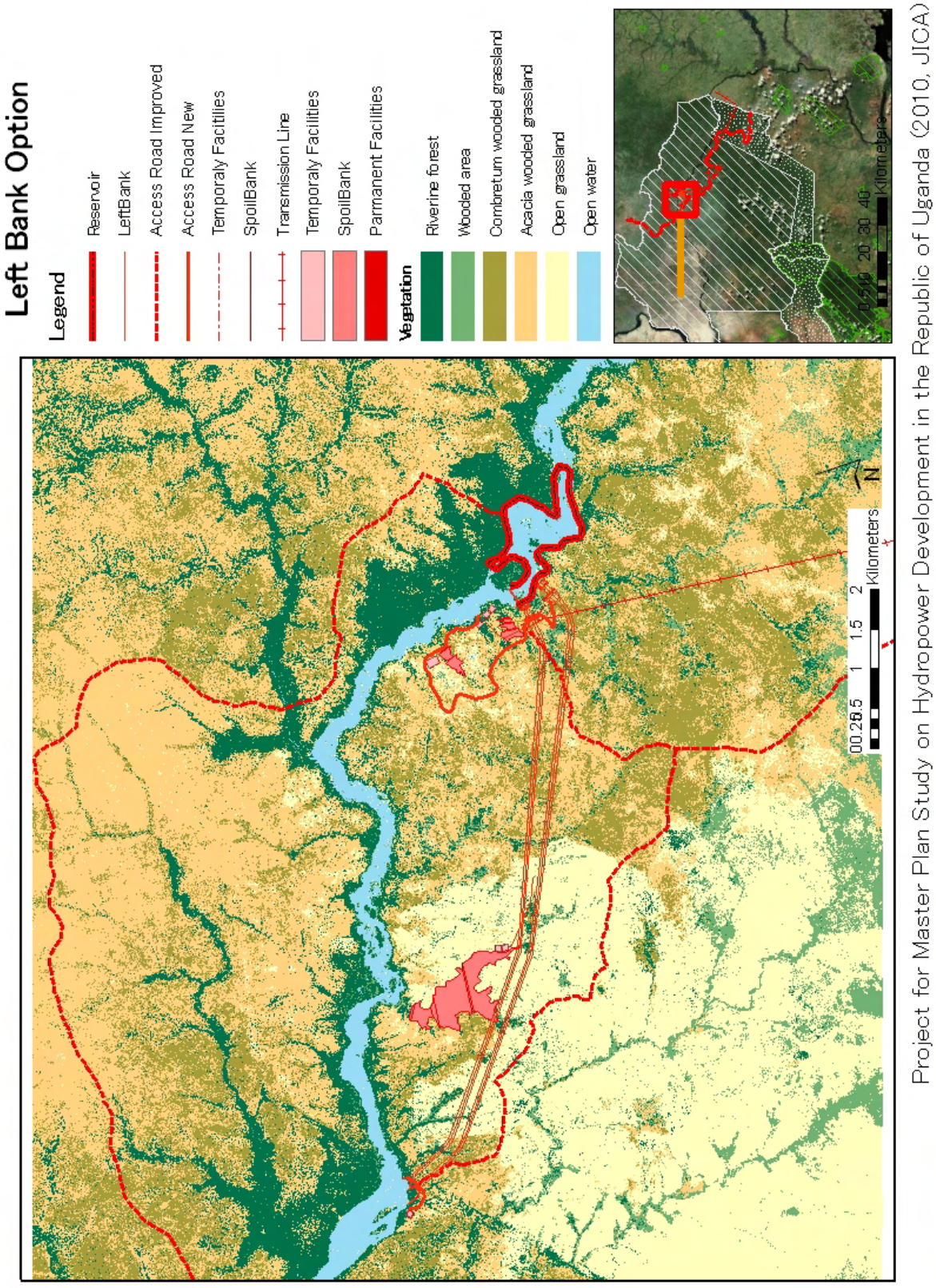

Figure 7.6.5-2 Left Bank Route and Vegetation (WGS_1984_UTM_Zone_36N)

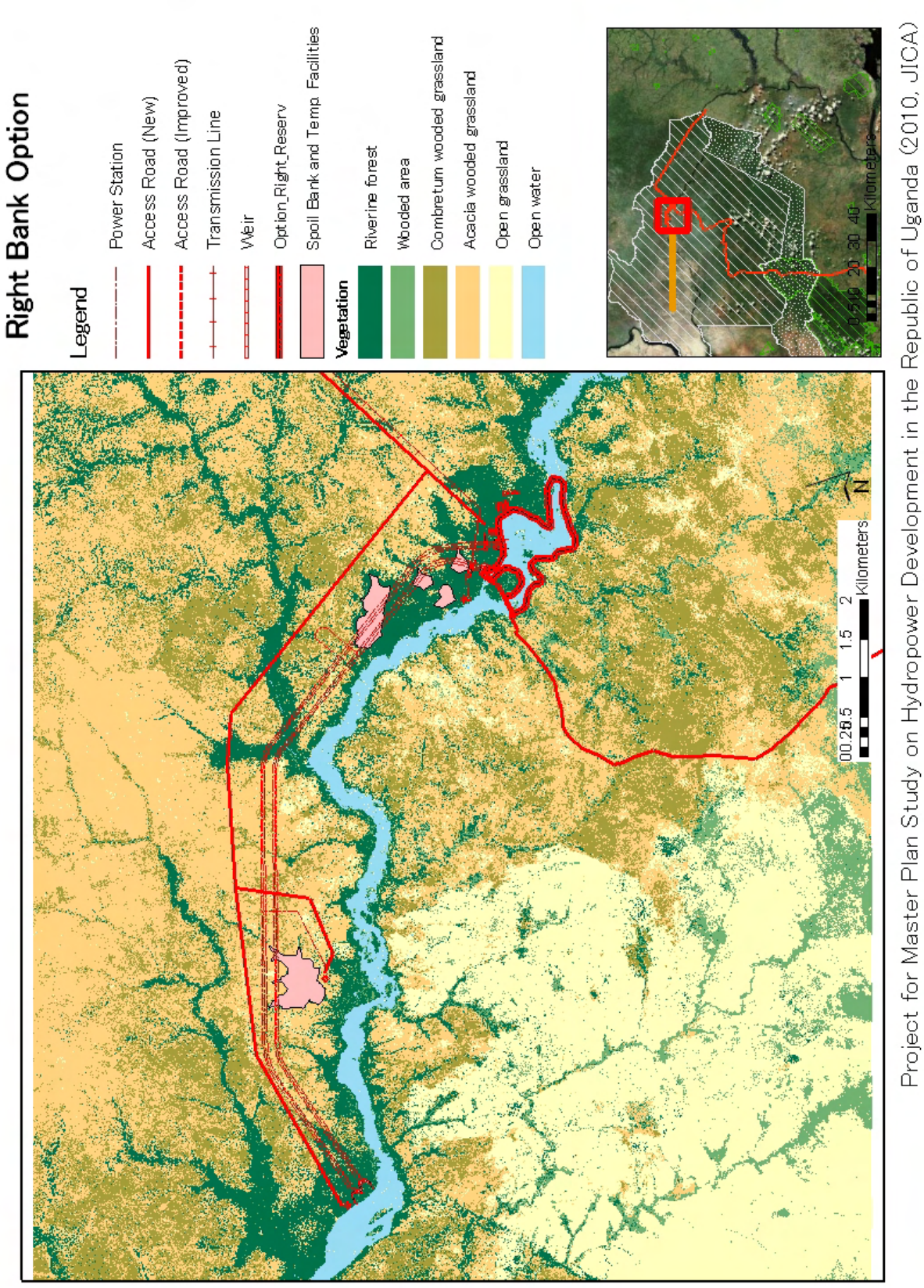

Figure 7.6.5-3 Right Bank Route and Vegetation (WGS_1984_UTM_Zone_36N)

(2) 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 7.6.5-4 Potential Species specific Impacts due to the different option

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
	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

Name			Relative Impact Assessment		
Family	**English name**	**Scientific name**	**Dam Waterway**	**Left Bank**	**Right Bank**
Thryonomidae	Savannah (Common) Cane Rat	*Thryonomys swinderianus*	1	1	1
Orycteropodidae	Aardvark (Ant Bear)	*Orycteropus afer*	1	1	1
Total			**42**	**37**	**41**
Rating			**C**	**B**	**C**

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 7.6.5-5 Assessment of significance of impacts on medium sized and large mammals (without mitigation)

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: Medium impact C: Bigger impact

(3) 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 7.6.5-6 Assessment of significance of impacts on birds (without mitigation)

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: Medium impact C: Bigger impact

(4) 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 7.6.5-7 Assessment of significance of impacts on amphibians and reptiles (without mitigation)

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)

Items	Dam Waterway	Left Bank	Right Bank
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: Medium impact C: Bigger impact

(5) 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 7.6.5-8 Assessment of significance of impacts on butterflies (without mitigation)

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: Medium impact C: Bigger impact

(6) 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 relatively lower impact than the Dam option, because of the lower height of the barrier and the smaller inundation area.

Table 7.6.5-9 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: Middle impact C: Bigger impact

7.6.6 Evaluation from Social Aspects

(1) Land acquisition

Land acquisition is 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 7.6.6-1 Assessment on Land Acquisition

Options	Dam Waterway	Left Bank	Right Bank
Area for transmission tower (m^2)	800	3300	800
Area for ROW for transmission line (ha)	11	49	11
Area for spoil bank (m^2)	0	0	0
Area for temporary facility (m^2)	0	0	0
Area for inundation (m^2)	0	0	0
Rating	B	C	B

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

(2) Flooding area

Flooding area is 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 7.6.6-2 Assessment on Flooding Area

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

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

(3) Number of Resettlements/ Affected People

Impact on local people is 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 7.6.6-3 Assessment on Number of Affected People

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

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

(4) Impact on Agriculture

Impact on agriculture is 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 7.6.6-4 Impact Assessment on Agriculture

Items	Dam Waterway	Left Bank	Right Bank
Agricultural area within 1km buffer from the project area (ha)	81,089	41,453	81,089
Agricultural area within 100m from transmission line (ha)	37	7,651	37
Agricultural area within 100m 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

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

(5) Impact on Historical and Cultural Properties

Impact on historical and cultural properties is 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 7.6.6-5 Impact Assessment on Historical and Cultural Properties

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

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

(6) Impact on Poaching Activities

Impact on poaching activities in the National Park is 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 7.6.6-6 Impact Assessment on Poaching Activities in Murchison Falls Protected Area

Items	Dam Waterway	Left Bank	Right Bank
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

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

(7) Impact on Tourism

Impact on tourism in the National Park is 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 7.6.6-7 Impact Assessment on Tourism

Items	Dam Waterway	Left Bank	Right Bank
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

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

7.6.7 General Evaluation

Multi Criteria Decision Analysis is conducted for the evaluation of the proposed layouts based on the results of evaluations from economic and technical aspects, environmental aspects and social aspects.

(1) Weighting of the evaluation criteria for the proposed layouts

Multi Criteria Decision Analysis is 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 is 19. All proposed layouts were evaluated from A to E or A to C for all criteria. The evaluations from A to E are converted from 5 to 1 (evaluations from A to C are converted from 3 to 1), multiplied by the weighs, and summed up by the projects. For sensitivity analysis, four cases of weightings are 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 7.6.7-1 Evaluation Items and Weighting

	Even Case		Environment weighting case		Economic Weighting Case	
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
Flora and Vegetation	33	7	40	8	26	6
Mammal		8		9		7
amphibians and reptiles		6		8		5
butterflies		6		7		4
Fishes		6		8		4
Land acquisition	31	5	31	5	31	5
Flooding area		5		5		5
Number of resettlement/ 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

(Source: Study Team)

(2) General evaluation of the proposed layouts

As a result of weighting and summing up all items by the projects, the general evaluations are shown in Table 7.6.7-2.

Current evaluation shows that Left Bank Option has relatively higher score than the other layouts for Even Case, Environment weighting case, and Economic Weighting Case. Then Pre feasibility study is conducted for Left bank option.

However, it is difficult to decide the optimal layout in this study, because a lot of uncertain conditions are remaining. Then the final decision of the layout should be done in the next feasibility study based on more detail survey.

Table 7.6.7-2 General Evaluation for 3 Layouts

		Weight (even)	Dam-Waterway Type	Left Bank Route	Right Bank Route
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
	Mammal	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 resettlement/ 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
			C	A	B
	Environment weighting case		152	215	188
			C	A	B
	Economic Weighting Case		172 C	218 A	187 B

(Source: Study Team)

7.7 Study on Optimum Development Scale

In general, for determination of the optimum development scale two following methods are applied. In the case that efficiency of investment is emphasized, such a development scale that shows the maximum benefit-cost ratio is to be optimum. On the other hand, in the case that effective utilization of hydropower potential is emphasized without any restriction of the amount of investment cost, such a development scale that shows the maximum annual surplus benefit is to be optimum.

In this study, an economic comparison by parameters of benefit-cost ratio (B/C), annual surplus benefit (B-C) and unit energy price (cent/kWh) is carried out between 7 development scales ranging from 100 MW to 800 MW of the run of river type with a left bank layout alternative which is optimum development type of the Ayago hydropower. The result of the comparison is shown in Table 7.7-1 and Figure 7.7-1.

Table 7.7-1 Optimization Study on Development Scale of Ayago Hydropower Project

Item	Unit	Description						
Installed Capacity	MW	100	200	300	400	500	600	800
Maximum Power Discharge	m^3/s	140.4	280.8	421.2	561.6	702	842.4	1122.8
Firm Discharge	m^3/s	467						
Min imum Amenity Flow	m^3/s	50						
Firm Power Discharge	m^3/s	140	280	417	417	417	417	417
Firm Capacity	MW	100.0	200.0	297.1	297.1	297.1	297.1	297.1
Annual Total Energy Production	GWh	876	1,740	2,592	3,285	3,830	4,244	4,800
Annual Firm Energy Production	GWh	876	1,740	2,568	2,568	2,568	2,568	2,568
Annual Incremental Total Energy Production	GWh		864	853	692	546	413	556
Annual Plant Factor	%	100	99	99	94	87	81	68
Station Services use	%	1.00						
Annual Forced Outage	%	0.50						
Annual Scheduled Outage	%	2.00						
Effective Total Capacity	MW	96.50	193.00	289.50	386.00	482.50	579.00	772.00
Effective Firm Capacity	MW	96.50	193.00	286.70	286.70	286.70	286.70	286.70
Effective Annual Total Energy	GWh	845	1,679	2,502	3,170	3,696	4,095	4,632
Effective Annual Firm Energy	GWh	845	1,679	2,478	2,478	2,478	2,478	2,478
Total Construction Cost	10^3US$	386,635	619,491	848,478	1,113,403	1,355,527	1,599,293	2,130,475
Total Annual Cost	10^3US$	46,365	74,258	101,683	133,335	162,301	191,439	254,835
Unit Firm Energy Price	Cent/kWh	5.48	4.42	4.10	4.92	5.71	6.54	8.12
Annual Surplus Benefit	10^3US$	65,216	147,479	228,634	277,146	311,319	329,890	330,468
Benefit Cost Ratio		2.41	2.99	3.24	2.93	2.70	2.49	2.08

Note: Unit Firm Energy Price is combined price of hydropower firm energy price and thermal power energy price

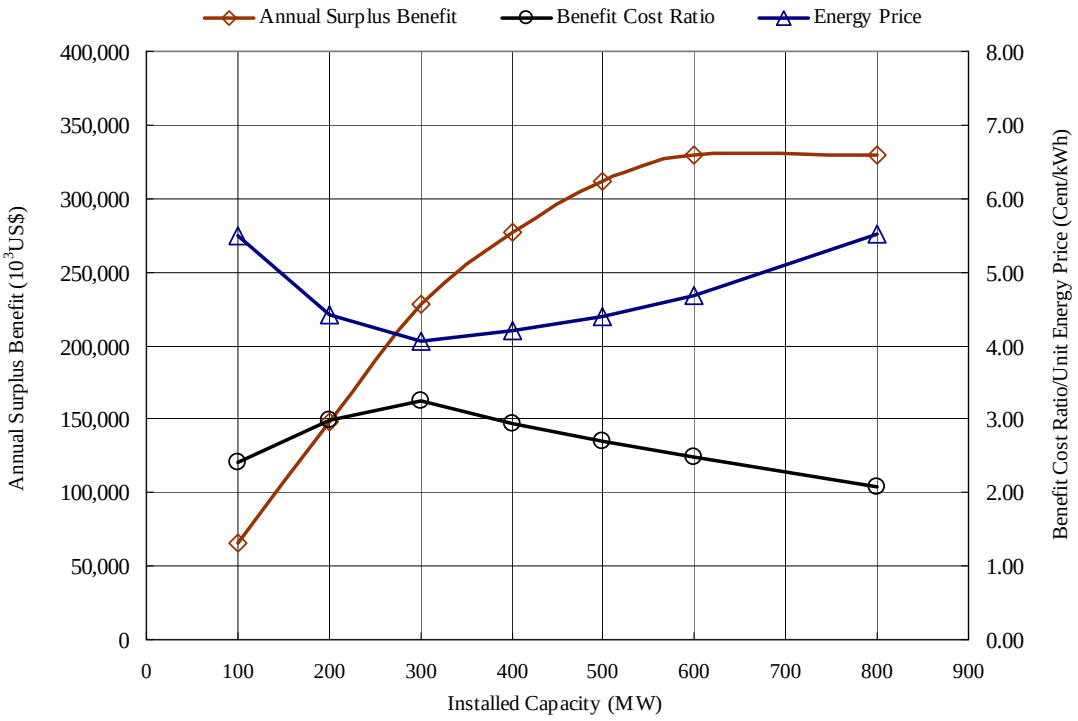

Figure 7.7-1 Optimization Study on Development Scale of Ayago Hydropower Project

As a result of the comparison, the 300 MW alternative shows the minimum unit energy price of 4.1 cents/kWh and the maximum benefit-cost ratio of 3.24. On the other hand, the annual surplus benefit increases according to expansion of development scale up to the 600 MW alternative.

Beyond this point, however, the annual surplus benefit does not increase any more. Accordingly, in the case that efficiency of investment is emphasized, the alternative 300 MW is the optimum scale and in the case that effective utilization of hydropower potential is emphasized, the alternative 600 MW is the optimum scale.

In this study, the output of Ayago hydropower is divided into the firm output which is guaranteed for 90 % of the period of a year and the secondary output which only can supply during a period when there is much flow in the Nile River. In general, in the power system with thermal power operating as main power supplier and hydropower as supplementary, the secondary output has fuel saving effect on thermal power plants. On the contrary, in Uganda, where hydropower is main supplier and thermal power supplementary, the secondary output, which is swayed by the amount of rainfall, is not dependable. Therefore, it is not wise to count the secondary output into the national electric power development plan.

Therefore, for development of Ayago hydropower, the eventual development scale is 600 MW and, however, in the near term until the first half of 2020, 300 MW is considered to be the optimum development scale. As for development of the remaining potential of 300 MW, it is recommended that the expansion should be carried out when the following conditions are satisfied.

1) If more firm discharge than the current firm discharge of 417 m^3/s, corresponding to 300 MW, is expected as a result of further deliberation of long-term discharge measurements in the Nile River
2) If the secondary output of the Ayago hydropower can contribute to fuel saving of thermal power in Kenya as a result of power export negotiation between Uganda and Kenya
3) If the secondary output of the Ayago hydropower can contribute to fuel saving of domestic thermal power after large hydropower developments are finished and there is no other choice than to add thermal power to meet future power demand.

This optimization study is carried out only based on the economics. It is necessary that in a further study for optimum development scale of the Ayago hydropower, consideration should also be paid on impacts on natural and social environment during the feasibility study of the Ayago hydropower.