HAKAN PEAT TO POWER PROJECT

BIODIVERSITY SURVEY ON THE AKANYARU PILOTE PEAT BOG (HLB, BLOCK1)

DRAFT FINAL REPORT

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I. GENERAL INTRODUCTION

I.1. Context

Hakan Mining and Electricity Generation Industry and Trade Inc. of Istanbul, Turkey (HAKAN) is developing a project in Rwanda based on the production of peat and its firing in one or more new peat-fired power plants (PFPPs) of total net capacity of 70 MWe in a first phase and another 35 MWe in the second phase.

HAKAN has registered a company incorporated under the Laws of Rwanda in the name of YUMN Ltd which is used as the developer of the project.

A number of reports were earlier produced for the project which include Sweco Reports (Environmental and Social Impact Assessment Report- Final Report, July-2013; Rwanda Peat Production and Harvesting – Final Report, 13 May 2013 and Rwanda Peat-Fired Power Plant - Draft Report, 18 March 2013 and later revisions based on revisions due to EWSA and HAKAN/YUMN Agreements to modify the size of the Power Plant).

More recently, four other reports have been produced:

(i) WESConsult's report (Socio-economic baseline study of Akanyaru peat production and power generation project, May 2014),

(ii) Dr Fabien Twagiramungu's Report (Resettlement Action Plan (RAP) of Hakan Peat production and power generation project, May 2014).

(iii) Dr Fabien Twagiramungu's complementary Report (Socio-economic baseline of people farming in Akanyaru peat bogs (800 ha) and survey of people living and/ or farming in ash disposal area (Buye village, Kabumbwe cell, August 2014)).

(iv) WESConsult's report (Social Assistance Plan (SAP) for people farming on the 20 ha Akanyaru peat bogs, June 2015).

HAKAN wishes to ensure that the peat harvesting activities incorporate all possible practical and cost effective measures so as to minimise environmental impacts and have sound environmental management on the site.

It is in that context that in addition to above mentioned studies, HAKAN has appointed an external environmental company, namely WESConsult to conduct the biodiversity survey on the pilot site of Akanyaru peat bog before commencing peat harvesting activities.

This pilot site is located in Akanyaru peat bog HLB where peat harvesting activities have already started. The site has a surface of about 29 hectares and was selected as a pilot site in

order to analyze the implementation of the peat harvesting project before upscaling of activities.

I.2. Author

WESConsult is a Rwandan based environmental company that has expertise in providing all services related to Environmental, Social Impact Assessment and Re-settlement Action Plans.

The Managing Director of WESConsult is Dr Fabien Twagiramungu. WESConsult has a number of recognised EIA experts in different fields of study namely; Chemistry, Biology, Socio-economic, GIS, Engineering, etc.

The baseline was conducted during two days (7th and 8th July 2015) but was followed by a weekly monitoring. This report is presenting data gathered during the two days. Results from the weekly monitoring will be presented in subsequent reports. The work was done by two consultants of WesConsult:

(i) Rutegwa Marcellin who holds a Bachelor of Science in Biology and Geography and a Master program in Environmental Sciences with a specialization in Limnology and Wetland management. He was previously involved in EIA/EMP for this project by undertaking animal inventory.

(ii) Gakwerere Francis who holds a Master of Science in Environmental Sciences with a specialisation in Environmental monitoring and modelling. He also holds a Bachelor of Science in Biological sciences. He is well acquainted with plant inventory and classification as phytosociology was a core part of his Master thesis and he had been involved in different studies related to the plant study in natural forests and degraded lands due to the mining activities.

I.3. Scope of the work

The scope of this work was to gather information about the current status of the wildlife and the flora on the pilot site of Akanyaru peat bogs HLB.

The bog is located in Buye Village, Kabumbwe Cell, Mamba Sector, Gisagara District in Southern province of Rwanda (**figure 1**). The aim of the work was to establish a starting point of the evaluation of the impact on flora and animal life in this specific area and to suggest appropriate mitigation measures.

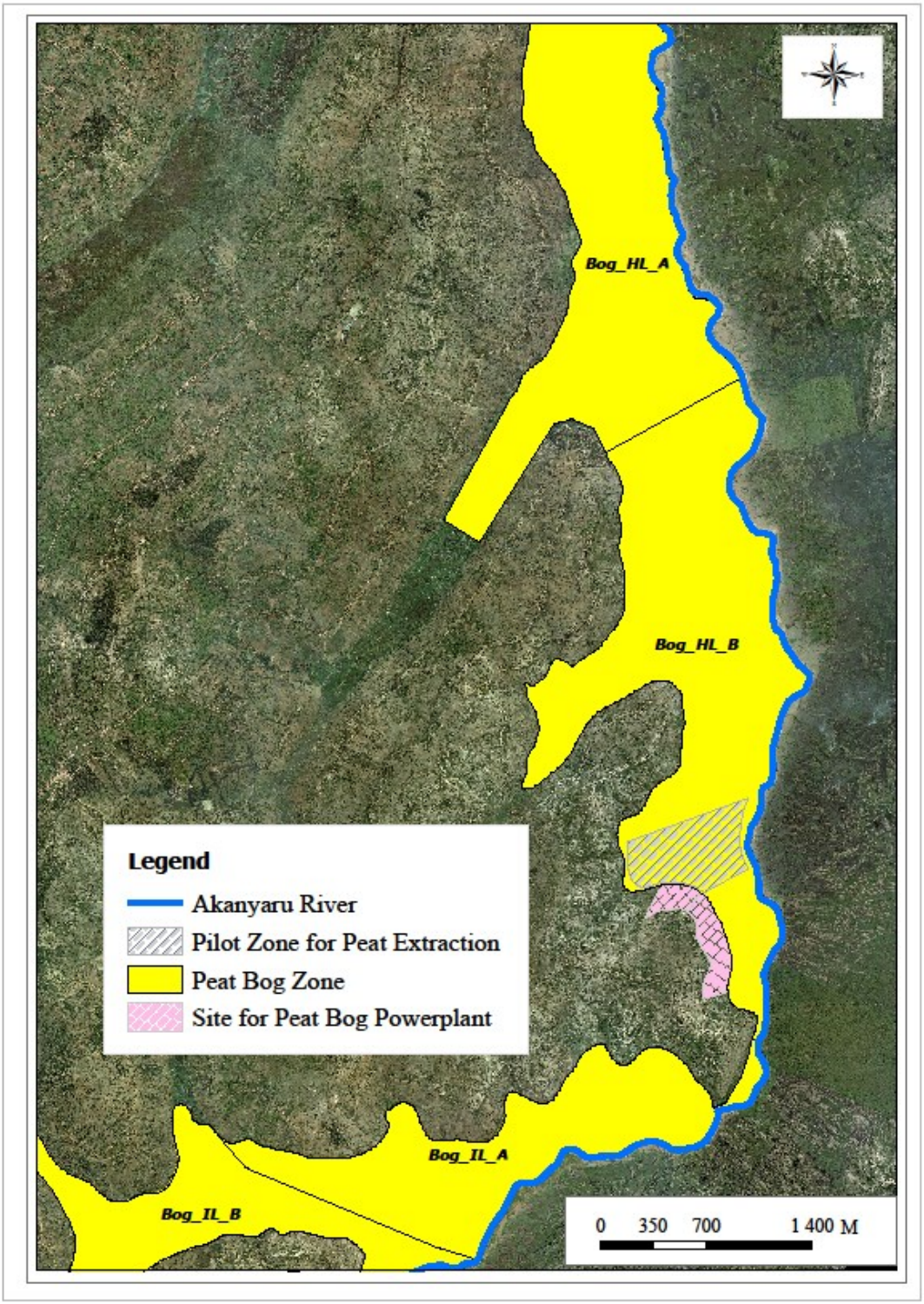

Figure 1: Location of peat extraction pilot site

I.4. Structure of Report

The report is divided into four main parts. The first part is introduction which deals with the context and the objective of the study. Section two gives a brief introduction of the wetlands. Section three discusses the fauna survey and section four is dealing with the flora survey.

II. GENERALITIES ON WETLANDS

II.1. Definition

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water (Cowaldin et al., 1979). Attributes of wetlands include a predominantly support of hydrophytes and hygrophytes, an undrained hydrous soil, or a non-soil substrate saturated or covered by shallow water.

Hydrology, trophic status, oxic and anoxic conditions and human activities are the main factors affecting wetlands. Natural wetlands have been classified into four types: salt marshes or mangroves lagoons, riverine (associated with running waters), lacustrine (associated with standing waters) and palustrine (not associated with a water body). There also exist human made wetlands for wastewater treatment. Akanyaru wetlands fall under riverine type of wetland.

Different names have been used to name wetlands mainly based on the source of water feeding them (**figure 2**). In the tropics and in Rwanda the term swamp or marsh is used.

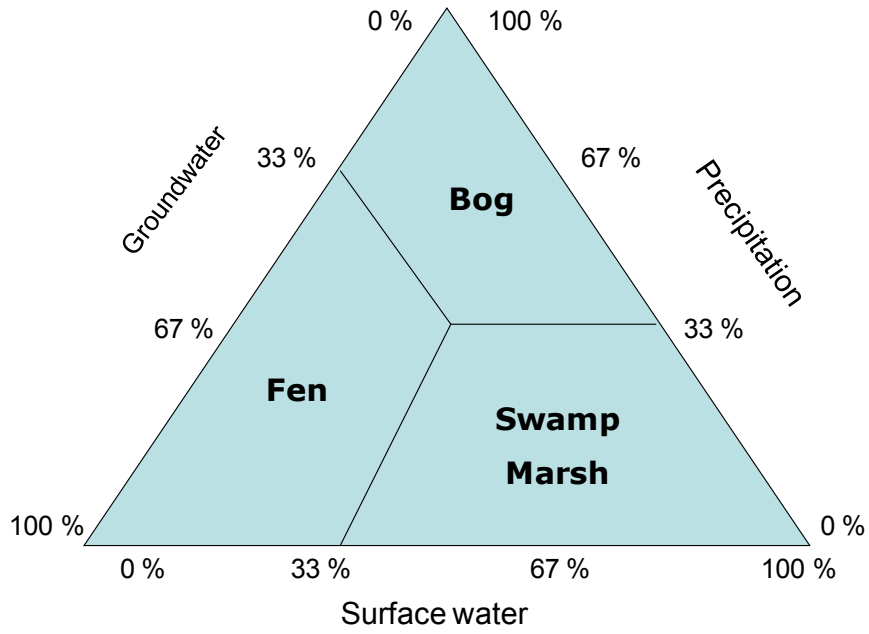

Figure 2: Wetland appellation (adapted from Keddy, 2000).

II.2. Rwanda Wetlands

The most recent inventory of swamps showed that Rwanda has a total of 860 swamps covering a surface of 278, 536 ha (REMA, 2008). 41% of the inventoried swamps are covered by natural vegetation, 53% are cultivated while 6% are fallow fields. The same reports recorded *Miscanthus violaceus, Cyperus latifolius, Lobelia, Ericaceae, Sphagnum spp, Cyperus papyrus, Syzgium cordatum, Phoenix reclinata, Typha domingensis, Polygonum pulchrum, Phragmites mauritanum* as the dominant species. But this inventory did not deal with animals.

Wetlands in Rwanda are used in different ways and play a great role in the development of the national economy. Functions of wetlands in Rwanda include agricultural production, hydrological functions, biodiversity reserves, peat reserve, climate regulation, tourism and source of raw materials used in art crafts. Inadequate institutional framework for wetlands managements, over exploitation, land use practices, agriculture intensification, pollution and invasive species are the major threats to Rwandan swamps. However there are no scientific studies that were carried out to quantify and evaluate their impacts.

II.3. Characteristics of peatlands

In those wetlands where the water level is stable near the surface (just below, at, or just above), the remains of dead plants and mosses do not fully rot away. Under conditions of almost permanent water saturation and consequent absence of oxygen they accumulate as *peat*. A wetland in which peat is actively accumulating is called *mire*. In most mires, the process of peat accumulation continues for thousands of years so that eventually the area may be covered with meters thick layers of peat.

An area of land with a soil of peat is called a *peatland*. Undrained peat contains between 85 % and 95 % of water, and can be regarded as "a mass of water wrapped up in some organic material"

Crucial for understanding peatlands is the awareness that in peatlands "plants", "water", and "peat" are very closely connected and mutually interdependent (**Fig. 3**).

The plants determine what type of peat will be formed and what its hydraulic properties will be. The hydrology determines which plants will grow, whether peat will be stored and how decomposed the peat will be. The peat structure and the relief determine how the water will flow and fluctuate.

These close interrelations imply that when any one of these components changes, the others will change too. Not necessarily at once, but in the longer run inevitably

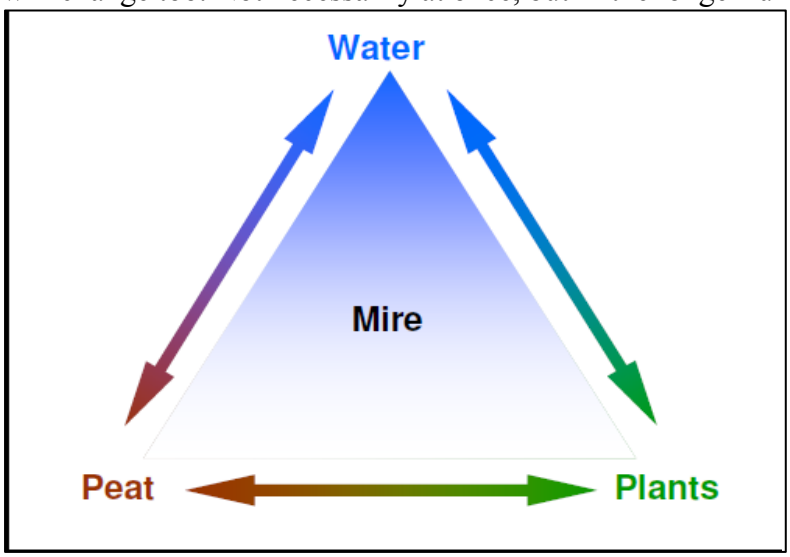

Figure 3: The interrelations between plants, water and peat in a mire

The presence of peat, the permanent water logging, and the continuous upward growth of the surface are the major characteristics of mires.

The organisms that live in mires are adapted to the special and extreme site conditions that prevail, including:

- The high water level and the consequent scarcity of oxygen and the possible presence of toxic ions (Fe^{2+}, Mn^{2+}, S^{2-}) in the root layer
- The continuous peat accumulation and rising water levels which suffocates perennial plants
- The often spongy soil, that makes trees easily fall over or drown under their own weight
- The scarcity of nutrients as a result of peat accumulation (by which nutrients are fixed in the peat), limited supply (as in rainwater-fed mires) or chemical precipitation (as in groundwater-fed mires, where phosphates are bound by calcium, iron and humic substances). Scarcity of ions in the mire water furthermore complicates osmoregulation in submersed organs and organisms
- The generally cooler and more humid climate than on the surrounding mineral soils, with strong temperature fluctuations
- The acidity caused by cation exchange and the abundance of organic acids
- The presence of toxic organic substances produced during decomposition and humification (i.e. the breakdown and alteration of organics material)
- The humus rich 'black' water, complicating orientation and recognition in aquatic animals.

As a result of these extreme conditions, mires are in generally species poor when compared to mineral soils in the same biographic region. Many mire species are, however, strongly specialised and not found in other habitats

III. FAUNA SURVEY

III.1. Key elements assessed

The following are the key elements that were assessed during the fauna survey and whose evolution will be carefully monitored during the peat harvesting on the pilot site.

III.1.1. Inventory of wildlife resources in the development area

The inventory consisted in the collection of information on the quantitative characterization of animal community structure i.e. species composition (species and population abundance).

This procedure allowed a ranking of species based on population abundance. Following the recommendations from the reviewers of the EIA/EMP of the same project realized in May 2013; the consultant put an emphasis on birds and fish that emerged as the most abundant in the Akanyaru floodplains.

In addition the method of interview with local population in order to identify animal species on the pilot site was discarded as it emerged that people were even giving names of animals that are no longer inhabiting or foraging in the Akanyaru floodplains following the population pressure in this area. Only animals that the consultant was able to encounter during his field visits are mentioned in this report. A cross check between animals identified in other reports and those spotted by the consultant in the area was carefully done.

III.1.2. Rare or endangered species

After establishing a list of animals inhabiting or foraging in the pilot site, identified species were scrutinized in order to see if any of them was indicated on the IUCN red list, protected by environmental regulations in Rwanda or by any international convention such as CITES (The convention on international trade in endangered species of wild flora and fauna).

III.1.3. Migration route and staging areas

Under this item, the consultant tried to gather information on whether the pilot was on the route of animal migration or a staging area of the migrating animals. This was done by searching about the habitat and habits of identified animal species. Through the literature review the consultant was able to identify if a given species is a resident or a migratory.

III.1.4. Habitat evaluation, distribution, and utilization; critical habitat

Under this item, the status of the floodplain as a habitat for wild animal was studied. In addition threats that may lead to their fragmentation, destruction or disturbance were identified. This led to the identification of the type, location, quantity and capability of habitat that will be disturbed or lost as a result of the project. A special emphasis was made to identify the breeding sites of birds. Nests were counted and the coordinates of their location recorded and mapped.

III.1.5. Sensitivity to disturbance

Under this item, threats to animal life that may arise from the extraction of peat were identified. In addition species that may be impaired by these threats were identified and mitigation measures were suggested.

III.1.6. Regional and local significance of populations

This sub-section dealt with the ecological services and functions of animal species colonizing the site in upper Akanyaru floodplains.

III.2. Methodology

III.2.1. Mapping

A *Garmin etrex 10* was used to collect geographical coordinates used to show on the map the pilot site and the transects used to observe birds and to sample plants. Maps were produced using ArcGIS software.

III.2.2. Birds inventory

The baseline was done during two days (7th and 8th July 2015) during the day time under favourable conditions to observe birds i.e with clear visibility, low cloud cover, not windy and no rain (Biby et al., 2000).

To survey the birds, the line counts method was used by walking continuously along a line from the edge of the bog to the Akanyaru river bank and all bird contacts were recorded and counted either side of the track. Three lines were selected based to the fact that the pilot stite has 29 hectares only (**figure 4).** A distance of 500 m is advised to separate two bird observation points in open environments (Ralph et al., 1995). It took 45 minutes to walk along each track.

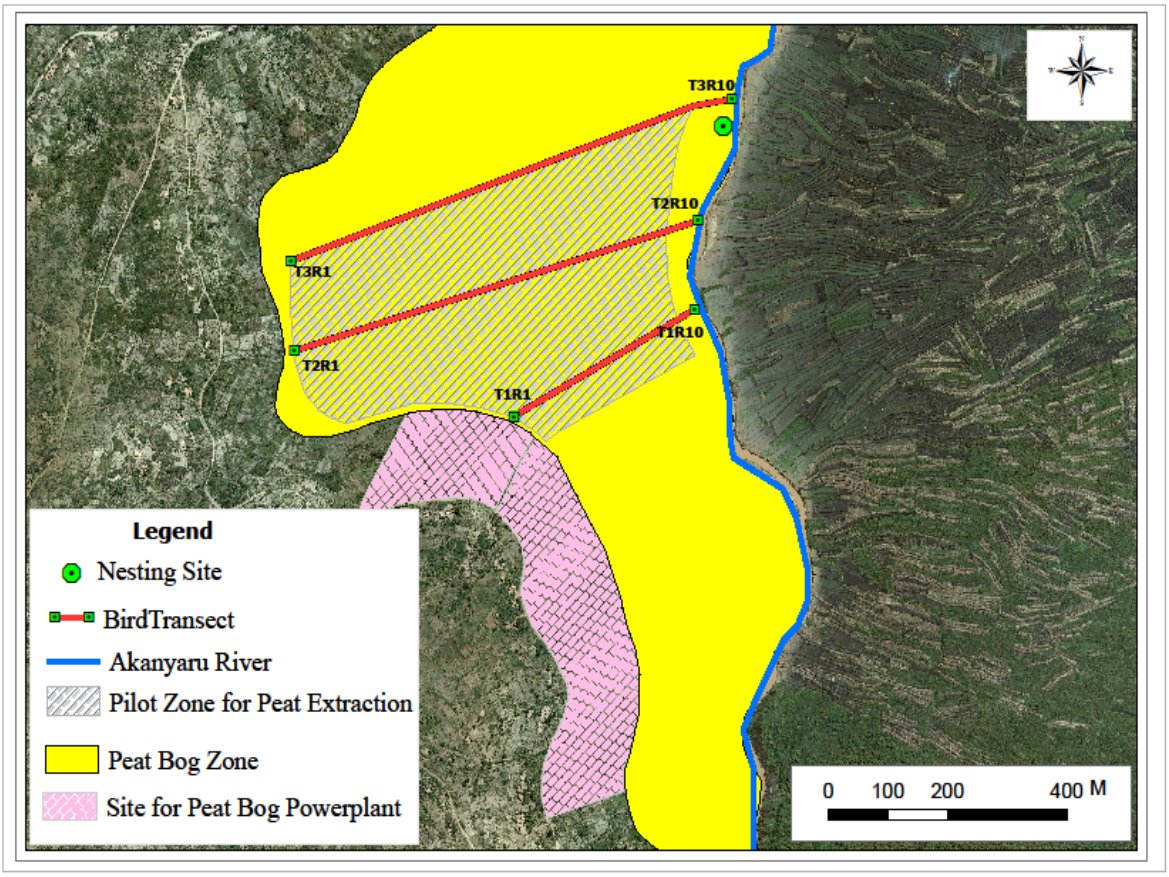

Figure 4: Bird observation transects and nesting site

III.2.3. Mammals, reptiles and amphibians

Mammals, reptiles and amphibians, encountered during walking along the bird line counts or along the transects used to identify plants were identified up to the species level whenever possible. Only their presence was noted but their abundance was not estimated.

III.2.4. Fish

During this survey, the species found within fish catches of local fishermen were used to identify fish species of Akanyaru River and its adjacent floodplain that pilot site is part and parcel. The consultant was lucky to find fish caught in drying mud after the retreat of water from the floodplain as the survey was conducted during the long dry season (June to September) (**figure 5**).

Figure 5: Fish found in drying mud of the floodplain

III.2.5. Invertebrates

Flying invertebrates were identified through direct observation. Aquatic ones were caught using an insect net that was passed in shallow water filled canals found either at the edge of the floodplain. They were identified up to species level as they are part of foodweb in this area. All animals were identified in situ, in case the consultant was not sure about the encountered animals he took pictures with Panasonic DCM TZ30 DIGITAL Camera.

III.3. Baseline Results

III.3.1. Study area

The inventory was carried out in HLB Bog located in floodplains of Akanyaru River, in Gisagara District, Southern Province in Rwanda. It is the southern border and nothern border of Rwanda and Burundi respectively. Its extension in Burundi is located in Bugabira Comune of Kirundo Province. The Ministerial order no 008/16.01 of 13th October 2010 establishing the list of swamps and their limits and regulating their management and use classified Rwandan swamps into three categories based on dominant vegetation, importance and management use (**Table 1**).

Table 1: Categories of swamps in Rwanda

Classification criterion	Categories
Dominant vegetation	Cultivated
	Fallow (farms and natural vegetation)
	Natural vegetation
Importance	Local
	National
	International
Management use	Use without specific conditions
	Use under specific conditions
	Full protection

Source: Ministerial order n° 008/16.01 of 13/10/2010

The same Ministerial order states that swamps that must be used under specific conditions should be exploited upon completion of environmental impact assessment (EIA). HLB Bog is part of Akanyaru South swamps tha fall under fallow category of international importance and must be used under specific conditions but it is not a Ramsar site. In Rwanda, the Rugezi wetland is the only Ramsar site so far. However following its categorisation of use under specific condition, its exploitation requires an EIA.

III.3.2. Habitat assessment

Studies on habitat are done either at a broad scale where it becomes possible to distinguish habitat types such as forest, grassland, shrubs, savannah and wetlands. They can also be done at a small scale where the researcher identifies habitat features such as canopy cover, tree architectures, water points etc.

This study was done on a small scale in a vegetation characteristic to tropical wetlands heavily impacted by human activities. HLB bog is located within a floodplain that is used to be dominated by Papyrus (*Cyperus papyrus*). But since 30 years ago the floodplains have been reclaimed by the local population who use it for crop production during the dry season and for grazing their animals (**figure 6**).

Figure 6: Agricultural activities in HLB bog in Akanyaru floodplain

Currently papyrus are less abundant and have been replaced by other water plants such as *Pulchrum spp*. The presence of a shallow water table and the Akanyaru river offers an aquatic habitat for fish, insects that spend part of their life in water as larvae or nymphs, amphibians and the floodplains are spawning field for fish such as *Clarias gariepinus*.

In addition it is an ideal foraging area for pichivore and insectivore birds. One nesting site was identified within the pilot site. The shrub has 36 unoccupied nests of weaver birds hanging over the river (**Figure 7**). This is a sign that birds use the place for breeding during the flooding period when human activities are less intense in the floodplain.

Figure 7: Nesting tree on the pilot site

III.3.3. Animal inventory

In total 35 species were identified in the pilot site, two species of fish, 15 species of birds, one species of mammals, 2 species of reptiles, three species of amphibians and 15 species of invertebrates (**Table 3**). Birds and invertebrates showed the highest number of species while mammals showed the lowest number of species. Abundance, habitat and habits were only determined for birds (**Table 2**). Bird abundance ranged between one and 23 individuals with an average of five individuals.

Table 2: Abundance, habitat and habits of identified bird species in the pilot site

Birds				
Species	**English name**	**Vernacular name**	**Number**	**Habitat and habits**
Milvus aegyptius	Yellow-billed Kite	Sakabaka	8	Singles to large groups are seasonally very common from sea level to over 3000 m. They inhabit villages, towns and open country with trees, often near water.
Falco tinnunculus	Common Kestrel	Agaca	5	Pairs or singles are common and widespread in a variety of open country.
Scopus umbretta	Hamerkop	Akabwanamajumbura	1	Single birds, pairs and sometimes flocks are common and widespread beside a wide range of waters from tiny temporary road side pools to the largest Rift Valley lakes. Often nomadic in drier countries responding to local rains.
Bostrychia hagedash	Hadada Ibis	Nyirabarazana	1	Pairs and small flocks are common and widespread in grasslands, marshy areas, and damp forest edges, as well as gardens and cultivation, mainly in the highlands but ranging from sea level to 3000 m.
Ardea cinerea	Grey Heron	Uruyongoyongo	1	Singles are rather solitary but widespread and reasonably common residents in a wide range of habitats from the coast to soda and freshwater lakes including temporally water.

Birds				
Species	**English name**	**Vernacular name**	**Number**	**Habitat and habits**
Lanius excubitoroides	Grey backed fiscal		2	Locally common in open woodland, acacia country and cultivated areas often near water and mainly between 600-1900 m, rarely to 3000 m. Small sociable groups are conspicuous and noisy, often gathering to display and wave their broad tails.
Spermestes cucullatus	Bronze manikin	Uduhuri	23	Most common manikin, widespread in all habitats except desert and forest interior from sea level to 2200 m.
Streptopelia capicola	Ring-necked Dove	Inuma	2	Pairs and flocks are widespread and may be very common at forest edge, in open woodland, dry bush and cultivation, mainly from sea level to 2200 m.
Turdoides jardineii	Arrow-marked Babbler	Ikijwangajwanga	15	Common within range but with a patchy distribution, inhabiting a variety of bushes and wooded country with undergrowth from sea level to 2200 m.
Threskiornis aethiopicus	Sacred ibis		3	Singles, small groups and larger flocks are widespread and common in many habitats, including cultivated lands, often near fresh or salt water, from sea level to 3000 m.
Ceryle rudis	Pied Kingfisher	Nyiramurobyi	1	Highly social: singles and groups are widespread and common residents besides all types of water, from sea level to 2300 m, including coastal shallows.

Birds				
Species	**English name**	**Vernacular name**	**Number**	**Habitat and habits**
Dicrurus adsimilis	Fork-tailed Drongo	Umunoga	4	Singles and pairs are common and widespread at forest edge, in open wooded country, semi-arid bush and cultivated areas from sea level to 2200 m.
	Lilac breasted Roller		1	Pairs are widespread and common residents in open bush country, wooded grassland, woodland and cultivation from sea level to 2000 m (less often 3000 m).
Alcedo cristata	Malachite Kingfisher	Nyiramurobyi	1	Common throughout East Africa from sea level to 3000 m. Occurring besides all types of water where fringed with vegetation. Some local movements appear to occur but are not well known.
Bubulcus ibis	Cattle Egret	Inyange	5	Small to large flocks are common and widespread, often with plains game or domestic stock, preferring damper grasslands and cultivation. Flocks often fly in disorderly lines with rapid direct wing beats.

Table 3: Other identified animal species in the pilot site

Species	English name	Vernacular name	Abundance
Fish			
Clarias gariepinus	Cat fish	Kamongo (Inshonzi)	
Protopterus aethiopicus	African lungfish	Imamba	
Mammals			
Canis adustus	Side-Striped Jackal	Nyiramuhari	1
Reptiles			
Dandroaspis polylepis	Black mamba	Insana	
Philothamnus nitidus	Green bush snake	Insharwatsi	
Amphibians			
Ptychadena mascareniensis	Mascarene Rigded Frog	Umutubu	
Phrynobatrachus natalensis	Dwarf puddle frog	Intaruka	
Bufo regularis	Toad	Igikeri	
Invertebrates			
Phalanta phalantha	Common Leopard Butterfly	Ikinyugunyugu	
Crocothermis sanguinolenta	Small scarlet	Kajugujugu	
Trithemis furva	Dark dropwing	Kajugujugu	
Orthetrum Julia	Julia skimmer	Kajugujugu	
Africallagma glaucum	Swamp bluet	Kajugujugu	
Acrida acuminate	Common stick grasshopper	Igihori	
Hirudo medicinalis	Leech	Umusundwe	
Lumbricus terrestris	Earthworm	Umunyorogoto	
Cybister tripunctatus	Yellow-edge water beetle	Inyogaruzi	
Gyrinus sp	Whirligig beetle	Inyogaruzi	
Chironomus formosipennis	Bloodworm	Isazi	
Biomphalaria spp	Snail	Ikinyamujongo	
Bulinus spp	Snail	Ikinyamujongo	
Dorylus helvolus	Red driver ant	Intozi	

Among the animals identified one species, *Bostrychia hagedash* (Hadada Ibis) is protected by the Convention in International Trade in Endangered Species of Wild fauna and flora (CITES).

Two species are protected by Rwandan regulations under Ministerial order n° 007/2008 of 15/08/2008 establishing the list of protected animal and plant species in Rwanda. The concerned species are *Scopus umbretta* (Hamerkop) and *Bubulcus ibis* (Cattle egret).

Kanyamibwa (2000) and ACNR (2003) placed Akanyaru wetlands among the IBA sites in Rwanda (**figure 8**) but did not precise if it is Akanyaru South (where Hakan peat to power project is located) or Akanyaru North.

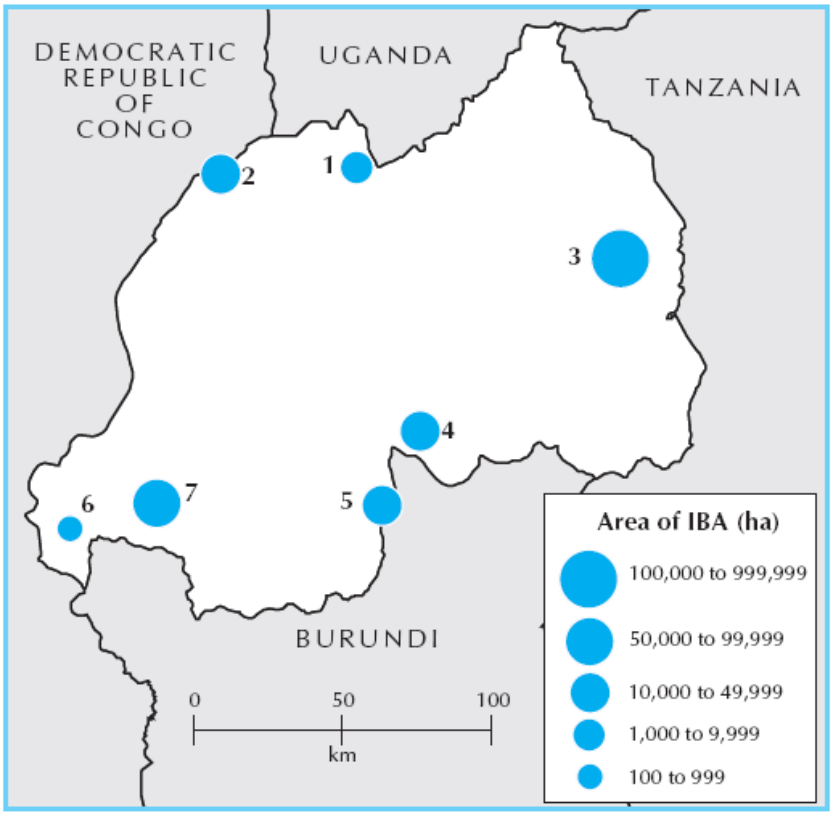

Figure 8: Location and size of important bird areas in Rwanda (Source: Kanyamibwa, 2000).

It has to be noted that the ACNR conducted birds' survey on short period without indications on their abundance. The ACNR survey has been undertaken in Bugesera District near the confluence of Akanyaru and Nyabarongo rivers. The Hakan peat to power project is located at about 100 km south from this confluence (**figure 9**)

Since WESConsult team starts visiting the peat harvesting pilot site, the important bird species that made Akanyaru an IBA have not yet been observed in situ (*Ardeola idae* and *Laniarius mufumbiri*).

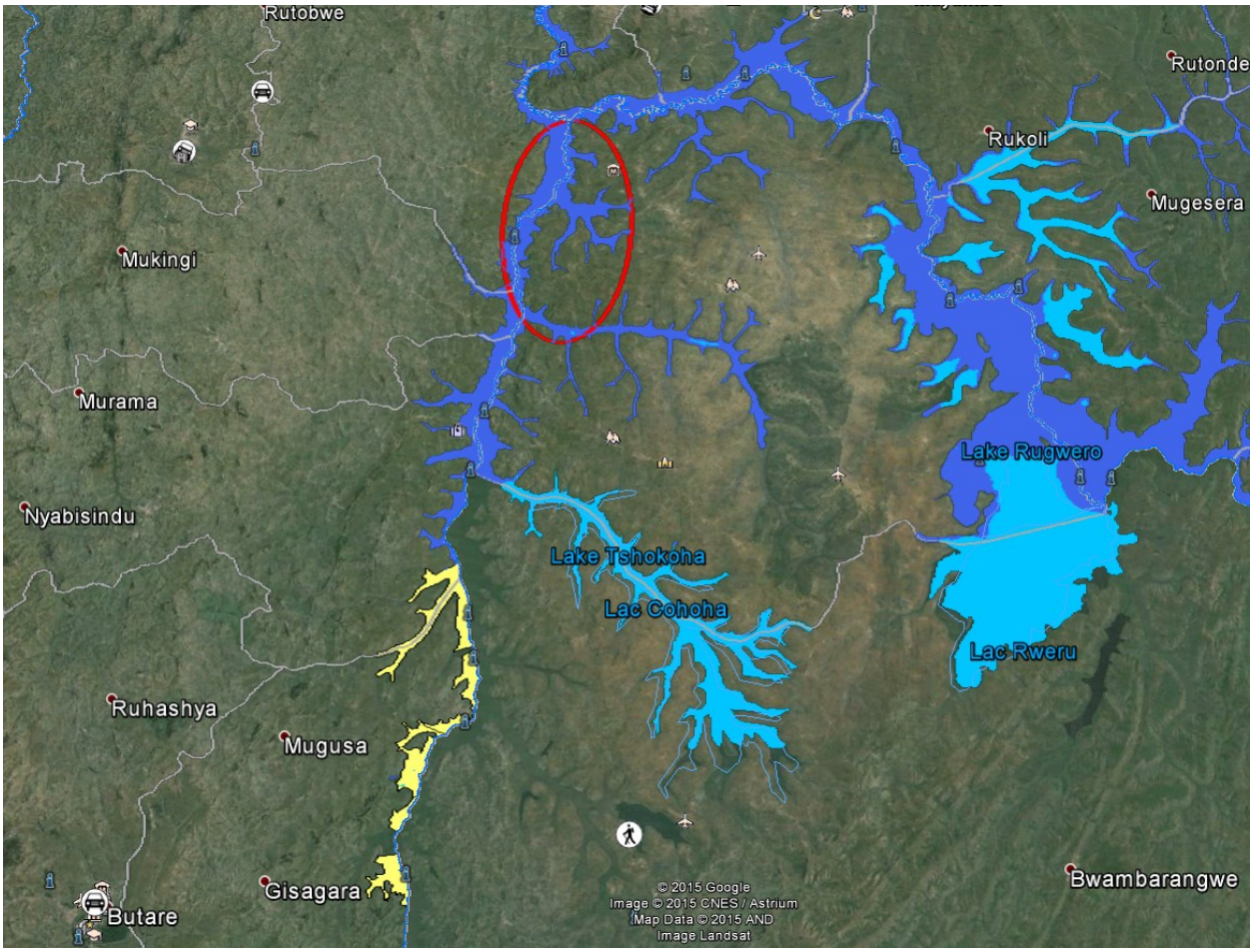

Figure 9: Location of Hakan peat to power project (in yellow) and the ACNR birds 'survey (in red)

IV. FLORA SURVEY

IV.1. Scope of work

The work aimed at determining the composition and structure of the vegetation and to evaluate the potential threats of peat extraction on the vegetation of Akanyaru peat bogs. The main objectives were:

- to describe the regional vegetation;
- to identify the dominant plant species
- to identify endangered or rare species, intruder or exotic species;
- to illustrate the location and document the area of various vegetation types that will be disturbed during peat extraction activities.

IV.2. Methodology

IV.2.1. Plant sampling

The phytosociological study of plant species found in HLB bog of Akanyaru swamps where a pilot peat harvesting activities are currently going on was done using the transect method. The transect method refers to the establishment of a line along which the sampling of plant species is conducted (Troupin, 1966).

This method is typically used when there is apparent vegetation heterogeneity on a site. For example, when sampling an area containing a river, wetland and upland, establishing a transect line that crosses these distinct habitats is a reliable method of collecting representative data.

Each transects crossed the pilot site and was perpendicular to the river bank (**figure 10**). In total, 3 transects were investigated and plants were sampled in each 10 m along transects, on a 16 m^2 surface plot. From the sampled plants in each plot, dominant plant species were selected for characterizing the vegetation due to the fact that those plants are supposed to be well adapted on such a type of soil.

Plants were identified in situ up to species level and when the consultant was not sure on the nomenclature of the plant, he collected a full specimen, wrap it in a newspaper and all collected samples were transported in a plant press to the UR-College of Education Biology laboratory. They were dried and conserved in the herbarium. The flora of Rwanda (Troupin, 1996) were also used to classify collected plants.

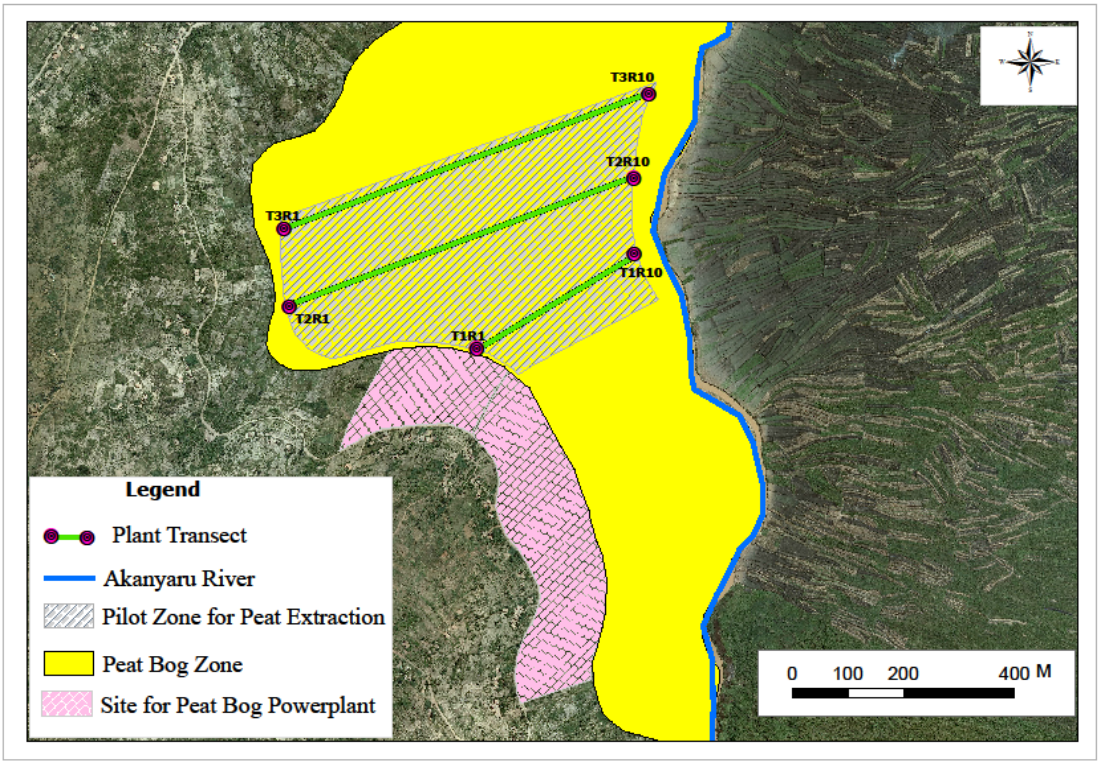

Figure 10 : Plant Transects location

IV.2.2. Abundance-dominance of the investigated plants

In situ each plant species was given a coefficient of abundance-dominance according to Troupin (1966) namely +, 1, 2, 3, 4, to 5. Each coefficient corresponds with a certain percentage of surface covered by vegetation.

- 5: plant species covering more than 75% of the sampled area,
- 4: plant species covering 50-75% of sampled area,
- 3: Plant species covering 25-50 % of sampled area,
- 2: plant species covering 5-25 % of sampled area,
- 1: few individual species covering less than 5 % of the sampled area,
- +: individuals with no significant coverage

The coefficients were used to determine the dominant plants in each transects and in the whole area based on the performance index. Following formulae were used to calculate the performance index of each species:

- ***F =(P/N)x100***
  Where F stands for frequency and N for the number of sampling points.
- ***RF= (Fi/∑F)x100***
  Where RF stands for relative frequency; Fi for frequency of i species and F for frequency
- **D= ∑C**

Where D stands for dominance and C for plant coverage.

- ***RD= (Di/∑D)x 100***
  Where RD stands for relative dominance; Di for dominance of i species and D for dominance
- ***Φ=(FD/∑FD)x 100***
  Where Φ stands for the performance index and FD stands for the dominance index

To calculate the similarity between the transects, the Jaccard coefficient was used. It is calculated as follows:

$$\mathbf{S_{i,j} = a\ (a+b+c)}$$

Where S stands for the Jaccard coefficient; i and j for the set of two transects; a for the number of joint presence; b for observation unique to transect 1 and c the number of observation unique to transect 2.

IV.3. Results

During the survey, 20 species were encountered (Table 1). In addition the results show that the *Cyperus papyrus* is endangered plant species while *Cyperus pustulatus*, *Cyperus latifolius* and *Pycreus spp* grew well in this disturbed site of HLB Bog. The phytosociological data analysis revealed that the vegetation of HLB Bog of Akanyaru can be defined as a shrubby-grassland dominated by *Leersia hexandra*, *Polygonum spp*. and *Polygonum pulchrum.*

Table 4: List of plant species and their performance indices (%) in different transects

Species	Family	Local name	T1	T2	T3	Protection status	
						Rwanda*	IUCN**
Leersia hexandra	Poaceae	URUKEMBAGUFA	31.38	16.08	29.63		
Polygonum pulchrum	Polygonaceae	IGOROGONZO	10.26	11.59	8.17		
Polygonum spp	Polygonaceae		15.93	14.54	14.22		
Triumfetta cordifolia	Marvaceae	UMUSHYIGURA	2.33	3.73	1.02		
Commelina benghalensis	Commelinaceae	INTEJA	3.79	5.72	2.05		
Ageratum conyzoides	Asteraceae	INKURUBA	2.33	3.93	3.51		
Ager sp	Asteraceae		0.27	1.78	0.79		
Cynodon dactylon	Poaceae	UMUCACA	14.81	11.31	10.40		
Cyperus pustulatus	Cyperaceae		6.54	7.34	7.04		
Cyperus latifolius	Cyperaceae	URUKANGAGA	4.48	6.80	8.89		
Panicum repens	Poaceae	UMUNIGI	2.60	6.59	4.69		
Brachiaria jubata	Poaceae		0.32	0.36	0.69		
Nephrolepis cor difolia	Pteridaceae	IGISHUHE?	0.27	0.71	1.03		
Ludwigia abyssinica	Onagraceae	UMUZIGANGORE	1.12	2.51	2.37		
Cyperus papyrus	Cyperaceae	URUFUNZO	0.29	0.84	2.42		
Typha campensis	Typhaceae	UMUBERANYA	0.32	0.36	0.34		
Crossocephalum bumense	Asterceae	IGIFURANINDA		1.89	0.69		
Sorghum bicolor	Poaceae	Ishaka	0.80	1.89			
Pycreus macrostachyos	Cyperaceae	INTARATARE	1.07	1.42	1.03		
Pycreus flavescens	Cyperaceae	INTARATARE	1.07	1.42	1.03		

Protection status

Rwanda*: Ministerial order N°007/2008 of 15/08/2008

IUCN**: International Union for Conservation of Nature

The jaccard coefficient showed that the vegetation is homogenous as it was 0.9 (a Jaccard coefficient higher than 0.5 indicates homogenous transects while a coefficient lower than 0.5 indicates heterogenous transects).

Our interview with people living in the vicinity of the swamp showed that some of these plant species have significant economic importance for their daily life as they are used to manufacture items that are sold or used locally and to feed cattle or goats. These species are for instance:

- *Brachiaria decumbens* and *Leersia hexandra* which are used as feed;
- *Cyperus dives*, *Cyperus latifolius* and *Typha capensis* for handcrafting.

It was observed that the crop production is now very intensive in the Akanyaru Wetland due to the current dry season. The main crops recorded include maize, sorghum, sweet potato, beans and vegetables.

Among the species recorded in the surveyed area none is classified under particular status to require specific protection.

However peat extraction will remove the vegetation cover and restoration works will be needed after peat harvesting activities.

V. POTENTIAL IMPACTS ON BIODIVERSITY AND MITIGATION MEASURES

V.1. Potential impacts

Habitat alteration is one of the most significant potential threats to biodiversity associated with this project. Habitat alteration may occur during any stage of this project cycle with the greatest potential for temporary or permanent alteration of terrestrial and aquatic habitats occurring during the project cycle.

Peat harvesting, site clearing are expected to destroy the existing vegetation of the project zone. Impacts due to peat harvesting include loss of ground cover and the associated of wildlife habitat and existing vegetation. The significance on terrestrial flora in this case is considered moderate to high.

The extraction of peat will totally remove the current vegetation in the area and it will be replaced by an artificial pond (**figure 11**).

Figure 11: Effect of peat extraction on vegetation cover in Akanyaru floodplains.

There is a risk of an invasion of the artificial pond by invasive species, the water hyacinth that is common in Rwandan water bodies.

V.2. Mitigation measures

Restoring a complex peatland ecosystem to its pre-extraction condition is not possible (Rochefort & Lode, 2006) but measures ought to be taken to restore key peatland ecosystem functions or rehabilitate the harvested area to serve another beneficial purpose within a human lifetime.

The main long-term objective of post-extraction peatland restoration is to re-establish self-regulatory mechanisms that will enable functional peat accumulation (Quinty & Rochefort, 2003).

Short-term objectives of post-extraction peatland restoration include: 1) re-establishment of peatland plants, 2) restoring the hydrological regime typical of peatlands (i.e., rewetting) (Quinty & Rochefort, 2003).

Essential peatland functions include: 1) adequate ecosystem productivity allowing carbon sequestration, 2) nutrient cycling, 3) re-establishing vegetation structure allowing for increased animal and plant biodiversity, and 4) restoring the ability to resist biological invasion (Rochefort & Lode, 2006).

A second post-extraction option is to rehabilitate the harvested area and transform it into a new functioning wetland, agricultural cropland, or farm fishing.

With respect of Akanyaru wetlands, mitigation measures include the respect of the buffer zone between the river and the peat harvesting area.

The area of 50 m between the river and the peat harvesting site may be used as a buffer zone and a corridor for animals moving from the peat extraction sites to unexploited sites.

To let the 50 m buffer zone to be recolonised by natural vegetation of the area will allow catfish for reproduction during the flooding periods. The same buffer zone may be used by birds for foraging and for nesting site and source of nesting materials.

It is also recommended to identify the source of sediments that will refill the place. The quantification of the amount of new sediments brought through erosion will be estimated. In addition sediments brought by Akanyaru river flooding will also be estimated. As this pilot peat harvesting will determine the maximum depth till which the peat extraction will be feasible before the area being filled with water, the time required to fill naturally this place with sediments will be estimated. In addition restoration procedure may study the feasibility of reintroducing *Cyperus papyrus* or *Miscanthidium spp*.

Post-extraction peatland rehabilitation is the transformation of the peat mine site into a new functioning wetland, agricultural cropland, or a forestry plantation (Daigle & Gautreau-Daigle, 2001). A peatland rehabilitation method gaining popularity is paludiculture, which is agriculture and/or forestry on wet and rewetted peatland which seeks to cultivate plant species that: 1) thrive in saturated conditions, 2) produce valuable biomass, and 3) facilitate the accumulation of peat. Rehabilitation is an alternative to restoration with the potential for enhanced greenhouse gas sequestration (Maljanen et al., 2010; Mander et al., 2012) and nutrient uptake (Cicek et al., 2006) with the additional benefits associated with the harvest of biomass (Cicek et al., 2006; Mander et al., 2012).

Successful peatland restoration requires several years to succeed; therefore, it is imperative that restoration commence as soon as possible to diminish post-extraction greenhouse gas emissions and nutrient loads downstream.

It is recommended that peatland restoration/rehabilitation commence immediately after the extraction of all the economically viable peat at each location if possible. In addition to restoration/rehabilitation of peat mine sites, mitigation of the environmental effects of peat mining can be carried out while active mining is taking place. Management of nutrient loading during production can be accomplished through management of runoff in appropriately designed sediment ponds or lagoons. Harvesting of biomass through paludiculture can further reduce nutrient loading. Similarly trading of carbon credits can neutralize the greenhouse gas emissions of peat harvesting.

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