HCVF Analysis

Analysis of the High Conservation Value Forest areas of Tain Tributaries Block II Forest Reserve, Brong Ahafo Region, Ghana

Form international

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1. Introduction

Form Ghana has commissioned Form international to conduct a High Conservation Value Forest analysis to contribute to the sustainable implementation of the company's reforestation activities in Tain Tributaries II Forest Reserve (Tain II). According to Rayden *et* al. (2006), "All types of forests are unique and important and of conservation value but High Conservation Value Forests (HCVFs) are simply forests with outstanding significant values that are of critical importance, which needs to be appropriately managed or protected in order to maintain or enhance the identified values". Consequently, reforestation activities shall consider how the (potential) high conservation values of the project area, if identified, can be managed and protected.

1.1 Form international

Form international is a Dutch consultancy firm established in 1992. It offers high quality advice on forest management, certification and technical assistance to plantation establishment and management. Form international has extensive experience in tropical forest management, mainly in West and Central Africa and is also active in Europe on Chain-of-Custody (CoC) certification and PEFC conformity assessments.

Form international advises branch organizations, international timber and forest companies, NGO's and many other organizations that play a role in the direct or indirect amelioration of forest management. Using a pragmatic approach, Form international's knowledge and experience in the field of sustainable forest management and certification is translated into a concrete advice ready to be implemented in the day-to-day forest operations of her clients.

1.2 Form Ghana

Form Ghana is a reforestation company established in Ghana in 2007, which aims at large-scale reforestation of degraded forest reserves in Ghana while conserving and restoring natural, riparian forest. Form Ghana is already established in the north of the Ashanti Region, near Akumadan, where the company has reforested the degraded Asubima and Afrensu Brohuma Forest Reserves between 2008 and 2012. Form Ghana has recently set up a Public Private Partnership (PPP) with the Forestry Commission of Ghana for the development of a commercial forest plantation within Tain II Forest Reserve.

Unique sustainability concept

Form Ghana's vision is to operate in a sustainable environment and to contribute significantly to the quality of people's life related to or affected by the company, to environmental protection and to the Ghanaian economy. Form Ghana is therefore committed to operate in compliance with the Principles and Criteria of the Forest Stewardship Council ™ (FSC™). An FSC certificate ensures an improved social standard and employment for the local population, the enhancement of the local economy, conservation of ecology and a guaranteed timber supply for the forest industry.

The following objectives have been stated by Form Ghana regarding this commitment:

- Both teak and indigenous tree species are planted on the lease area;
- Degraded riparian zones will be actively restored and conserved;

- The project will be executed in close collaboration with local communities and other stakeholders;
- There will be transparent benefit sharing with relevant stakeholders;
- Job opportunities will be created for local people in several plantation activities;
- Farmers are offered the opportunity for intercropping between the one and two year old seedlings. Rotational harvesting ensures continuous presence of young trees throughout the plantation.

Biological diversity, water sources and fragile ecosystems found in or near the plantations will be conserved or restored where possible. This includes the riparian buffer zones; 30 meters on each side of the waterway. The carbon storage function of the plantation forests contributes to climate change mitigation. Trees planted on the plantations consist of teak and a mix of local species.

Public Private Partnership (PPP)

The Forestry Commission and Form Ghana signed a 50-year Public-Private Partnership (PPP) Lease Agreement to jointly reforest an estimated 14,000 ha of degraded forest land within the Tain Tributaries II Forest Reserve near Berekum in the Brong Ahafo Region. Additionally, the Forestry Commission, Form Ghana and the Berekum Traditional Council signed a Benefit Sharing Agreement to formally document the responsibilities and future benefits of each of the three key stakeholders.

The PPP is part of the national policy to restore degraded forest reserves in Ghana, which is a strong policy instrument showing the commitment of the Government of Ghana to conserve and restore natural resources and to promote the sustainable use of forest resources in the country. The degraded forest reserves are of major concern to the Government of Ghana, because approximately 94% is in a deplorable condition as a result of unsustainable harvesting, encroachment of illegal farmers and devastating wildfires. Restoring these areas is therefore a key component of Ghana's 1994 Forest and Wildlife Policy and the 1996-2020 Forestry Development Master Plan as well as other related sector policies including the Ghana Poverty Reduction Strategy (GPRS) paper. The proposed reforestation project in Tain II Forest Reserve fits well within this policy. The reserve has been declared degraded by the Forestry Commission and has suffered from ongoing degradation since then. Based on the series of satellite images below (figure 1), it is evident that most of the FR was deforested by 2012.

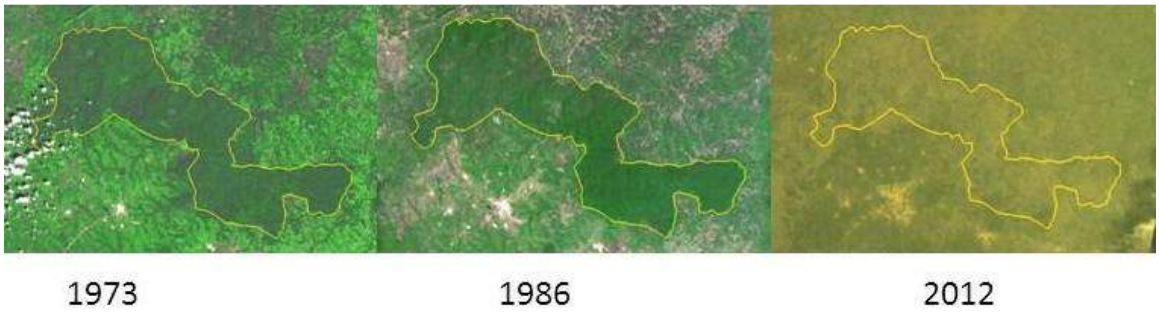

Figure 1*. Deforestation of Tain II Forest Reserve 1973 to 2012. Source: Google Earth.*

1.3 High Conservation Forest Value Analysis

According to FSC principles, an FSC certified company should ensure 'maintenance of high conservation value forests – to maintain or enhance the attributes which define such forests.' These High Conservation Value Forests (HCVFs) first have to be identified in the project area before they can be maintained or enhanced. The Forest Stewardship Council (FSC™) has provided a definition for High Conservation Value Areas, with 6 'High Conservation Values' (see below). We adopted this definition, replacing 'areas' with 'forests', since this is the focus of Form Ghana as a forest plantation company.

FSC™ definition of HCVF

High Conservation Value Forests possess one or more of the following attributes:

1. Forests containing globally, regionally or nationally significant concentrations of biodiversity values (e.g. endemism, endangered species, refugia);
2. Forests containing globally, regionally or nationally significant large landscape level forests, contained within, or containing the management unit, where viable populations of most if not all naturally occurring species exist in natural patterns of distribution and abundance;
3. Forests that are in or contain rare, threatened or endangered ecosystems;
4. Forests that provide basic services of nature in critical situations (e.g. watershed protection, erosion control);
5. Forests fundamental to meeting basic needs of local communities (e.g. subsistence, health);
6. Forests critical to local communities' traditional cultural identity (areas of cultural, ecological, economic or religious significance identified in cooperation with such local communities).

Source: adapted from FSC-STD-01-001 (version 4-0) EN

1.4 Report structure

This report presents an analyses of the presence (or absence) of these six HCVF attributes in the part of Tain II FR that is managed by Form Ghana. Chapter 2 describes the applied methodology for this assessment. A general overview of the area is presented in chapter 3 covering the abiotic, social and biological characteristics of Tain II FR. In chapter 4, the presence or absence of each of the 6 HCVFs are assessed. The report ends with a conclusion and recommendations of the HCVF analysis which are captured in chapter 5.

2. Methodology

For the correct interpretation of the six HCVFs, the national HCVF toolkit developed for Ghana was applied during the identification (Rayden *et* al., 2006). The study employed field research, literature review and stakeholder consultation to obtain the required data for these analyses.

2.1 Field research

A number of field studies have been used during this HCVF analysis:

- Social and Environmental Impact Assessment (SEIA) (Tollenaar, 2013)
- Soil Study Tain II FR (Scholten *et* al., 2012)
- Hydrological assessment Tain II FR (Ghana Water Company Ltd, 2012)

The SEIA consists of an environmental assessment and a socio-economic assessment including a stakeholder consultation. The environmental assessment was carried out by Oduro & Danquah (2012) and contains information on land use stratification, vegetation (species and characteristics) and fauna (mammals, birds, reptiles). The hydrological characteristics of the area and the water quality is determined in the hydrological assessment and further described in the SEIA. The results of the soil study are also included in the SEIA. The SEIA report can be downloaded from the website: www.formghana.com (tab: downloads).

For the methodology of the field surveys, please refer to Appendix A-C.

2.2 Literature

A variety of documents and databases have been used to verify the protection status of the area and the species encountered in the Tain II FR:

- Literature on biodiversity (in the vicinity of Tain II FR)
- Map of Globally Significant Biodiversity Areas (GSBAs) in Ghana
- IUCN Red List online database
- Ghana Wildlife Conservation Regulations (1971) and Amendments (1988)

It was verified whether or not the Tain II FR was positioned close to a Globally Significant Biodiversity Area (GSBA) using a map that indicated Ghana's Forest Reserves, GSBA's and Ramsar sites, see Appendix D. Also, Tain II FR's proximity to an Important Bird Area was checked with a map depicting Ghana's Important Bird Areas, see Appendix E.

The conservation status of each encountered species was assessed using the IUCN Red List online database (http://www.iucnredlist.org/) and the Ghana national Wildlife Conservation Regulations (1971) and Amendments (1988).

The IUCN Red List knows seven categories for indicating the vulnerability of a species:

- Least concern
- Nearly threatened
- Vulnerable
- Endangered
- Critically endangered
- Extinct in the wild
- Extinct

These respond to certain criteria linked to the tendency of their populations, the size and structure of the population and to their geographical distribution. “Threatened species” include fauna classified as vulnerable, endangered or critically endangered (IUCN, 2011).

The Ghana national Wildlife Conservation Regulations and Amendments distinguish between three different levels of conservation priority: first, second and third schedule species. The regulations that apply for each of these categories are noted in the box below.

Ghana Wildlife Conservation Regulation (1971)

First schedule
Animals completely protected. The hunting, capturing, being in possession or destroying of any species in this schedule is absolutely prohibited at all times.

Second schedule
The hunting, capturing or destroying of any species listed in the schedule is absolutely prohibited between 1st August and 1st December in year any year. The hunting, capturing or destroying of any young or adult accompanied by its young of any species listed in this schedule is absolutely prohibited at all times.

Third schedule
The hunting, capturing or destroying of any species listed in this schedule is absolutely prohibited between 1st August and 1st December in any year.

2.3 Stakeholder consultation

Stakeholders were consulted on two levels:

- Stakeholder consultation performed by Tollenaar (2013) as part of the SEIA
- Specific feedback on this HCVF analysis

After a draft version of this report was available, a number of stakeholders from renowned Ghanaian and international organisations were asked for their input, comments and suggestions.

Feedback on the draft version of this report was received from the Kwame Nkrumah University of Science and Technology (KNUST) and IUCN Ghana. Reviewers are thanked for their contribution.

3. Characteristics Tain II Forest Reserve

3.1 Study area

The study site is located in Tain Tributaries Block II Forest Reserve, further referred to as Tain II Forest Reserve (Tain II FR) in Berekum District, Brong Ahafo region. Tain II FR lies within a grid reference of 7N35, 2W30. The forest area is 409.2 km^2, (=40,920 hectares) with a perimeter of 269.43 km. Approximately 14,596 ha of this reserve is allocated to Form Ghana Ltd. for commercial plantation development.

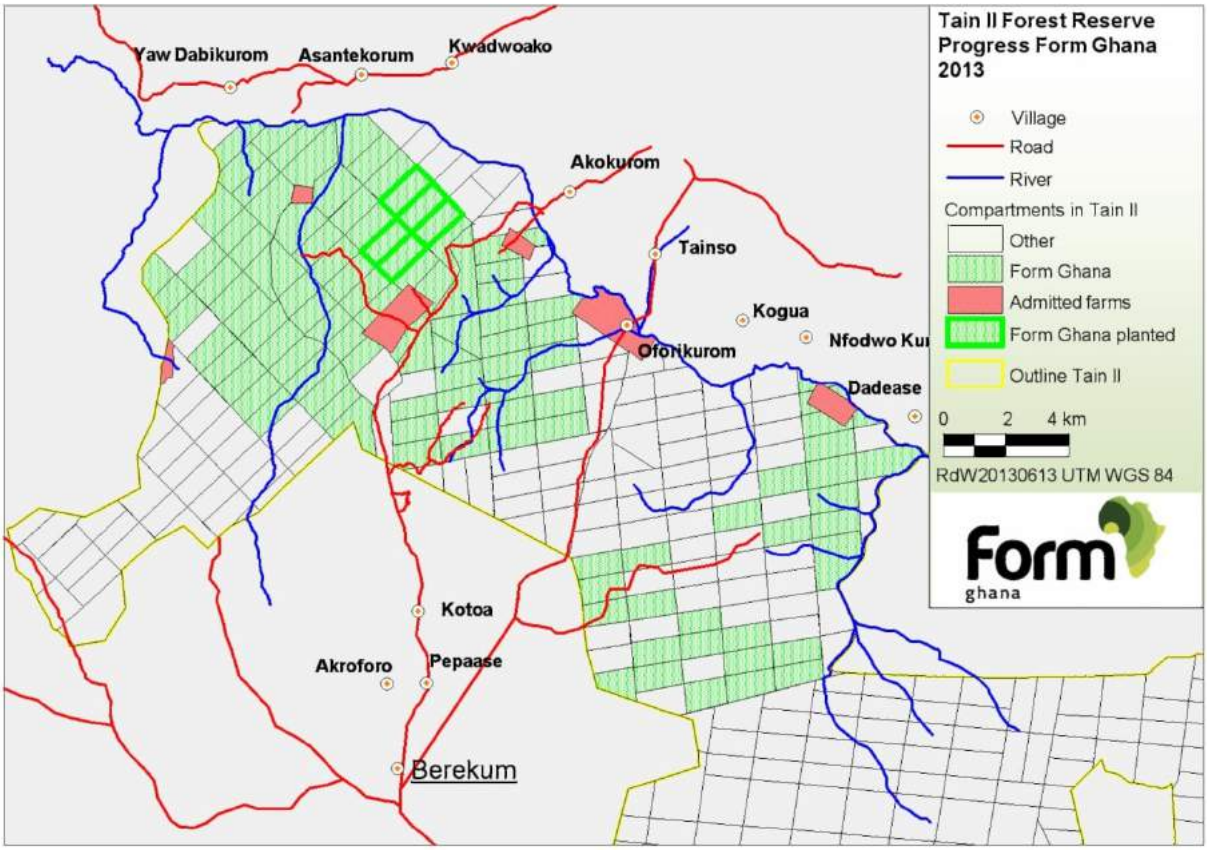

***Figure 2**. Map Tain II FR area managed by Form Ghana.*

The establishment of Tain II Forest Reserve started in 1931 and was finalized in 1932. Taungya systems were introduced in the reserve in 1964, allowing farmers to intercrop food crops with commercial tree species like Ofram (*Terminalia superba*) and Emeri (*Terminalia ivorensis*). In 1970, an agreement was signed for the adoption of the current forest management plan. Included in this plan was the establishment of pilot Teak plantations within the reserve. Large degradation of the entire reserve occurred in 1983, during a large bushfire. The patches of Teak planted after the fire were harvested (clear-felled) between 2000 and 2008. Now the trees have coppiced but there is no coppice management (Tollenaar, 2013).

The entire reserve is located within the dry semi-deciduous forest zone (DSFZ) (Hall & Swaine, 1981). The terrain is undulating and covered with savannah vegetation with a very open canopy, alternating with forested and open sandy-rock patches. Originally, the main vegetation type in the reserve was the dry semi-deciduous forest, which generally contains valuable timber trees such as Wawa (*Triplochiton scleroxylon)*, Odum (*Millicia excelsa*),

Sapele (*Entandrophragma cylindricum*) and Kokrodua (*Pericopsis elata*). Today however, large areas of the reserve are covered by savannah, resulting from human induced land degradation (see figure 1). Due to intensive farming and reported annual fires very little of the original forest remains and what is left is secondary forest and grassland. In the past, farmers protected the large trees on their farms but most of them have been logged eventually so that very few remain today (Tollenaar, 2013).

3.2 Abiotic environment

Climate

Tain II Forest Reserve has a bi-modal rainfall pattern with a major and minor peak in June and October respectively. The main dry season is from November to March and there is a second dry spell in August. The mean annual rainfall is 1200mm and the maximum and minimum annual temperature for 26 years were 23.6°C and 26°C (Orgle, 1994). Relative humidity in the dry season ranges from 100% at night to 30% near midday when the Harmattan wind is strongest. Bushfires occur frequently in Tain II Forest Reserve. In the dry season of 2011-2012 38 bushfires occurred.

Relief & hydrography

The topography of the area is gentle undulating with moderately steep slopes between 5 – 12%. The summits are nearly flat and broad with slopes of 0 – 4%.

There are streams and drainage grooves all over the area which drains northwards into the Tain River. The Tain rises in the southern highland wedge and flows due north to the Black Volta, and both it and its several affluents have narrow floodplains and headwater swamps (Ramsar Wetlands, 2013). Drainage conditions range from well drained in the summits and upper slope sites to moderately to imperfectly drained on middle to lower slopes and poorly drained in the valley bottoms.

Soils

The soil survey exposed five different soil series present in the area; Bekwai, Nzema, Kokofu, Oda and Wenchi, three of which are suitable for teak cultivation, despite a relatively low nutrient content. A total of 12,240 ha or 84% of the total soil surface is suitable for planting teak. The major soils encountered have no physical restriction to the root movement, but they are susceptible to erosion and therefore will require effective soil conservation and management practices such as contour ploughing, strip cropping, mulching leaving of vegetal strips between fields and establishing of cover crops at the initial stages of planting.

Infrastructure

A paved road runs from Berekum to the villages Mpatapo, Kutre 1 and Kutre 2 and to Mpatasie. After this, the roads are all unpaved and often in poor condition. The villages Dadease, Arkokrom, Kojoakokrom and Asantekrom are especially inaccessible during the rainy season (Tollenaar, 2013). Form Ghana recently constructed a 22 km road from Berekum past 3 villages (Mpatasie, Pepaase and Kotaa) into the Forest Reserve.

3.3 Social environment

Tain II Forest Reserve is located at the border of 4 districts: Jaman North, Jaman South, Seikwa and Berekum. The towns of Seikwa in the north and Berekum in the south are the

nearest locations for facilities like markets, hospitals and higher levels of education. In the social assessment conducted as part of the social environmental impact assessment by Tollenaar (2013), 18 fringe communities were selected to represent the social environment around the reserve. Only one community was found to be located within the reserve, on an admitted farm area. All information in this paragraph is from Tollenaar (2013) unless otherwise specified.

Characteristics of settlements

Approximately half of the houses was built with clay, some of them plastered, some of them uncovered. The other half was built with either blocks or bricks. Bricks and blocks are building materials shaped in a rectangular wooden or metallic box, either manually or mechanically. Bricks are made purely from clay, similar to the bricks used in modern buildings whereas blocks are made from a mixture of sand and cement. Traditional clay buildings are made solely from clay, not moulded into rectangular shapes or dried before building. Most of the houses used corrugated steel for roofing but there was still 18% with thatched roofing, made from grass species found in the forest reserve: *Imperata cylindricum* and *Hyparrhenia spp*.

The interviewed households had 1 to 12 rooms at their disposal, with an average of 4 rooms, for an average of 8 residents. Approximately 78% of the households owned at least one bicycle, 15% owned a motorcycle. Main means of motorized transportation are taxis (close to Berekum) and market trucks.

Facilities

The facilities present in the villages surrounding Tain II FR are described below.

Water

Most of the communities fringing Tain II Forest Reserve had access to a borehole. These have been established in the region since 1983. Water quality and quantity was generally perceived to be good. However, many of the boreholes were non-functional at the time of this assessment and have been left discarded for the past years. Mpatasie is the only village with tap water from Berekum. In Meremano, a reservoir and pump system had been established with a network of pipes throughout the village. Asantekrum and Oforikrum still depended on Tain River for their water, but people living in communities with boreholes often preferred the river water to the borehole water. Some people explained this water is more 'filling' than the water from the boreholes.

***Figure 3**. Pumping water.*

Electricity
10 of the 18 villages are connected to the electricity network. The villages in the South are generally connected while those in the North are not.

Churches
The villages around the forest reserve had between 0 and 10 church buildings, with an average of 4. The most common Christian churches were Roman – Catholic, Presbyterian, Methodist and Anglican. Only 3 villages had a mosque.

Hospital
The nearest hospital for most of the villages around Tain II Forest Reserve is the Berekum Holy Family Hospital. There are also small clinics in Akrofoa, Mpatasie and Namasua with 5, 5 and 2 nurses respectively as a permanent staff.

Schools
All of the villages have a primary school within 3 miles radius. For Junior High School (JHS) though, some students have to travel up to 16 miles (Dadease). Most of the villages have at least one primary school and Junior High School (JHS). The only Senior High School in the area is located in Mpatasie (Star Business College). Other students travel to Berekum or even to Sunyani if they want to continue after JHS. They commonly stay with relatives in the town where they attend school and come back to their village at weekends or during holidays, depending on the distance. In the box below the school system is explained in more detail.

Market
The main markets in the area are in Berekum and Seikwa, on Thursdays and Fridays respectively. Other markets are in Drobo and Goka. Market trucks come to all villages to pick up people and their products, but during the rainy season the condition of the roads is sometimes too poor to cross, making the remote villages (Dadease, Nfodwokrom) inaccessible. This is a problem for the inhabitants of those communities that cannot sell their crops.

Fire service
Bushfires are a great pain for the farmers that risk losing their crops, and also poses a threat to the communities as they are often located close to the fire. Several villages have been struck by the fires in the past years; e.g. Kotoa and Pruso. In order to counteract these fires, the districts work together to locate hazards as quickly as possible and combat the hazards effectively. In addition to the banning of hazardous activities in and outside of the reserves, the district fire office developed systems to alarm communities and educates volunteers in fire extinguishing techniques.

Population composition and employment
Average household size is 8 people, usually consisting of the household head, his wife and their children. Approximately 14% of the respondents were children before school attendance, ca. one third were students. Over half of the respondents were working (52%) or unemployed (2%). Of the working respondents, the vast majority were farmers (76%). The next most frequently occurring occupations were traders (5%) and masons (3%). Other professions included tailors, taxi drivers, hairdressers and teachers.

Form Ghana employs permanent workers and casual workers. In 2013, 44 permanent workers have been hired of which 38 are from the surrounding area. In addition, 514 casual labourers from the area were employed for land preparation and planting activities.

Land use

Households commonly have some acres of land supplying the bulk of food crops used for their staple food (used for e.g. fufu and banku) and a small piece of land with vegetables. These crops are grown in a mixed cropping system, with an average size of 9 acres. Some households grow perennial crops like cocoa, cashew or palm nut. The main bulk crops cultivated in the area, calculated by the frequency of cultivation by the households included in the social assessment, are cassava, maize and plantain, followed by cocoyam and yam. Most frequently cultivated vegetables are pepper, okra and garden eggs, followed by tomatoes, onions and green beans. Some households grow fruits like pineapple and watermelon but this is a small minority. The average yield for maize is 18 bags per year. Cocoa was the most frequently grown perennial crop, followed by cashew and palmnut.

***Figure 4**. Sun drying farm produce. In the back, fire wood is stacked.*

Most farmers farm on their own land or in the forest reserve. Only a few farmers reported to pay rent to or share their benefits with the land-owner. Most of the households were farming outside the forest reserve (74%). Approximately half of the households with a farm inside the reserve also farmed on land outside the reserve. The households that farm inside the reserve were located in the communities closest to the forest reserve. The farms located inside the forest reserve were on average twice as big as the farms located outside of the reserve; 6.8 ha and 3.1 ha respectively.

A large share of farmers used artificial ways to stimulate growth of their crops. Herbicides were used by over 90% of the households, and pesticides by nearly 70%. Fertilizers were

used less frequently (30% of the households). Many farmers indicated that they would prefer to use them but couldn't afford it.

The production of maize per ha is much higher within the forest reserve than outside of the forest reserve: 2.8 bags/ha/year compared to 1.9 bags/ha/year. This can be explained by the conditions in the forest reserve that induce farmers to farm in the FR, or by the farming techniques used by the farmers that farm in the FR. It is likely that the soils within the reserve have not been exhausted yet, and that abiotic conditions are more favorable to farming than outside the reserve. It can also be attributed to the efforts of the farmers farming inside the reserve. Farmers inside the reserve are mainly migrants from the northern parts of Ghana. They may be motivated to farm with a higher intensity compared to the native inhabitants.

Stakeholder input
During group discussions, community members were asked to express their expectations and concerns about the proposed project of Form Ghana coming to Tain II Forest Reserve. The overall impression of their reaction was positive. Most communities expressed their excitement about the employment opportunities and were understanding when it came to the restrictions on farming in the plantation.

3.4 Biological environment

Before the biodiversity of Tain II FR is described, the area is put in a context by describing the biodiversity and conservation status in Ghana and the direct surroundings of the forest reserves. Then, the reserves are divided into broad categories: stratification of land-uses that are present within the area. Finally an overview is given of the vegetation and fauna recorded in Tain II FR.

Context
In West-Africa, the Upper Guinea Forest Ecosystems are recognized as one of the 25 global biodiversity hotspots (Myers *et* al., 2000). Originally, 36% of Ghana used to be covered by forest. This share has drastically reduced by the end of the 20th century: to 23% in 1972, 13.3% in 1990, and 10.2% in 2000 (Van Roosbroeck, 2006). The Government's Forestry Commission has designated 29 Forest Reserves as Globally Significant Biodiversity Areas (GSBAs). Further, there are 16 wildlife reserves and 6 Ramsar sites. There are no GSBAs, wildlife reserves, Important Bird Areas nor Ramsar sites in the vicinity of the area managed by Form Ghana (see Appendix D and E).

Tain II FR falls under the authority of Berekum District. In the part of Tain II FR that is not managed by Form Ghana, other companies are active with logging operations and reforestation activities.

Stratification
The satellite image from 2012 demonstrates that little forest remains in Tain II FR before planting commenced (figure 1). Inventory on the ground confirmed this. Four main vegetation types were identified and classified as forest, teak plantation, farmlands and degraded areas (see table 1***Table 1***).

***Table 1**. Main vegetation types surveyed.*

Vegetation type	Characteristics
Forest	Natural forest fragments riverine/gallery forests, secondary forests
Teak plantation	Teak monocultures at various stages of development and management
Farmland	Actively cultivated areas (maize, cassava, vegetables, etc) including fallowed areas
Degraded areas	Severely disturbed areas, grasslands, chromolaena stands, bare soil, etc.

Forest vegetation represented natural forests with little human disturbance. Teak plantation represented areas with monocultures of teak whilst farmlands were actively cultivated areas including fallowed areas used for the production of a variety of food crops including maize and cassava. Degraded areas represented highly disturbed forests and grasslands with thickets of *Chromolaena odorata* and isolated. These areas were constantly razed by fires in the dry season. In the southern sections of the FR, near Kotoa, degraded areas also served as active Fulani cattle grasslands. Although these activities are perceived by locals to be less destructive compared to logging and clearing of forests, cattle grazing sites were frequently sighted close to streams and water bodies thus polluting them. Degraded areas (73%) constituted the major vegetation type followed by teak plantation (13%) and farmlands (9%). Forest was the least encountered vegetation type (5%).

Figure 5. Approaching a riverine forest in Tain II FR.

Vegetation

In the degraded areas (basal area of less than 10 m^2/ha) the vegetation consists predominantly of human-induced grassland containing the invasive species *Pennisetum purpureum*, *Chromolaena odorata*, *Broussonetia papyfera* and *Imperata cylindrical* (Oduro & Danquah, 2012). There was no clear pattern in the distribution of degraded areas and teak plantation; farmland was recorded mostly towards the fringes of the reserve. Although the percentage of actively farmed land for food crops varied across the study area, fallowed areas (farmbush) was more or less evenly distributed.

Generally, forest patches were prevalent along the main water bodies, especially along the Tain River and its tributaries. These forests generally existed as riverine forests and occurred along the northern and western fringes of the reserve. The tree basal area (DBH>10cm) ranged from 20 - 30 m^2/ha in slightly disturbed areas to 10 – 19 m^2/ha in moderately disturbed areas (Oduro & Danquah, 2012). There were also smaller forest fragments dotted within the central portions of the reserve.

Indigenous trees representing 22 Families and 56 Species were confirmed in the study area. *Tectona grandis* (teak) was concentrated in isolated local plantations but ranked highest in abundance, followed by *Ficus exasperata, Albizia adianthifolia*, *Cola gigantea*, *Antiaris toxicaria*, *Holarrhena floribunda*, *Newbouldia leavis, Aningeria altissima*, *Trema orientalis*, *Morus mesozygia* and *Albizia ferruginea*. Very rare species included *Mareya micrantha*, *Piptadeniastrum africanum* and *Mucuna pruriens*. See appendix G for a list of identified vegetation species in the study by Oduro & Danquah (2012).

DBH class distribution

As figure 6 shows, in the tree population of Tain II FR fewer young individuals than mature trees have been identified. Very few trees are bigger than 40 cm DBH and none have a DBH over 60 cm.

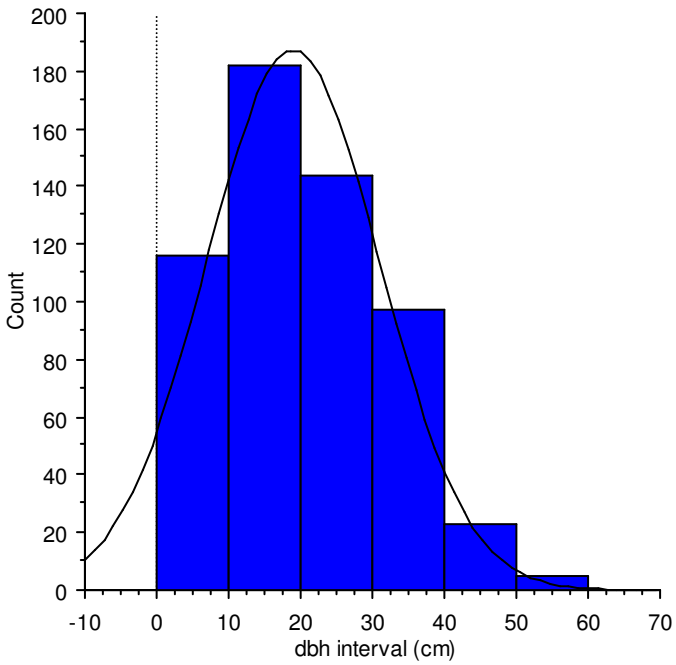

Figure 6: Size (DBH) class distribution of trees recorded in Tain II FR sample plots. Source: Oduro & Danquah, 2012.

Height class distribution

The height class distributions of the main vegetation types recorded in the various plots of Tain II FR are shown in figure 6.

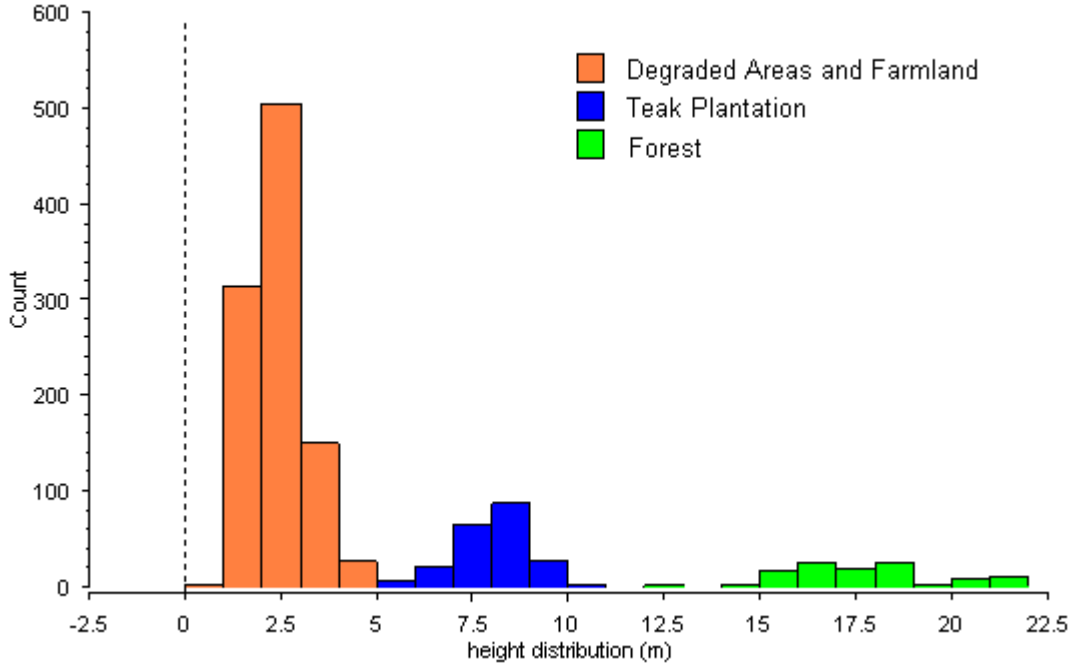

Figure 6. Vegetation height class distribution recorded in sample plots. Source: Oduro & Danquah, 2012.

The height class range of 1.0m - 5.0m represented most grassland, thickets and farms (orange); there were few bare areas of vegetation height (<1.0m) and virtually no areas with vegetation higher than 5.0m. Most teak trees (blue) ranged in height of between 7m to 9m. For the forest vegetation type, no tree exceeded a height class of (>22.50m) and tree individuals of less than 12.50m were almost absent.

There seems to be some similarity between the height class distributions recorded in degraded areas and farmland, teak plantation and forest. Generally, the younger and older individuals in all vegetation types were few and the size classes did not have the "normal" logarithmic representation (Richards 1998 in Oduro & Danquah, 2012).

Fauna presence

The presence of the following fauna types has been studied in Tain II FR: small and medium sized mammals, reptiles, birds and frogs. Appendix F gives an overview of encountered fauna species in Tain II FR.

Mammals & reptiles

In total, individuals of four species of terrestrial small mammals were captured. Two species were endemic to West Africa: Tullberg's soft furred mouse (*Proamys tullbergi*) and the shrew *Crocidura gradiceps*. Due to the small numbers of captures, it was impossible to make realistic comparison between vegetation types, but most rodent species seemed to favour forest vegetation.

Of the medium-sized mammals, rodents were the most widespread group of species in the study area with grasscutters and brush-tailed porcupines representing the most abundant species. Giant rats and ground squirrels were however restricted in abundance and distribution. Common carnivores were mongooses, civets and genets. Although these species occurred in lower densities, they were largely restricted to forest vegetation with highest densities occurring in the riverine vegetation. Bushbucks were the most abundant ungulates followed by Maxwell's duiker whilst red river hogs and royal antelopes were comparably restricted to just a handful of sites.

No direct recordings of primate activity were made throughout the study. Nevertheless, a few hunters interviewed confirmed the presence of Demidoff's galago and Bossman's potto in a few sites, particularly in some of the forested vegetation.

Apart from the forest cobra and green mamba, the activities of reptiles including the Nile monitor were among the least recorded animal signs.

Overall, mammals and reptiles were most often spotted in the forest vegetation type where canopy foliage gaps and density in the understory stratum were lowest. Cane rats (commonly called grasscutters) formed an exception as they were particularly recorded in farmlands and degraded areas. Fewer animal signs were recorded in the remaining three vegetation types (teak plantation, farmland and degraded area) where canopy openness and understory foliage density was greatest. Comparative analysis confirmed little overlap in species composition between the two land-use categories.

Avifauna

Sixty species, belonging to 23 families were recorded on transects. More than 10% of the species recorded belongs to the Weavers and Malimbes family (Ploceidae). Other families included Flycatchers (Muscicapiidae), Bulbuls, Greenbuls (Pycnonotidae), Pigeons and doves (Columbidae). Most bird species were recorded in the forest vegetation (38), followed by degraded areas (33), teak plantations (21) and then farmlands (19). The transect and mist net sampling protocols recorded different species on each sampling day. This is a good indication that the Tain II Forest Reserve may still hold an impressive number of birds.

Amphibians

Fourteen frog species consisting of 62 individuals were found during the study in Tain II FR. Amphibians were generally difficult to encounter in the study area and individuals encountered represented a variety of habitats including savanna (degraded area), forest, or grassland vegetation types. It is expected that when the canopy in the teak plantation closes with time, a shift in species will occur. Closed canopy species will thrive as teak stands mature.

Factors affecting mammal distribution

The distance to water sources, number of hunting signs, length of forest and distance to roads had effect on the density of mammals in the study area. Length of forest is classified as the length of the transect that has been determined as 'forest vegetation type'. Length of farmland, degraded area and teak plantation did not appear to influence animal density. Mammal density generally increased steadily with increasing length of forests. Highest

numbers of fauna species are found at maximum intensities of forest vegetation where tree cover is abundant. Proximity to roads emerged as the third most important variable influencing mammal density. Signs of hunting were relatively low in the study area surveyed, mostly of rat hunting activities (50%).

Hotspots

Animal sightings were most abundant in the western part of Tain II Forest Reserve, west of the road leading northwards from Kotoa. This reflects the analysis shown previously about factors affecting wildlife distribution; it is a remote area, far from villages and roads, where human presence is generally low. Carnivores, rodents and ungulates show a similar distribution pattern to the total animal sighting distribution but reptiles show a different pattern. Reptiles occur less often in the strip where mammals are most abundant, and more often in the centre part of the reserve, east of the road from Namasua to Seikwa.

4. High Conservation Value Forests Analysis

Based on the findings from the studies in the previous chapter, an analysis was carried out to assess the presence or absence of each of the six High Conservation Value Forests in the area of Tain II FR managed by Form Ghana.

4.1 High Conservation Value 1

"Forest areas containing globally, regionally or nationally significant concentrations of biodiversity values (e.g. endangered species, endemism, refugia)."

In the Ghanaian interpretation of HCVs this high conservation value:

1. equals the status of protected areas, i.e. national parks, resources reserves, global protection reserves, globally significant biodiversity areas (GSBAs), hill sanctuaries, provenance protection areas and wildlife sanctuaries (Rayden *et* al., 2006).
2. refers to forest that contain outstanding concentrations of threatened or endangered species, i.e. GSBAs, concentrations of globally threatened IUCN red-listed species, or species nationally listed as protected under the National Wildlife Conservation Regulation (Rayden *et* al., 2006).

No parts of Tain II Forest Reserve have been set aside as a protected area nor are there any National Parks or GSBAs bordering Tain II FR.

The only endangered specimen that was encountered in the forest reserve was a shrew: *Crocidura gradiceps*. This animal is ranked Near Threatened on the IUCN red list (Hutterer, 2008 in IUCN, 2012) but is not included in the national Wildlife Conservation Regulations. This shrew was encountered twice, indicating that there is not a large population present of these animals. Therefore, the information at hand does not indicate outstanding concentrations of threatened or endangered species are present in the area.

Species listed as protected under the national Wildlife Conservation Regulation with their Mean Encounter Rate (N° encounters/ km) in the biodiversity study by Oduro & Danquah (2012): 0.00-0.49 (rare); 0.50-0.99 (uncommon); 1.00-1.49 (common); 1.50-1.99 (abundant); =>2.00 (widespread) are the following:

Schedule 1

<u>Mammals:</u>

- Bosman's potto (*Perodicticus potto*) – only from interviews with local hunters
- African civet (*Viverra civetta*) – rare

<u>Birds:</u>

- Yellow billed Kite (*Milvus aegyptius*) – rare
- Grey Kestrel (*Falco ardosicicens*) – rare

Schedule 2

<u>Mammals:</u>

- Bush genet (*Genetta tigrina*) – rare
- Cusimanse mongoose (*Mungos obscurus*) – rare

- Marsh mongoose (*Atilax paludinosus*) – rare
- Bushbuck (*Tragelaphus scriptus*) – common
- Maxwell's duiker (*Cepahlophus maxwelli*) – uncommon
- Royal antelope (*Neotragus pymaeus*) – rare
- Red River Hog (*Potamochoerus porcus*) – rare
- Brush-tailed porcupine (*Artherurus africanus*) – common

Birds:

- Laughing Dove (*Stigmatopelia senegalensis*) – uncommon
- Red-eyed Dove (*Streptopelia semitorquata*) – widespread
- Green Fruit Pigeon (*Treron calva*) – uncommon
- Blue-headed Wood Dove (*Turtur brehmeri*) – rare
- Tambourine Dove (*Turtur tympanistria*) – uncommon
- Lavender Fire-Finch (*Estrilda caerulescens*) – rare
- Orange-cheeked Waxbill (*Estrilda melpoda*) – uncommon
- Bronze Manikin (*Spermestes cucullata*) – uncommon
- Green Turaco (*Tauraco persa*) – uncommon
- Red-headed Bishop (*Anaplectes melonotis*) – common
- Northern Red Bishop (*Euplectes franciscanus*) – uncommon
- Black-winged Bishop (*Euplectes hordeaceus*) – widespread
- Black-headed Weaver (*Ploceus melanocephalus*) – rare
- Viellot's black Weaver (*Ploceus nigerrimus*) – widespread

Reptiles:

- Royal python (*Python regius*) – rare
- Rock python (*Python sebae*) – rare

Schedule 3

Mammals:

- Striped Ground Squirrel (*Euxerus erythropus*) – rare
- Giant Rat (*Cricetomys gambianus*) – rare

Birds:

- Ahanta Francolin (*Francolinus ahantensis*) – uncommon

Most species listed under the National Wildlife Conservation Regulation that were encountered in Tain II FR were rare (0.00-0.49 per km) or uncommon (0.50-0.99 per km). A few species were considered common in the area. However, concentrations were still too low to speak of 'outstanding concentrations of threatened or endangered species'.

Three bird species enlisted in the national Wildlife Conservation Regulation were encountered frequently, and are therefore classified as 'widespread' in the biodiversity study by Oduro & Danquah (2012): the Red-eyed Dove, Black-winged Bishop and Viellot's black Weaver. The species are listed as 'second schedule species' in the national Wildlife Conservation Regulations, which means certain restrictions apply for hunting and trapping these animals. They are however not fully protected and classified as species of least

concern by the IUCN Red List of Threatened Species. Therefore, these species are not considered to be threatened or endangered.

To conclude, High Conservation Value 1 is not present in the area of Tain II FR that is managed by Form Ghana.

4.2 High Conservation Value 2

"Forest areas containing globally, regionally or nationally significant large landscape level forests, contained within, or containing the management unit, where viable populations of most if not all naturally occurring species exist in natural patterns of distribution and abundance."

Intact Forest Landscapes are defined as "an area of at least 50,000 ha of forest that is un-fragmented by roads or other forms of man-made disturbance" (p.10 Rayden *et* al., 2006). According to the global database of Intact Forest Landscapes, developed by Greenpeace, the Rainforest Action Network and the World Resources, no forest areas in Ghana meet these criteria.

Therefore, it can be concluded that High Conservation Value 2 is not present in Tain II FR.

4.3 High Conservation Value 3

"Forest areas that are in or contain rare, threatened or endangered ecosystems."

During the workshop organised for the development of the HCVF Toolkit for Ghana, participants agreed that 'ecosystems' would be defined as both 'broad forest types' and smaller 'habitats types', considering those that:

1. are naturally rare;
2. have been dramatically reduced from their original extent due to the activities of man;
3. are so threatened by existing and planned activities that they should be considered threatened/ endangered" (p.11 Rayden *et* al., 2006)

Tain II FR is located in the Dry Semi-Deciduous Forest Zone. According to the Toolkit, the forest type Dry Semi-Deciduous is reduced in extent or quality and is threatened by current and future changes (Rayden *et* al., 2006). It is indeed confirmed that in Tain II FR the forest area has reduced in extent and quality. For that reason, according to Rayden *et* al. (2006) the area is a candidate for HCVF 3.

However, 73% of the area was considered 'degraded', with a basal area of less than 10 m^2/ha. Only 5% of the forest reserve was still considered forest, according to Oduro and his field team, and this forest was patchily distributed along the riparian zones of rivers and streams in the forest reserve. The patchy nature of the forest area reduces the relevance as essential habitat for endangered species as the areas are too small to support viable populations. In addition, the remaining forest is severely degraded and therefore less valuable as an ecosystem.

Therefore, it can be concluded that HCVF 3 is not present in Tain II FR.

4.4 High Conservation Value 4

"Forest areas that provide basic services of nature in critical situations (e.g. watershed protection, erosion control)."

Besides watershed protection and erosion control, forest providing barriers to destructive fire may be classified as HCVF, more specifically parts of forest reserves along road margins and when there is evidence of a fire risk from the activities of man. Finally, forests that play a critical role in local climate regulation (e.g. dramatically increased fire risk or exposure to drying winds, negatively affecting agriculture) could be designated as HCVF. Forest areas situated in the transition zone (between the High Forest Zone and the dry savannah) that provide protection against the North East trade winds and/or 'Harmattan' dry winds will be considered potential HCVF (Rayden *et* al., 2006).

There is currently no forest on steep slopes and only very few forest patches remain that serve to protect rivers and streams in Tain II FR. Hydrological analyses show that water quality is generally low in the forest reserve. Many communities depend on these streams for their water consumption, as well as sanitation and irrigation of their food crops, hence their health is at risk.

Tain II Forest Reserve is located in the transition zone between wet and dry climatic regions and wildfires occur frequently during the dry season. The fact that wildfires occur several times a year in the forest reserve indicates that the current vegetation cover does not serve as a protection against fires.

The need for forest to protect the water courses and to function as a fire-belt indicates that High Conservation Value 4 is present in potential. It is however highly unlikely that the present vegetation can provide any purifying or regulating function for the water bodies, or serve as a protection against fire or strong winds.

HCVF 4 is therefore not present in Tain II Forest Reserve.

4.5 High Conservation Value 5

"Forest areas fundamental to meeting basic needs of local communities (e.g. subsistence, health)."

According to the Ghanaian interpretation of HCVFs, "a forest will be considered HCVF when it is the source of a basic need in a situation where the majority of the local people or the poorest population among the local people have no realistic alternative" (p.18 Rayden *et* al., 2006). Basic needs include: food (e.g. bushmeat when this is a fundamental protein component of their diet), non-timber forest product (NTFP) harvesting (for essential household income), medicines (in absence of local clinics or when this is the only affordable option), building materials, firewood or pestles. Immigrants and very remote settlers are more likely to suffer from extreme poverty, which will make them more dependent on their direct environment for their survival (Rayden *et* al., 2006).

The SEIA carried out by Tollenaar (2013) shows that all identified fringe communities depend on agriculture for their livelihoods. None depend on the resources from the forest itself for essential household income. Since there is hardly any forest left, resources have been exhausted and are now largely unavailable to the communities. The SEIA by Tollenaar (2013) showed that 18% of the houses had thatched roofing, made from grass species found in the forest reserve as well as out of the reserve; *Imperata cylindricum* and *Hyparrhenia spp.* Firewood is collected in the reserve as well as outside of the reserve (see figure 3). Over the past decades availability of these resources has decreased considerably and this is expected to continue to decrease if no interventions take place. The proposed reforestation project of Form Ghana is likely to cause an increase in firewood supply rather than a decrease..

It can be concluded that this High Conservation Value 5 is not present in Tain II Forest Reserve since the area is severely degraded and produces very few resources today.

4.6 High Conservation Value 6

"Forest areas critical to local communities' traditional cultural identity (areas of cultural, ecological, economic or religious significance identified in cooperation with such local communities)."

For communities adjacent to the forest reserve, forests often have a deep spiritual and cultural meaning. Practices expressing this cultural identity, traditional beliefs and norms are reflected in pouring libations, in saying prayers to forest gods, festivals and rituals, folklores and oral history, burial grounds of stools and skins. In Ghana, generally these HCVFs are associated with dense/ intact forests, the so-called sacred groves (Rayden *et* al., 2006).

The social survey conducted by Tollenaar (2012) as part of the SEIA has not identified any areas in the forest reserve as important for the cultural identity of those living near the area that will be managed by Form Ghana: "None of the villages performs rites or rituals within the forest reserve". Village members indicated that the forest is no longer considered a true forest since degradation has become more and more severe over the years. One of the communities has a small patch of 'sacred forest', but this forest is located outside the forest reserve.

It can therefore be concluded that High Conservation Value 6 is not found in the area of Tain II Forest Reserve that is managed by Form Ghana.

5. Conclusion and management implications

Conclusion

At the time of this study, the status of the forest vegetation in Tain II Forest Reserve is highly degraded. The only forest that remains is distributed in small patches in riparian areas. Because of the current conditions, no High Conservation Value Forest has been identified in the Tain II Forest Reserve area managed by Form Ghana.

Management implications: restoration

Form Ghana already has a set of measures to conserve and enhance the biodiversity values in the forest area under their management. Wildlife will be protected by prohibiting poaching and hunting which is controlled by the security team that patrols the area. Connecting the various patches of forest can significantly increase the ecological value of the forest reserve, providing suitable habitat for local flora and fauna, refugia for wildlife and a buffer for soil erosion. Management of these buffer zones is geared towards protection and restoration using indigenous species of local provenances (cf. recommendation 6.4.4 in Rayden *et* al., 2006). Seeds of the endangered Kokrodua tree have been used to produce seedlings that will be planted in the buffer zones scattered over the area to boost the current Kokrodua population, an endangered species, and conserve the species for the future. The current state of the vegetation makes it obvious that the watercourses are not sufficiently protected. Form Ghana is therefore actively engaged in the restoration of the buffer zones along water ways and in monitoring water quality to determine the effect of the activities and measures taken. Also, Fulani cattle will not be allowed in the Forest Reserve area managed by Form Ghana (cf. Ghana National Law), so they will no longer be bathing and defecating in rivers and streams. This is expected to severely reduce water turbidity and increase water quality.

Future

With reforestation of the degraded land it is expected that certain ecosystem services will be restored, e.g. water quality and climate regulation. The active reintroduction of endangered species (e.g. Kokrodua) and protection of wildlife can potentially make the area managed by Form Ghana an important habitat for flora and fauna. Future analyses will show whether the forests will gain HCVs .

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Appendix A – Methodology of socio-economic study

Socio - economic study

The social impact assessment was executed by a field team consisting of M. Tollenaar, consultant at Form international and M. Armani, independent consultant. In the period of 31 October to 17 November 2012, structured field data was collected and informal interviews with stakeholders were held. Stakeholders are defined as parties that are likely to be affected by the proposed project. Included in this assignment were the following stakeholders: Berekum district fire service, Ghana Education Service, Berekum Holy Family Hospital, Berekum District Assembly, Agriculture Office, Chiefs and paramount chiefs of Berekum and Seikwa, NCCE and Sunyani District Forestry Office. Interviews were held about their perception of the impact of the proposed project.

In addition to the service providers and government agencies, farmers were also included in the stakeholder assessment. Eighteen communities were selected for this assessment (Table 2). In each of the communities, 2-8 households were asked to fill out a questionnaire and a group discussion was held with the focal people and opinion leaders of the villages (chief, assembly man, village elders etc.) to acquire general information on the village.

Table 2. *Villages included in Social Impact Assessment, per district.*

District	Village	Number of people interviewed	Number of households	Average nr. of people per household
Berekum	Akrofoa	31	5	6
	Ampenkrom	25	2	13
	Domeabra	20	2	10
	Kotaa	67	8	8
	Kutre 1	61	8	8
	Kutre 2	79	8	10
	Mpatapo	69	8	9
	Mpatasie	63	8	8
	Namasua	55	8	7
	Oforikrom	11	3	4
	Pepaase	70	8	9
Seikwa	Arkokrom	28	4	7
	Dadease	20	4	5
	Kojoakokrom		*-----Only group discussion-----*	
	Nfodwokrom	32	4	8
	Tainso	58	8	7
Jaman North	Asantekrom	28	4	7
Jaman South	Meremano	61	7	9
	Total	**781**	**99**	**8**

Appendix B – Methodology of environmental study

A biodiversity assessment was conducted by W. Oduro and E. Danquah in November 2012. Using GIS applications, a grid consisting of cells, each 1-km of length or breadth was superimposed on a map of Tain II FR showing the Form Ghana compartments (Figure6).

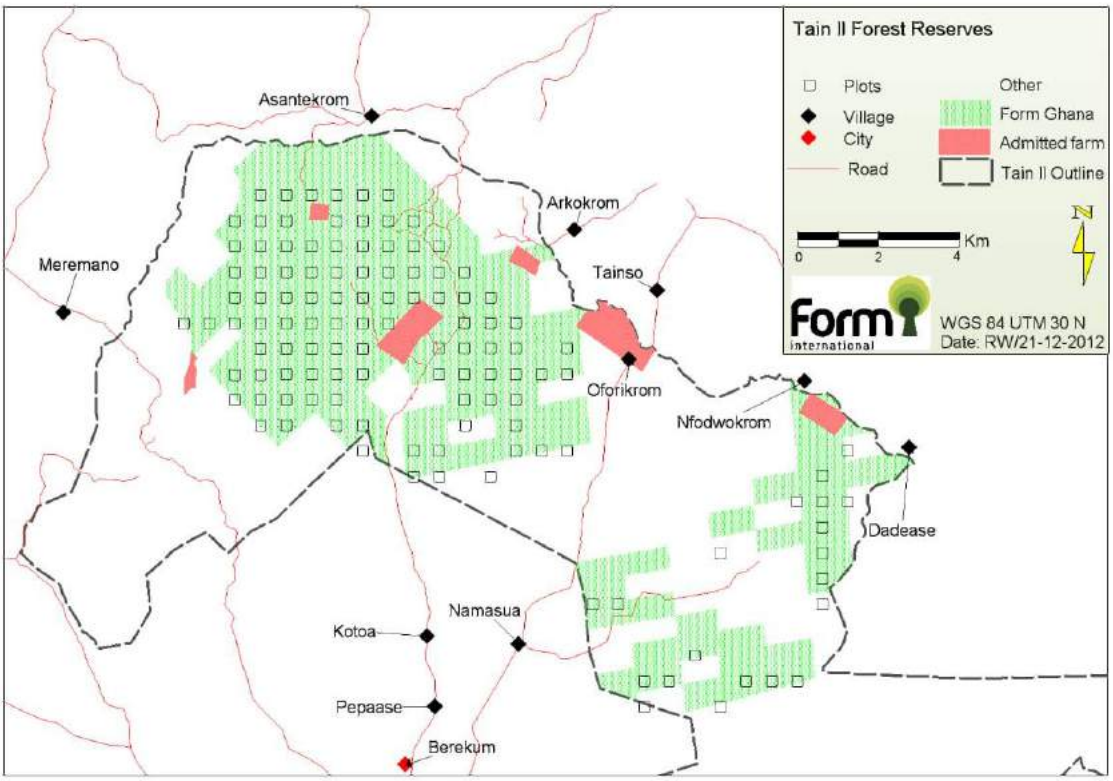


***Figure 6**. Map of Tain II Forest Reserve showing distribution of compartments and transects.*

One hundred and twenty transects of 1km in length were systematically distributed over the various compartments based on the number or cluster of compartments found at a particular place. The intersections of the grid formed the beginning of each transect. A total of 100 transects was laid out the biggest cluster (constituting about 100 compartments) located in north-west of study area. The remaining twenty transects were distributed equally over the two smaller clusters located in north-east and south of the study area, conforming to a systematic segmented line transect design. All transects were oriented northwards as a rule of thumb (Norton-Griffiths 1978).

Determination of the survey transect system set-up was based on three basic requirements;

1. a length of transect long enough to cover animals with large territories and home ranges (ungulates, carnivores);
2. a transect system sufficiently fine-grained to determine the habitat preferences and density estimation of species with restricted range and small territories;
3. a length of transect long enough to include most vegetation and farm types typical of the study area.

As a basis for comparing flora and fauna relationships, each transect was associated with a vegetation plot. Thus each vegetation plot was systematically placed in the middle and across a fauna assessment transect (Norton-Griffiths 1978).

It is impossible to count animals directly in the forest/farm/farmbush mosaic such as that of the study area because of the poor visibility. Hence, the field team conducted a sign count survey, using the line transect method (Burnham *et al*., 1980; Buckland *et al*., 1993, 2001) adapted for forest conditions. Two survey teams of four technicians, led by a forest guard (line cutter) did the identification of organisms to ensure consistency in data collection procedures. The technicians consisted of experts in four taxonomically well-known groups: mammals, herpetofauna, avifauna and vegetation. The following notes were made each time an animal sign was recorded:

- Distance along the transect, measured by the GPS
- Vegetation type in the area
- Date that the transect was walked
- Number and types of animal signs
- Number of hunting activity (empty cartridges, wire snares, etc.)
- Number of farming activity
- Distance to water sources
- Length of vegetation type traversed on transect (km)

Other notes were made on ecological and human factors that might explain the distribution of animals including distance to water sources (ponds, rivers, streams) and number of human signs (farming and hunting activity).

The starting point of each transect was reached by navigation with a compass and a GPS. Once on the transect, all animal signs observed along the transect centre-line were recorded. The team member responsible for navigation directed the line cutter whilst all team members walked in line towards the line cutter, scrutinising the undergrowth and foliage on either side for animals or their signs including droppings, trails, feeding activity and vocalizations.

Flora survey

Sample plots were laid at the mid-point (500m) of each transect. Plots were sized 50m by 50m dimensions for forest vegetation and 20m by 20m for any other vegetation type. Each of these plots was associated with a 5m by 5m and 2m by 2m plot for more detailed assessment of saplings, seedlings and grass species. The sample plots were demarcated with the help of ranging poles, a prismatic compass and a linear measuring tape. The transect line passed through the middle of the plot to facilitate movement through the plot.

An enumeration team was made up of a tree spotter and a recorder. Moving clock-wise, all trees were identified, recorded and diameter at breast height (dbh) measured and recorded. Nomenclature of tree species followed Hawthorne and Jongkind, (2006) and Hawthorne and Ntim Gyakari, (2006).

Tree density and relative density were estimated as;

$$\text{Tree density} = \frac{\text{Total number of trees in all plots}}{\text{Total sampled area}}$$

$$\text{Relative density} = \frac{\text{Number of a particular species}}{\text{Total number of species}}$$

Small mammals

Mammals are considered 'small' in this study if they weigh less than 1kg, as described by Stuart and Stuart (2006). Examples of small mammals are rats and squirrels. Small mammal populations are strongly related to habitat, vegetation cover and flora diversity. Higher vegetation cover and diverse flora habitat have proved to result in higher abundance and diversity of small mammals (Blouin-Demers et al., 2003). Reasons for this relationship are their short lifespan, rapid population dynamics and low hunting pressure in comparison to larger mammals.

Only live-trapping methods were used for small mammals. Fifty Sherman live traps were used simultaneously. Trap lines were set along trails, hauling roads and selected transects, in various habitat types. Traps were placed either randomly or at fixed intervals of 25m on each side of roads, paths and cut lines. Majority of traps were placed on the ground, lightly covered with leaves, bark etc., whereas some were placed on fallen trees or lianas. Others were set close to heaped brushwood, network of aerial roots, holes in the ground or hollow trees. Traps were baited with peanut butter. Trap sites were indicated by ribbons made of orange nylon rope fixed at eye height on twigs. Voucher specimen were collected and preserved as wet specimens in 70% ethanol and later identified at the Faculty of Renewable Natural Resources museum.

Medium-sized mammals

Mammals were classified as 'medium-sized' when the average weight was over 1kg (Estes, 1991; Stuart and Stuart, 2006). Many medium-sized mammal species have been exploited locally and are likely to have been driven to local extinction during the past century (eg. Wilson, 1988). The IUCN Red List noted that many animals found in Ghana are threatened, endangered or extinct (IUCN 2010). Indiscriminate hunting and clearing of forest for agricultural purposes have played a major role in the decline and extinction of wildlife species in the area. In Ghana, however, there are few records that show the loss of wildlife species in the country. Mammals assist the maintenance and regeneration of tropical forest by predation, seed dispersion, grazing, and frugivory (Cuaron, 2000).

Large mammal surveys comprised both direct and indirect methods (White and Edwards, 2000). All large mammals and their signs were included in the survey to make a complete species list for the area. Direct sightings, vocalizations, dung (scats and pellets) and tracks (trails) counts were recorded systematically along line transects and also on ad hoc basis outside transects. For the most part, transect surveys began in the early hours of the morning but the major determinant of the duration of a survey was the type of vegetation and the availability of animal signs. Mammal signs recorded on transects were used to generate a species list**.**

Avifauna

Birds are good indicators of spatial biodiversity and sustainability because they are high in the food chain and occupy a broad range of ecosystems Compared to other taxa, a wealth of data has been (or can be) collected by volunteers and professionals. Bird population sizes, trends and conservation status are often well known and they appeal to a wide audience. Therefore, an increasing interest in the use of ornithology data can be observed. Habitat indicators can be used to assess macro level changes, but also to identify more subtle changes in biodiversity within habitats. By highlighting these changes, bird indicators can point to the need for more detailed research to identify the causes of changes in population of different species. As West-African forests are rapidly disappearing, the survival of the birds is becoming increasingly dependent on ever fewer areas. Despite of a number of field studies conducted in the region in recent years (e.g. Demey and Rainey 2004; Rainey and Asamoah 2005; De Laat 2011), the avifauna in the majority of these forests remains largely unknown.

Shorter transects were used to survey the avifauna of the area. Transects were located near make-shift camps in the forest along existing tracks and. Field work was carried out in the morning, from dawn (usually 6:30GMT) until noon, and in the afternoon from 15:00GMT until sunset (18:00GMT). In order to avoid the high temperatures in the afternoon in which bird activity is generally low.

Additionally, mist netting was employed to capture the shy and cryptic understory bird species that are difficult to record during the transect walks. Notes were taken on both visual observations and bird vocalizations. Some recordings were made for archiving purposes. For each field day, a list was compiled of all the species that were recorded. Numbers of individuals or flocks were noted, as well as basic information on the habitat in which the birds were observed. For the purposes of standardization, we followed the nomenclature, taxonomy and sequence of Sinclair and Ryan (2003).

Reptiles and Amphibians (herpetofauna)

Herpetofauna surveys comprised both direct and indirect methods. Species were recorded systematically along line transects and also on ad hoc basis outside transects. Suitable habitats and refuges for reptiles were also visited and surveyed for different species. A combination of both visual and acoustic encounter survey techniques were used to detect and record frogs. All individuals sighted were captured marked and released. Each site was visited for 10 times over the survey period. Voucher specimen were collected and preserved as wet specimens in 70% ethanol and later identified at the Faculty of Renewable Natural Resources museum.

Data analysis

An indirect technique such as an index count, which produces relative numbers based on encounter rates, was used to estimate species densities.

Animal sign density = [number of signs / total distance walked]

Index counts relate animal numbers to an index of animal signs detected along line transects (Buckland *et al*., 2001; Barnes *et al*., 1997).

EstimateSWin800 version 8.0.0 (Colewell, 2006) was used to determine species diversity and richness in the various vegetation types. Habitat preferences of the various mammal

species were assessed based on Jacobs' Preference Index (Jacobs, 1974). Comparative analysis to show species composition similarity between vegetation types was done using Jaccard Similarity Index (Southwood and Henderson, 2000). Where appropriate, simple descriptive statistics was used and results presented in the form of graphs, tables and charts for easy observation and understanding.

Factors affecting fauna distribution

Regression analyses were used to assess the factors that influence fauna distribution in the study area. In this case, the statistics package StatView 5.0.1 was used. The goal was to build mathematical models that described the distribution of animal species.

As the response variable, the number of animal signs recorded on transects are typical count data: they are not normally distributed and they consists of integers, positive numbers and sometimes there are many zeroes. Therefore, variables were statistically normalised before analysing.

Appendix C – Methodology of hydrology and soil survey

Hydrological survey

Hydrological samples were taken in Tain II Forest Reserve in 2012. Out of 32 intended sample points, 29 samples were obtained (Figure 7). The other 3 samples (20, 21 and 32) could not be taken due to inaccessibility of the site or desiccation of the water source. The samples were analyzed in a laboratory. The following parameters were measured and the values compared to the maximum values for safe drinking water according to the WHO: pH, Apparent color (PtCo), Turbidity (NTU), Conductivity (µs/cm), Dissolved/Suspended solids, Alkalinity, Hardness, Calcium/Magnesium Hardness, Calcium, Magnesium, Chloride, Nitrate, Sulphate, Copper, Iron.

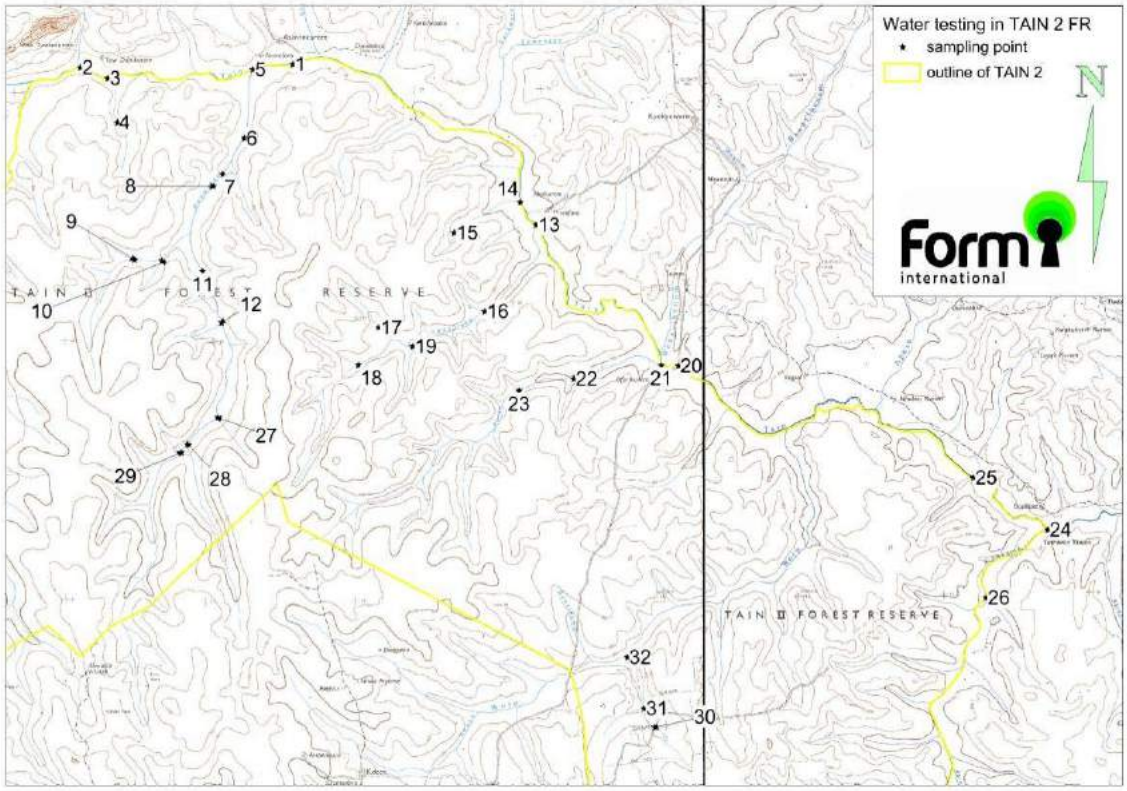


Figure 7. *Water sample points in Tain II Forest Reserve.*

Soil survey

Data for the soil survey were obtained from the soil reconnaissance assessment in Tain II Forest Reserve, executed in September/ October 2012 by a soil survey team from Soil Research of Ghana consisting of Mr. Dwomo Owusu and Mr. Anim Boafo. The team was later assisted by Mr. A. Augustine of Form Ghana and Mr. Hans Scholten from Humisphere consultancy.

The study was carried out to map out the soil units. Chisel and auger examination borings were made at 200m regular intervals and at breaks of slopes along tractor tracks, footpaths, streams and river courses and along the forest reserve boundary in the various compartments. At each examination point, the soils were examined and identified. The measured parameters included soil texture, structure, consistency, colour, drainage, coarse

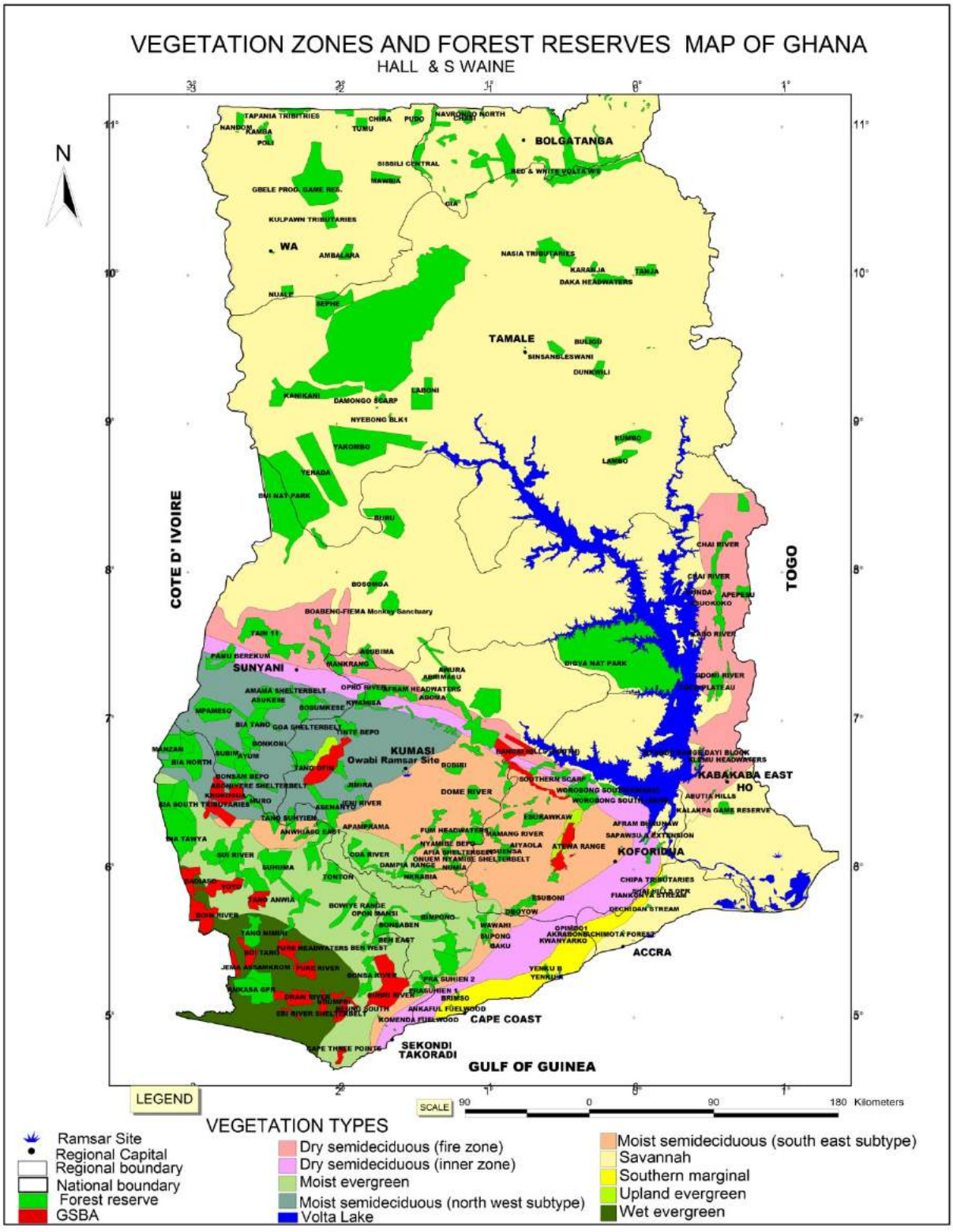
fragments content and land use. The GPS coordinates were taken from each of the observed point and plotted area base map.

A total of 162 soil observations was made and five profile pits measuring 1.5m x 1.0m x 1.5m were dug. For the Wenchi series, pits were dug until the lithic surface was reached and for the Oda series until groundwater level was reached. The soil boundaries were drawn by interpolation with the aid of a topographic map of the area.

Land evaluation was completed using the Food and Agriculture Organisation (FAO) land evaluation methodologies (FAO, 1976). The soils were classified using the World Reference Base for Soil Resources (WRB) of FAO (2006) and United State Department of Agriculture (USDA, 2007) soil classification system. At the end of the exercise, soil and soil suitability maps of the area were produced

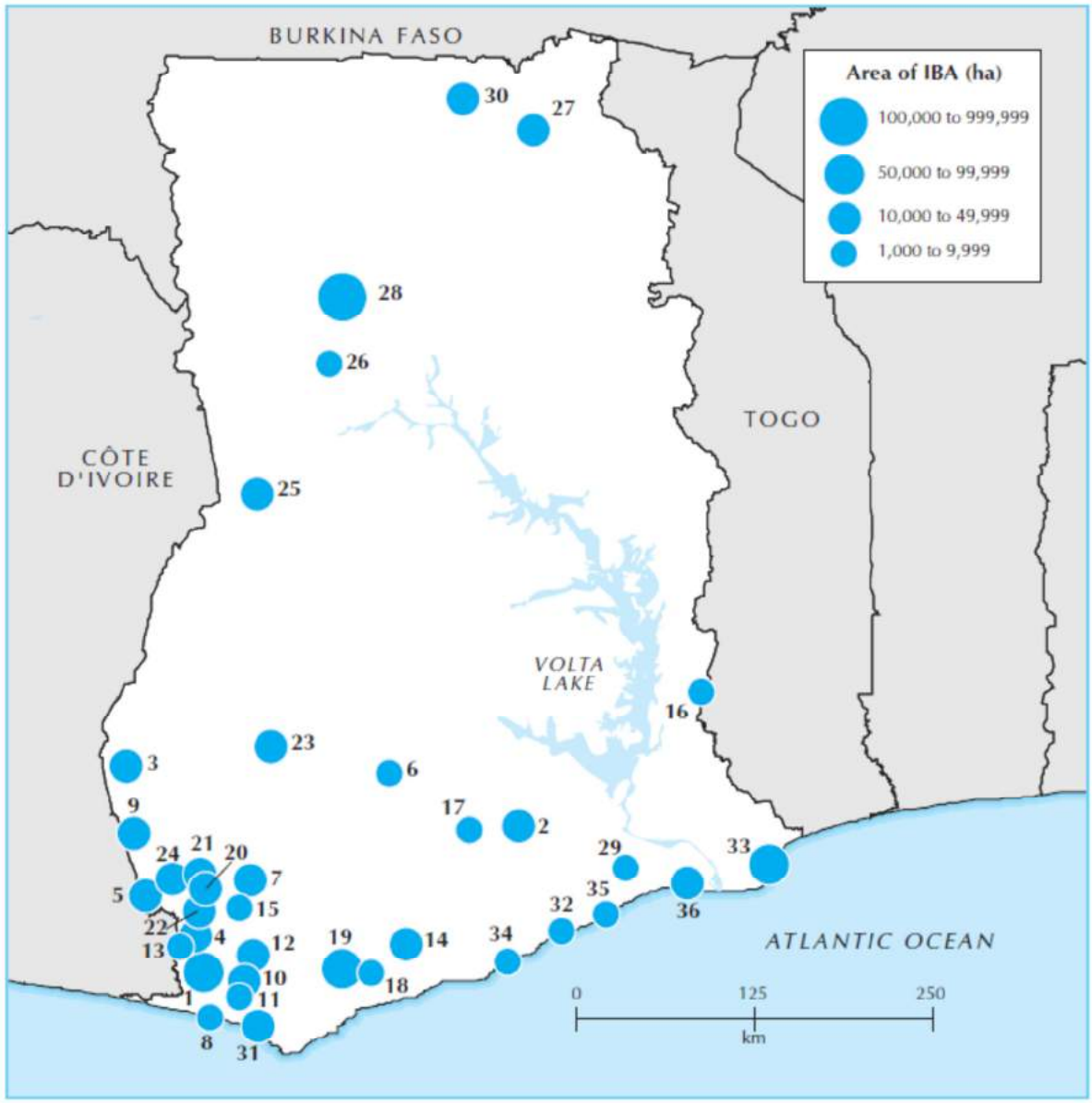
Appendix D – Map of forest reserves and GSBAs in Ghana

Globally Significant Biodiversity Areas (GSBA's) are indicated in red. Please note that complete reserves are indicated as GSBA, while in reality the GSBA's are determined per compartment. Tain II FR is located just North of Sunyani, near the border with Ivory Coast.



Appendix E – Map of Important Bird Areas in Ghana

Important Bird Areas (IBA's) are depicted with a blue dot. Tain II FR is located in the triangle between 25. Bui National Park, 23. Tano Offin FR and 3. Bia National Park.



Source: Ntiamoa-Baidu *et* al., 2001.

Appendix F – Encountered fauna species in Tain II FR

Table 3. *Mammals and reptiles encountered in Tain II FR.*

Category	Species	Scientific name	Teak	Degraded	Forest	Farm-land
Carnivores	Civet	*Civettictis civetta*	1		20	1
	Cusimanse Mongoose	*Crossarchus obscurus*			54	
	Genet	*Genetta tigrina*	2		35	
	Marsh Mongoose	*Atilax paludinosus*	2	3	33	
Reptiles	Cobra	*Naja melanoleuca*	10	17	17	20
	Green Mamba	*Dendroaspis viridis*	5	8	9	15
	Monitor Lizard	*Varanus niloticus*			10	1
	Puff Adder	*Bitis arietans*			1	4
	Rock Python	*Python sebae*	2	1		1
	Royal Python	*Python regius*	1	2	1	1
Rodents	Brush-tailed Porcupine	*Antherurus africanus*	7	7	98	14
	Giant Rat	*Cricetomys gambianus*		3		7
	Grasscutter	*Thryonomys swinderianus*	19	39	2	71
	Ground Squirrel	*Euxerus erythropus*	1			3
Ungulates	Bushbuck	*Tragelaphus scriptus*	9	44	72	9
	Maxwell duiker	*Cephalophus maxwelli*		10	108	
	Red River Hog	*Potamochoerus porcus*			37	
	Royal Antelope	*Neotragus pygmaeus*			9	

***Table 4**. Birds encountered in Tain II FR.*

Family	Common name	Scientific name
Accipitridae	Yellow billed kite	*Milvus aegyptius*
Alcedinidae	African Pygmy Kingfisher	*Ispidina picta*
Apodidae	African Palm Swift	*Cypsiurus parvus*
Bucerotidae	African Grey Hornbill	*Tockus nasutus*
	African Pied Hornbill	*Tockus fasciatus*
Capitonidae	Red-rumped Tinkerbird	*Pogoniulus atroflavus*
	Yellow-billed Barbet	*Trachyphonus purpuratus*
Cisticolidae	Zitting Cisticola	*Cisticola juncidis*
Columbidae	Blue-headed Wood Dove	*Turtur brehmeri*
	Green Fruit Pigeon	*Treron calva*
	Laughing Dove	*Streptophelia senegalensis*
	Red-eyed Dove	*Streptophelia decipens*
	Tambourine Dove	*Turtur tympanistria*
Coraciidae	Blue-throated Roller	*Eurystomus gularis*
	Broad-billed Roller	*Eurystomus glaucurus*
Cuculidae	Grey-headed Bristlebill	*Bleda canicapilla*
	Klaas Cuckoo	*Chrysococcyx klaas*
	Senegal Coucal	*Centropus senegalensis*
	Yellowbill	*Ceuthmochares aereus*
Dicruridae	Fork-tailed Drongo	*Dicrurus adsimilis*
	Shining Drongo	*Dicrurus atripennis*
Estrildidae	Bronze Manikin	*Spermestes cucullata*
	Grey-crowned Negro-Finch	*Nigrita canicapilla*
	Lavender Fire-Finch	*Estrilda caerulescens*
	Orange-cheeked Waxbill	*Estrilda melpoda*
Falconidae	Grey Kestrel	*Falco ardosicicens*
Meropidae	White-throated Bee-eater	*Merops albicollis*
Muscicapidae	Black and White Flycatcher	*Ficedula hypoleuca*
	Northern Black Flycatcher	*Melaenornis edolioides*
	Pale Flycatcher	*Bradornis pallidus*
	Paradise Flycatcher	*Tersphone viridis*
	Red-bellied Paradise Flycatcher	*Tersiphone rufiventer*
Musophagidae	Green Turaco	*Tauraco persa*
Nectariniidae	Collared Sunbird	*Anthreptes collaris*
	Copper Sunbird	*Cinnyris cupreus*
	Little Green Sunbird	*Nectarinia seimundi*
	Superb Sunbird	*Nectarinia superba*
Paridae	White-shouldered Black Tit	*Parus guineensis*
Phasianidae	Ahanta Francolin	*Francolinus ahantensis*
Phoeniculidae	Black scimitarbill	*Rhinopomastus aterrimus*

	Green Wood Hoopoe	*Phoeniculus purpureus*
Picidae	Cardinal Woodpecker	*Dendropicos fuscescens*
	Fire-bellied Woodpecker	*Dendropicos pyrrhogaster*
Ploceidae	Black headed Weaver	*Ploceus melanocephalus*
	Black-winged Bishop	*Euplectes hordeaceus*
	Grey-headed Sparrow	*Passer griseus*
	Northern Red Bishop	*Euplectes franciscanus*
	Pin-tailed Whydah	*Vidua macroura*
	Red-collared Widowbird	*Euplectes ardens*
	Red-headed Bishop	*Anaplectes melanotis*
	Viellot's black Weaver	*Ploceus nigerrimus*
	Yellow Mantled Widow Bird	*Euplectes macroura*
Pycnonotidae	Common Bulbul	*Pycnonotus barbatus*
	Grey-headed Bristlebill	*Bleda canicapilla*
	Honeyguide Greenbull	*Baeopogon indicator*
	Icterine Greenbul	*Phyllastrephus icterinus*
	Little Greenbul	*Andropadus virens*
	Simple leaflove	*Chlorocichla simplex*
Sylviidae	Grey-backed Camaroptera	*Camaroptera brachyuran*
	Olive-green Camaroptera	*Camaroptera chloronota*
	River Prinia	*Prinia fluviatilis*

Table 5*. Frog species encountered in Tain II FR.*

	Scientific Name	Local Name	Number of Individuals
1	*Afrixalus dorsalis*	Striped Spiny Reed Frog	5
2	*Arthroleptis spp*	Crowned bullfrog	11
3	*Hoplobatrachus occipitalis.*		4
4	*Hyperolius concolor*		2
5	*Hyperolius fusciventris*		1
6	*Hyperolius guttulatus*		4
7	*Hyperolius nitidulus*		3
8	*Hyperolius picturatus*		2
9	*Kassina senegalensis*	Senegal kassina	2
10	*Leptopelis spiritusnoctis*		3
11	*Phrynobatrachus calcaratus*		6
12	*Phrynobatrachus gutturosus*		11
13	*Phrynobatrachus latifrons*		7
14	*Phrynobatrachus plicatus*		1
Total	14		62

Appendix G – Encountered vegetation species in Tain II FR

Table 6. Density of flora species in the study area

Family/ Scientific Name	Local Name	Life Form	Density (trees/ha)	Relative Density	Local Status
ASTERACEAE (COMPOSITEAE)					
Chromolaena odorata	Acheampong	Herb	19%	>100	Widespread
ANACARDIACEAE					
Anacardium occidentale	Cashew	Tree	12	0.22	Rare
BIGNONIACEAE					
Newbouldia leavis	Sesamasa	Tree	60	1.10	Uncommon
Spathodea campanulata	Kuokuonisuo	Tree	20	0.37	Rare
COMBRETACEAE					
Terminalia avicennoides	Petrii	Tree	20	0.37	Rare
Terminalia glaucascens	Ongo	Tree	8	0.15	Rare
Terminalia superba	Ofram	Tree	8	0.15	Rare
Anogeissus lerocarpus	Kane	Tree	40	0.74	Rare
CAESALPINIOIDEAE					
Afzelia africana	Paopao	Tree	12	0.22	Rare
EUPHORBIACEAE					
Alchornea cordifolia	Gyama	Shrub	16	0.29	Rare
Mallotus oppositifolius	Satadua	Shrub	28	0.52	Rare
Mareya micrantha	Odubrafo	Tree	4	0.07	Rare
Margaritaria discoidea	Pepea	Tree	44	0.81	Rare
Ricinodendron heudelotii	Wama	Tree	32	0.59	Rare

FABACEAE (LEGUMINOSAE-MIM)					
Albizia adianthifolia	Pampena	Tree	196	3.61	Abundant
Albizia ferruginea	Ewiemfo Samina	Tree	56	1.03	Uncommon
Albizia zygia	Okro	Tree	44	0.81	Rare
Centrosema plumieri	Centrosema	Herb	5%	>100	Widespread
Griffonia simplicifolia	Kagya	Shrub	32	0.59	Rare
Erythrophleum suaveolens	Potrodom	Tree	36	0.66	Rare
LEGUMINOSAE-CAES.					
Anthonotha macrophylla	Totoro	Tree	28	0.52	Rare
LEGUMINOSAE-MIM					
Piptadeniastrum africanum	Dahoma	Tree	4	0.07	Rare
Senna siamea	Cassia	Tree	32	0.59	Rare
Tetrapleura tetraptera	Prekese	Tree	24	0.44	Rare
LEGUMINOSAE-PAP					
Dalbergia hostilis	Wota	Tree	20	0.37	Rare
Milletia zechiana		Shrub	44	0.81	Rare
Millethia rhodantha	Tetetoa	Shrub	44	0.81	Rare
Mucuna pruriens	Apea	Shrub	4	0.07	Rare
MALVACEAE(BOMBACACEAE)					
Ceiba pentandra	Onyina	Tree	24	0.44	Rare
Bombax brevicuspe	Onyina Koben	Tree	40	0.74	Rare
Bombax buonopozense	Akonkodie	Tree	24	0.44	Rare
MALVACEAE (STERCULIACEAE)					
Cola gigantea	Watapuo	Tree	124	2.28	Common
Cola milleuii	Ananse Dodewa	Shrub	36	0.66	Rare
Mansonia altissima	Oprono	Tree	8	0.15	Rare

Sterculia rhinopetala	Wawabima	Tree	8	0.15	Rare
Sterculia tracagantha	Sofo/Foto	Tree	36	0.66	Rare
Triplochiton scleroxylon	Wawa	Tree	40	0.74	Rare
MELIACEAE					
Khaya anthotheca	White Mahogany	Tree	16	0.29	Rare
Trichilia prieureana	Kakadikro	Tree	20	0.37	Rare
MORACEAE					
Antiaris toxicaria	Kyenkyen	Tree	80	1.47	Uncommon
Ficus anomani	Odoma	Tree	24	0.44	Rare
Ficus capensis	Kotre Amforo	Tree	20	0.37	Rare
Ficus exasperata	Nyankyere	Tree	308	5.67	Widespread
Morus mesozygia	Wonton	Tree	56	1.03	Uncommon
Milicia excelsa	Odum	Tree	40	0.74	Rare
PALMAE					
Elais guineense	Abe	Tree	44	0.81	Rare
POACEAE					
Pennisetum purpureum	Elephant grass	Grass	26%	>100	Widespread
Pannicum maximum	Guinea grass	Grass	40%	>100	Widespread
SAPINDACEAE					
Blighia sapida	Akyee	Tree	40	0.74	Rare
Lecaniodiscus cupanioides	Dwendwera	Shrub	20	0.37	Rare
Paullinia pinnata	Toatin	Herb	28	0.52	Rare
ULMACEAE					
Celtis mildbraedii	Esafufuo	Tree	16	0.29	Rare
Trema orientalis	Sesea	Tree	56	1.03	Uncommon

SAPOTACEAE					
Aningeria altissima	Asamfinanini	Shrub	56	1.03	Uncommon
Chrysophyllum delevoyi	Akasaa	Tree	16	0.29	Rare
GENTIANACEAE					
Anthocleista vogelii	Bontodie	Tree	36	0.66	Rare
APOCYNACEAE					
Holarrhena floribunda	Sese	Tree	64	1.18	Uncommon
RUBIACEAE					
Morinda lucida	Konkroma	Tree	12	0.22	Rare
Nauclea latifolia	Sresokusia	Shrub	16	0.29	Rare
CECROPIACEAE					
Myrianthus arboreus	Nyankuma	Tree	20	0.37	Rare
VERBENACEAE					
Tectona grandis	Teak	Tree	3240	59.60	Widespread
Number of Species	61				

Relative Density: 0.00-0.99 (rare); 1.00-1.99 (uncommon); 2.00-2.99 (common); 3.00-3.99 (abundant); =>4.00 (widespread)

NB: Density for herbs and grasses are estimated in percentages and hence, have not been included in the relative density calculations