



# Forest Management Plan

Tain Tributaries Block II Forest Reserve,  
Ghana



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## FOREWORD

Form Ghana is proud with the acquisition of the land lease covering nearly 15,000 hectares in Tain II Forest Reserve. This allows an expansion of our reforestation activities in partnership with Ghana's Forestry Commission. We can build upon the experience gained from the reforestation of Asubima and Afrensu Brohuma Forest Reserve that was realised between 2008 and 2012. Form Ghana now aims at reforesting 20,000 ha of degraded Forest Reserves in Ghana.



**Figure x.1.** Overview Tain II Forest Reserve.

I am pleased to present you this management plan for the areas in Tain II Forest Reserve managed by Form Ghana. In the near future, FSC™ certification as well as VCS verification will be strived for, like is now the case for the reforested areas in Asubima and Afrensu Brohuma Forest Reserve managed by Form Ghana. Therefore, in Tain II Forest Reserve, we adopted responsible and sustainable practices from the start. I am confident that this management plan forms a solid basis to establish a sustainable forest plantation.

Our major challenge now, is building and maintaining good relations with surrounding communities.

Form Ghana Ltd.

Mr. Willem Fourie  
Chief Executive Officer

## LIST OF ABBREVIATIONS

DBH	Diameter at Breast Height
FC	Forestry Commission
FORIG	Forestry Research Institute of Ghana
FR	Forest Reserve
FSC™	Forest Stewardship Council
FSD	Forestry Services Division (part of FC)
Ha	hectares
Kg	kilogram
M	meter(s)
Mm	millimetre(s)
NTU	Nephelometric Turbidity Unit
PPP	Public Private Partnership
PSP	Permanent Sample Plot
Pt/Co	Platinum and Cobalt scale
VCS	Verified Carbon Standard

## INTRODUCTION

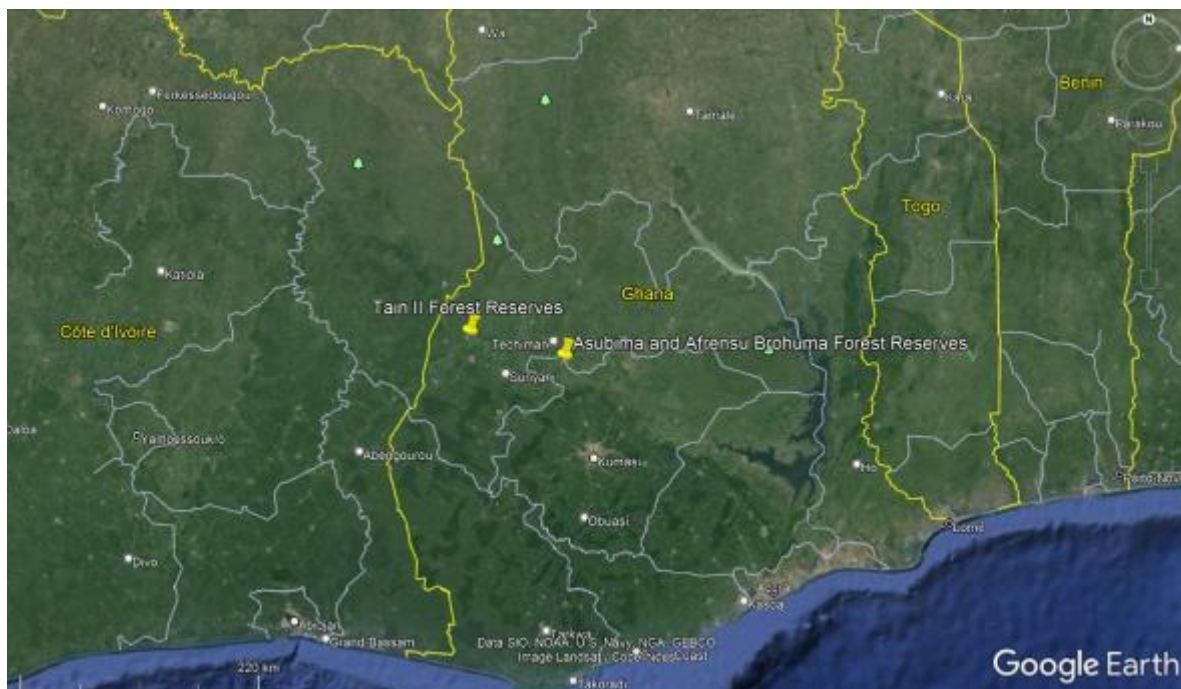
### Ghana's forest and timber industry

Ghana's forest area has been reduced in previous decades, due to land use change in community areas for agriculture, over-exploitation and encroachment of its forest reserves. Efforts are now being made to slow and at least reverse some of these losses.

Forest Reserves are managed by the Forestry Services Division of the Forestry Commission. Harvesting of indigenous forests and state-owned plantations is carried out under logging concessions by private companies. Ghana has made considerable efforts towards bringing her natural forests under sustainable management. The National Forest Plantation Development Programme (NFPDP) aims at reforestation of degraded Forest Reserves and private lands via multiple strategies, among others through land leases and benefit sharing agreements with private investors. Ghana has also identified the Transitional and Forest Zones as being threatened in their priority interventions identified in their AFR100 commitments, with commitments to restore 2 million hectares of land under these commitments.

### Reforestation by Form Ghana

Form Ghana Ltd. is owned by Sustainable Forestry Investments the Netherlands (SFI NL) and based in central Ghana. The company was established in 2007 and has since then been active in the north of the Ashanti Region, near Akumadan, where the company had started to reforest the highly degraded Asubima and Afrensu Brohuma Forest Reserves in 2008 and 2011 respectively. Further to this it is current restoring areas in Tain II Forest Reserve, near Berekum in the Bono Region. (See Map 1 below).

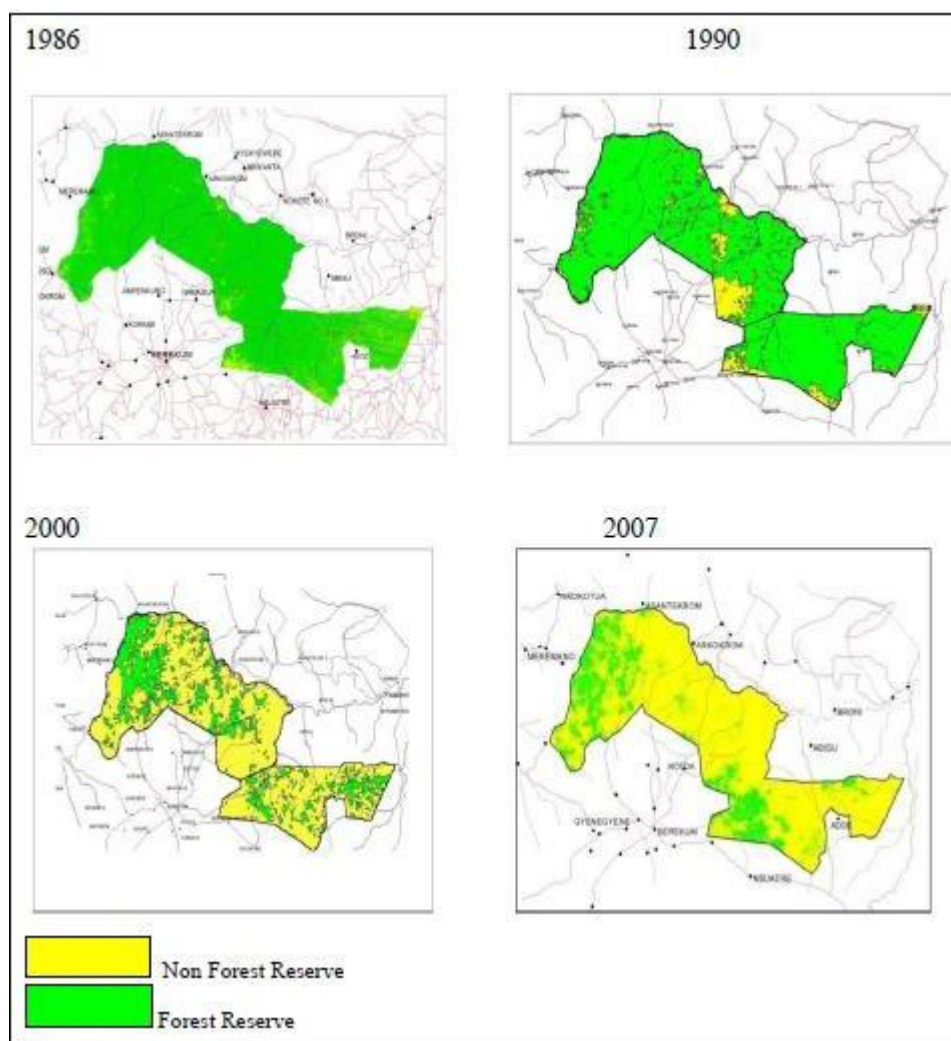


Map 1: Location of From Ghana plantations in Ghana

For the Tain II Forest Reserve, a Public Private Partnership (PPP) has been established between Ghana's Forestry Commission, the local landowners and Form Ghana (the private



investor). Historical Management Plans dating back to the 1980's indicate that Tain II was in a highly degraded state and considered further management to plantations as part of the objectives at that time. The goal of the PPP is aligned with these historical objectives for the Forest Reserve to increase the amount of commercial reforestation in the degraded forest reserves of Ghana. A lease was obtained from the Forest Service Division of the Forestry Commission for 14576 hectares of degraded forest land in the Tain II Forest Reserve that are favourable for growing teak. In areas where Form Ghana has not yet taken full management control (planting and forest maintenance) the Forestry Commission of Ghana still undertakes prevention of illegal activities control, and Form Ghana provides fire management and control activities. Each year, Form Ghana advises the Forestry Commission on new areas within the reserve where Form Ghana will take formal control and start restoration and development activities.



**Figure 1.1.** Forest cover Tain II FR from 1986 – 2007. Source: Kosoe, 2012.

Within the partnership, every party has their own specific responsibilities. The Forestry Commission provides assistance on specific activities such as demarcation, mapping, fire sensitization of communities, yield marking and monitoring. The local landowners provide access to land and the private investor is responsible for the provision of all further financial, management and technical inputs of the plantation establishment.

A benefit sharing agreement has been signed between the three parties in the PPP, see section 10.3.

## Management of timber plantation in Tain II FR

### ***Management plan***

Form Ghana Ltd. (Form Ghana) has elaborated a reforestation plan for the establishment of a commercial timber plantation in the Tain Tributaries Block II Forest Reserve (further referred to as Tain II FR), which after submission has been approved by the Forestry Commission of Ghana. However, since the reforestation plan is too general to work with in the field, Form Ghana has elaborated a management plan for the company's reforestation activities in Tain II Forest Reserve.

This Management Plan describes the management system of Form Ghana Ltd., based on the FSC™ Principles and Criteria, includes the following topics:

- An overview of the physical environment (climate, water and soil condition, biodiversity, etc.) and social-economic environment (village facilities, occupation, level of education, housing and transportation etc.) of Tain II FR.
- The forest management objectives, elaborating on each of the three sustainability pillars (ecological, economic and social) and it describes the way land-use is impacted on the long-term
- The organization of the managed areas including the plantation infrastructure and field planting program
- The tree species selection and forest type allocation
- Tree nursery practices
- The various silvicultural practices that will be carried out during the entire plantation rotation cycle
- Risk management, including prevention of illegal activities, fire management and control of pests
- A social plan that covers the involvement of stake-holders, benefit sharing, employment and intercropping by local farmers
- Environmental management, concentrating on soil and water, biodiversity and High Conservation Value Forests
- The various monitoring activities

A number of studies and reports was used as input for this Management Plan, each based on relevant preliminary studies of the area:

- The Reforestation Plan of Tain II Forest Reserve
- The Social and Environmental Impact Assessment (SEIA) report for Tain II Forest Reserve
- The High Conservation Value Forest analyses of Tain II Forest Reserve and updates.
- The Terrestrial Fauna Study, Form Ghana, Forest Restoration, Tain II Reserve, November 2021

### ***Management procedures and stand sheets***

Complementary to the Management Plan, Form Ghana uses a system of separate protocols that describe the processes of environmental and social management. A list of the protocols is included in Annex A of this Management Plan. Throughout the management plan, reference will be made to these protocols.

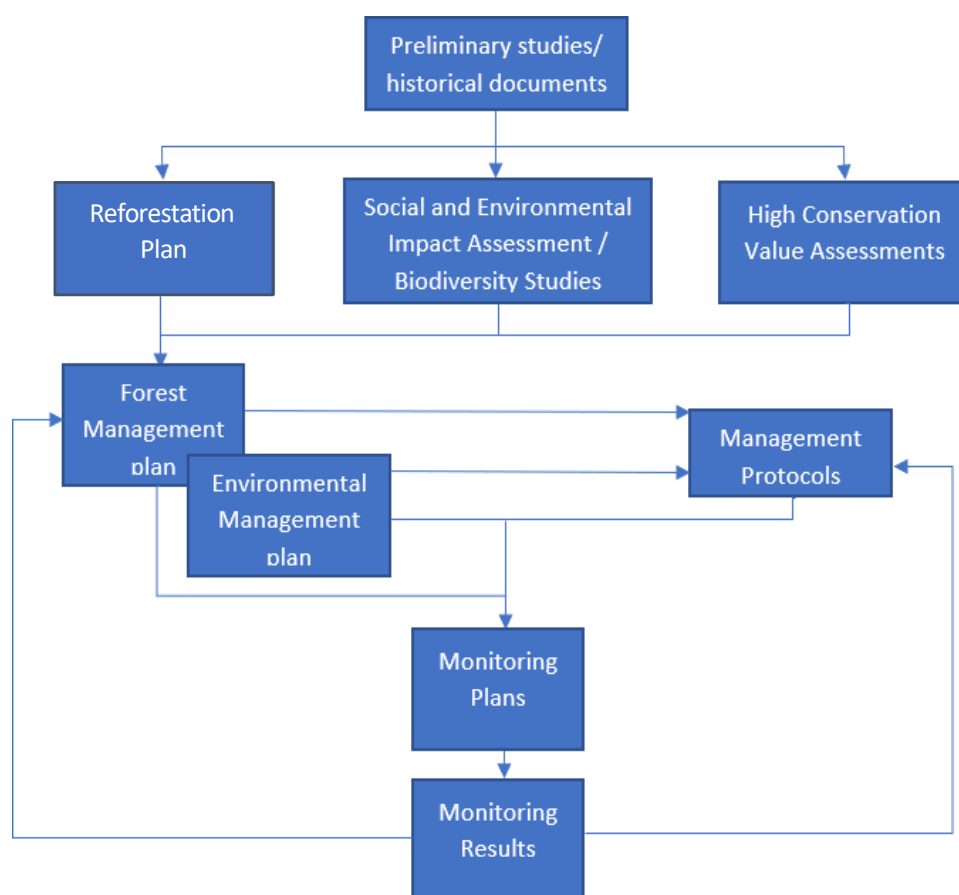
Also, there are stand sheets which are filled in or updated every planting year. These stand sheets form the basis of the operational management plan (see chapter 13). They describe the area planted per year and the way in which that area will be managed specifically. They are important to keep track of the stands and to conserve information through time. For an example see Annex B.



## Monitoring

Management is a continuous process. This means that it will be adapted over time as a consequence of changes in the field or new insights. To keep track of these management changes, Form Ghana applies a monitoring system which involves annual information gathering on plantation growth and condition, social impact, soil and water protection and biodiversity (see chapter 12).

The effectiveness of management is checked annually through monitoring activities. The Management Plan and Protocols serve as input for the monitoring system. Findings from monitoring activities are fed back into the management system through the adaptation of protocols or management plans. The process of evaluation and adaptation will lead to further fine-tuning of the management plan. The relations between the various documents is described in the schedule below (figure 1.2).



**Figure 1.2.** Links between various documents

### ***Validity of management plan***

As is mentioned in the section above, the management plan is updated every year to incorporate new information from the field. Every year during the dry season, the plan is closely compared with the current situation in Tain II FR. If the field situation has changed, the management plan is adapted accordingly. Likewise, information from monitoring is used to update the management plan (if the nature of the information dictates so).

## **Report structure**

This management plan first introduces the company Form Ghana Ltd and the sustainability approach taken (Ch. 2). Then, in chapter 3 an overview is presented of the physical environment (climate, water and soil condition, biodiversity, etc.) and social-economic environment (village facilities, occupation, level of education, housing and transportation etc.) of Tain II FR.

Chapter 4 states the forest management objectives elaborating on each of the three sustainability pillars (ecological, economic and social) and it describes the way land-use is impacted on the long-term. The organisation of the managed areas is presented in chapter 5 including the plantation infrastructure and field planting program. The tree species selection and forest type allocation is described in chapter 6, followed by the tree nursery practices in chapter 7. Chapter 8 gives a full description of the various silvicultural practices that will be carried out during the entire plantation rotation cycle.

Chapter 9 is devoted to risk management including prevention of illegal activities, fire management and control of pests. The social plan (chapter 10) covers the involvement of stakeholders, benefit sharing, employment and intercropping by local farmers. Environmental management, concentrating on soil and water, biodiversity and High Conservation Value Forests, is covered in chapter 11. The various monitoring activities are described in chapter 12. Finally, the set up and maintenance of the operational management plan are discussed in chapter 13.

## COMPANY

Form Ghana Ltd. is a forest plantation management company, based in central and Western Ghana (Figure 1). The company was established in 2007. The core business of Form Ghana is the restoration of some of Ghana's Forest Reserves as part of the Ghana government's strategic plans for these Forest Reserve areas. This will be achieved through the establishment and management of sustainable forest plantations to restore land, carbon sinks and strategic timber resources and the restoration and protection of indigenous forest areas, in degraded forest reserves. These areas used to be productive semi-deciduous forest ecosystems until overexploitation, bush fires and illegal conversion to agricultural land caused severe degradation of the land and natural resources prior to Form Ghana acquiring management control of the areas.

This chapter first elaborates on the core value of Form Ghana: sustainability. Directly linked to that, paragraph 2.2 is about the corporate social responsibility of Form Ghana. Then, in paragraph 2.3 details are given of the legal compliance of Form Ghana, the organizational structure is presented in 2.4 and the infrastructure is briefly described in paragraph 2.5.

## Sustainability

Form Ghana envisions carrying out its activities in a social, ecological and economical responsible way. The figure below gives an overview of Form Ghana's unique sustainability concept that is applied in all the plantation units managed by Form Ghana.

### The unique sustainability concept of Form Ghana

Social	Ecological	Economical
<ul style="list-style-type: none"> <li>• Landlease instead of purchase</li> <li>• Creating local employment</li> <li>• Intercropping by local farmers</li> <li>• Trainings and good working conditions for employees</li> <li>• Revenues partly return to local community</li> <li>• Stimulate outgrowing</li> </ul>	<ul style="list-style-type: none"> <li>• Reforestation of degraded land</li> <li>• &gt;5% of the planted seedlings are local species</li> <li>• Conservation and restoration of bufferzones along waterways</li> <li>• Enhance biodiversity</li> <li>• Restore water and soil quality</li> <li>• Positive influence on global carbon balance</li> </ul>	<ul style="list-style-type: none"> <li>• Respond to declining supply and growing demand for sustainable timber</li> <li>• Boost local economy</li> <li>• Yield much higher and harvesting cycle shorter than natural forest</li> <li>• Main tree species teak is highly profitable</li> <li>• Periodic revenues due to annual planting</li> <li>• Besides timber, income generation from carbon credits</li> </ul>

High quality on a technical as well as on a social and environmental level is the key to success for Form Ghana. This has resulted in FSC™ (<https://ic.fsc.org>) certification for responsible forest management in 2010 on the Akumadan plantation and validation of a reforestation carbon project under the Verified Carbon Standard (VCS) since 2013. 'Under VCS, projects are issued unique carbon credits known as Verified Carbon Units or VCUs. Each VCU represents a reduction or removal of one ton of carbon dioxide equivalent (CO<sub>2</sub>e), which can be generated by reducing or removing greenhouse gases.' ([www.v-c-s.org](http://www.v-c-s.org))

On the next page, the sustainability policy of Form Ghana is presented. In the following chapters these aspects will be elaborated in detail for the Tain II FR.

### **Sustainability Policy of Form Ghana Ltd.**

Form Ghana commits itself to manage its plantations in a responsible and socially, environmentally and economically sustainable way. To this end, it strives to operate in compliance with the Principles and Criteria of the Forest Stewardship Council (FSC™)

In this way, the company will contribute significantly to the environment, the Ghanaian economy and to the quality of life of people related to and in the direct vicinity of the company. High quality on a technical as well as on a social and environmental level is the key to success for Form Ghana.

Form Ghana offers its employees a safe and healthy working environment, with good employment terms, favourable insurance policy conditions and pension build-up. Besides employment, local people can benefit indirectly from the activities of Form Ghana, through revenue sharing.

Form Ghana aspires to conserve and restore biological diversity, water sources, and fragile ecosystems found in or near its plantations. Plantations will be managed in such a way that they will contribute to climate change mitigation by having a positive influence on the global carbon balance.

The production from forest plantations certified for sustainable management will ensure the enhancement of the local economy and a guaranteed timber supply for the forest industry.

Form Ghana will operate with respect to Ghanaian laws as well as the international conventions valid in Ghana.

## **Corporate Social Responsibility**

Form Ghana aspires to continue meeting the standards of the Forest Stewardship Council (FSC™). Besides technical performance, Form Ghana has a policy for the corporate social responsibility.

### **Corporate Social Responsibility Policy of Form Ghana Ltd.**

#### *Code of conduct*

Form Ghana will uphold and / or develop cultural values by respecting local customs and maintaining good relations with the local chiefdoms.

Form Ghana will not allow any form of discrimination to take place on the premises. Discrimination based on race, sex, sexual preference, age or religion is explicitly prohibited at Form Ghana.

#### *Employment*

At Form Ghana all labour is voluntary and regulated by contracts that were negotiated in freedom. No forced labour shall take place on Form Ghana premises.

At Form Ghana there shall be no child labour. No people are employed that are less than 18 years of age.

There is a preference to employ people from the neighbouring towns and villages to stimulate the local economy. If specific expertise/ background is not available locally, Form Ghana will employ people from elsewhere. Employees are preferably housed in their own houses. The company organises the

transport from a central collecting point to the nursery and the plantation. For staff living outside the area the company will provide appropriate lodging facilities.

Workers receive the training necessary to adequately perform their jobs. Most of this training is on the job and repeated annually. In some cases, special schooling may be awarded when deemed necessary by the management.

#### *Payment*

Workers will receive at least the nationally agreed minimum wage. For the permanent staff this salary can be transferred to the respective bank accounts of the employees or be paid cash. For temporary workers payment will be in cash.

Form Ghana pays the SNITT for the permanent workers as is due.

Form Ghana offers a possibility for a loan to permanent workers.

#### *Worker's unions*

At Form Ghana the employees have all rights for organization and collective negotiations.

A Consultative structure exists consisting of worker representatives who meet with management on a monthly basis.

#### *Safety*

Form Ghana has performed a health and safety analysis in the workplace. Based on this analysis, a schedule of safety equipment has been drawn up. This equipment is provided to the relevant workers.

Form Ghana provides water from a tested source for its employees.

Form Ghana has a first aid centre with a trained nurse. Employees are trained in providing first aid annually. Also, there is an agreement with the Holy Family hospital in Techiman and the Holy Family Hospital in Berekum, so that injured workers of Form Ghana will be admitted immediately and paper work is arranged later. Workers who have fallen ill can have their medical expenses refunded against presentation of the bills of medicines and a doctor's order for these same medicines.

Form Ghana insures the permanent workers through the national health insurance programme. This insurance covers the medical costs of workers and their families.

#### *Local farmers*

Form Ghana collaborates with farmers through, among others, the following arrangements:

- Providing farmers with temporary access to farm land within the plantation according to specified criteria and options set by Form on a sustainable basis (this concerns intercropping).
- Provide training in bush fire prevention and fighting for the fringe communities.
- Transparent benefit sharing with relevant stakeholders.

## Legal compliances

Form Ghana Ltd. is officially established in Ghana through documents CA-387,338/2421 (registration certificate), CA-37,338 (certificate of incorporation) and CA-37,338 TIN 824VO25997 (certificate to commence business).

In 2013, Form Ghana has obtained a lease for 110 compartments in Tain II Forest Reserve, for the duration of 50 years (renewable). These are: 30-32, 34-38, 42-52, 54-63, 65-74, 76 92, 99, 102-104, 108, 110-115, 118-126, 135, 136 and 138-140 (block A, 81 compartments),

193, 205, 207, 216-224 and 226 (block B, 13 compartments) and 150-152, 155, 157, 158, 160, 162, 182, 183, 185-188, 212 and 213 (block C, 16 compartments), see figure 5.1.

Form Ghana implements its activities according to the applicable national legislation and international conventions. Protocol P01 describes in detail how this is realized by the company

## Infrastructure

### **Offices**

Form Ghana has offices in three locations. One office is built in Akumadan near the plantations established in Asubima FR and Afrensu Brohuma FR. Another office is located in Kotaa near the Tain II FR. Finally, there is an office located in Sunyani.



**Figure 2.2.** Office in Sunyani

### **Workshops and Stores**

Workshops and stores have been established near the plantations at the Akumadan and Kotaa Office sites.



## CHARACTERISATION OF THE ENVIRONMENT

In this chapter some background information is given on the project area. First, the physical environment is described (climate, soils, topography, hydrography, vegetation and fauna) followed by the social characteristics (household size, age & occupation, housing & transportation, ethnicity & religion, village facilities, level of education, health and farming practices). Information included in this chapter is obtained from the Social and Environmental Impact Assessment by Tollenaar (2013) unless otherwise specified.

Form Ghana operates in three historically degraded forest reserves in Ghana, Tain II is covered by this plan (Figure 2), and is situated in transitional zone between the dry semi- deciduous and savannah zones falling under the authority of the Forestry Commission in the Sunyani Forest District

Below, a map is shown of the Tain II Forest Reserve and the area managed by Form Ghana is depicted in green.

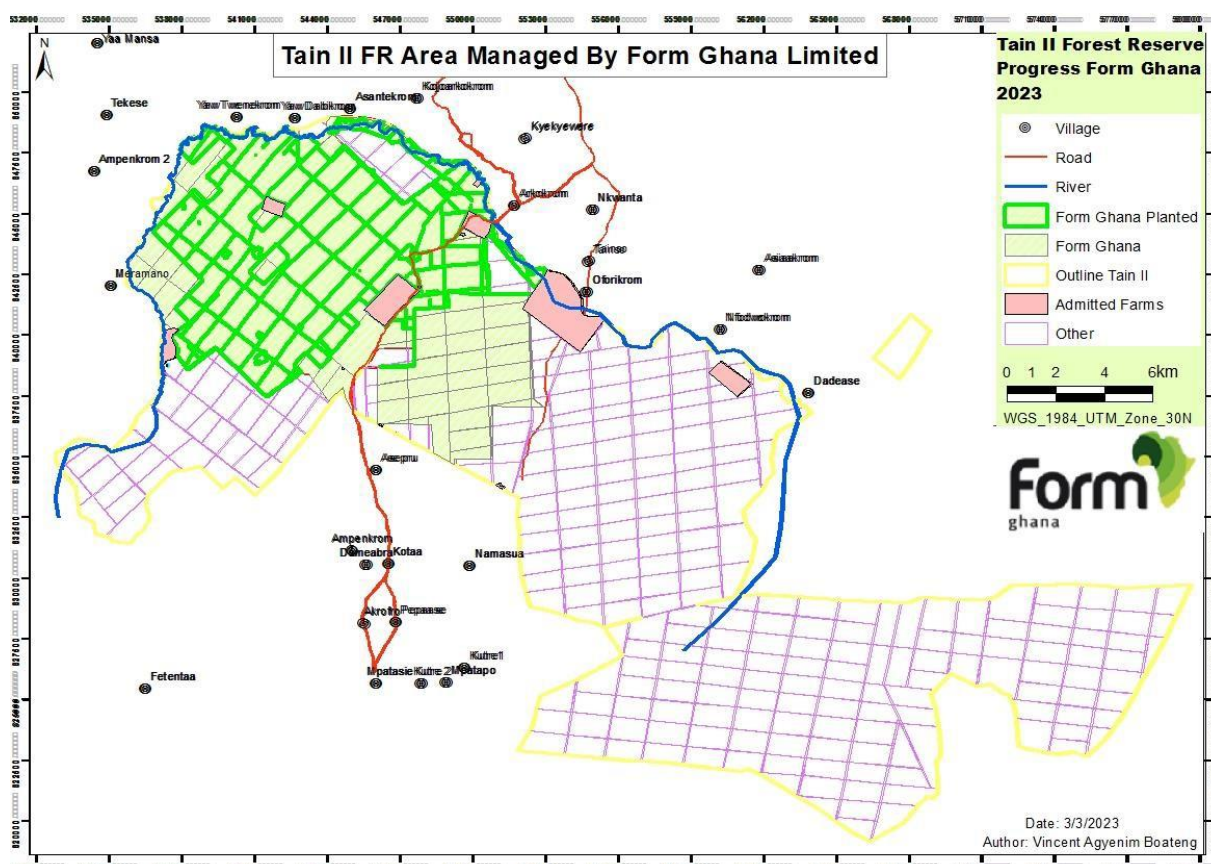
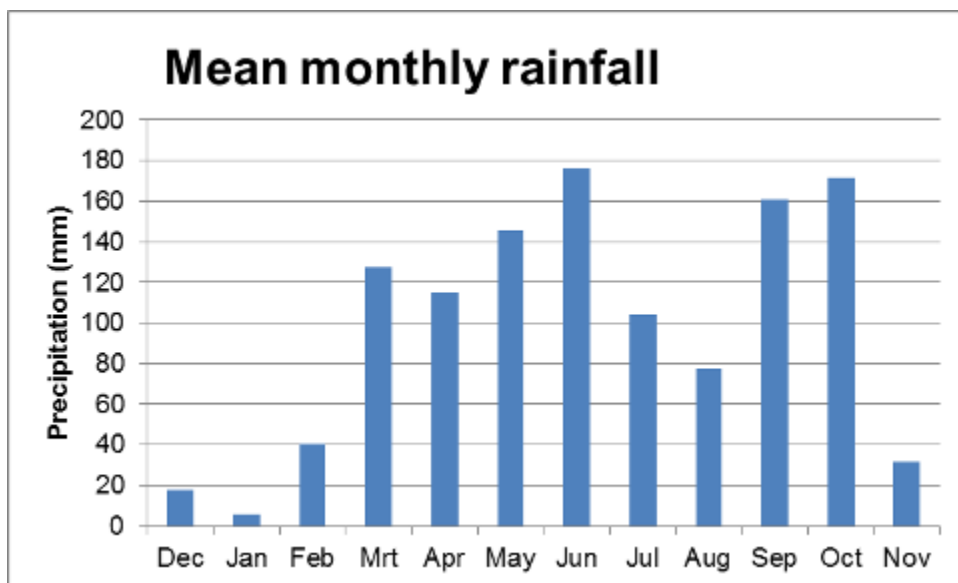


Figure 3.1. Map Tain II FR area managed by Form Ghana as at 2022.

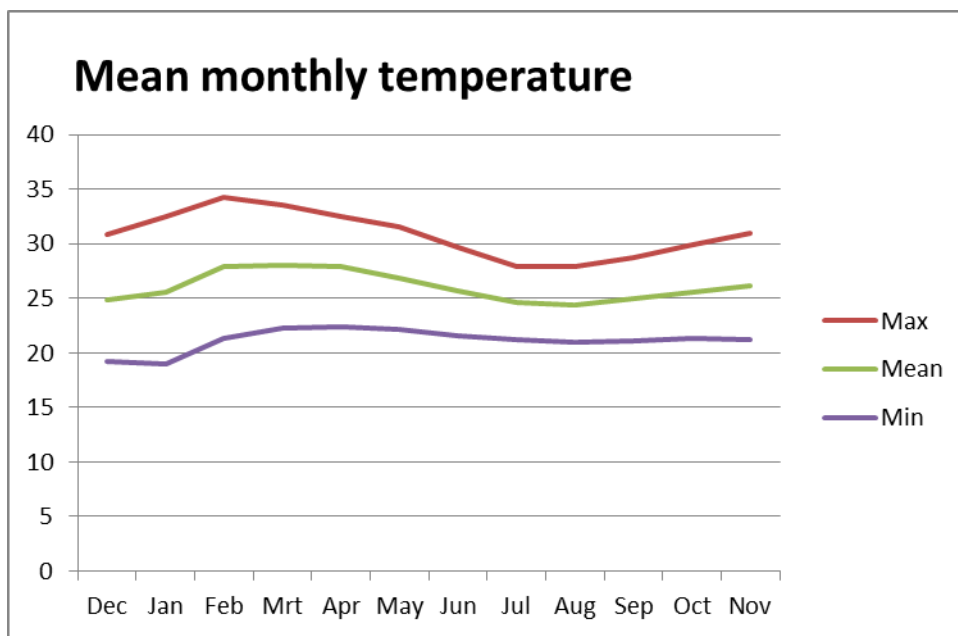
## Physical environment

### 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 1200 mm and the minimum and maximum 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.



**Figure 3.2.** Mean monthly rainfall in Sunyani measured over thirty years. Source: reforestation plan, 2013.



**Figure 3.3.** Mean monthly temperature in Sunyani measured over thirty years. Source: reforestation plan, 2013.

## Soils

The soil survey by Scholten *et al.* (2013) exposed five different soil series present in the area: Bekwai, Nzima, Kokofu, Oda and Wenchi, three of which are suitable for teak cultivation, despite a relatively low nutrient content (table 3.1). The Wenchi soil series are unsuitable due to limitations in depth and presence of stones, gravels and iron pan. The Oda soil series are marginally suitable due to restrictions in drainage capacity (Scholten *et al.*, 2013).

**Table 3.1. Soil series found in Tain II Forest Reserve. Source: Scholten *et al.*, 2012.**

Soil series	Suitability	Constraints	Favourable	Ha	Cover
<b>Bekwai series</b>	High	Low nutrient content	Drainage and soil depth	718	4.93%
<b>Nzima series</b>	High	Low nutrient content	Drainage and soil depth	1,883	12.92%
<b>Kokofu series</b>	Moderate	Internal drainage	Deep topsoil with humus up to 35 cm depth.	9,639	66.12%
<b>Oda series</b>	Low	Drainage	Topsoil rich in humus	2,203	15.11%
<b>Wenchi series</b>	Marginal	Shallow soil	Topsoil rich in humus	135	0.93%

The Bekwai and Nzima series, located on summits and upper to middle slope sites were found to be moderately deep to deep, well drained, stony and gravels brown to red in colour, well developed in-situ. They have well developed alluvial clay accumulated subsoil horizons. The soils were classified as Ferric Acrisols (WRB) and Typic Paleudult (USDA). The two soils were assessed as moderately suitable for rain fed agriculture (Scholten *et al.*, 2013).

The major upland soils encountered in the compartment namely Bekwai, Nzima and Kokofu series are considered suitable for cultivation of teak. Therefore, a total of 12,240 ha, or 84% of the total soil surface is suitable for planting teak. These soil series are soils with no physical restriction to the root movement. However, they are susceptible to erosion and therefore will require effective soil conservation and management practices. Scholten *et al.* (2013) strongly recommend to maintain or to improve the level of organic matter in the soils. Erosion should be prevented, and organic matter should be recycled as much as possible. Finally, burning should be avoided as valuable organic matter is destroyed by burning while carbon, nitrogen and sulphur are lost into the air as gases.

More detailed soil research will be carried out during the end of 2013.

## Topography

The area is gently undulating with moderately steep slopes ranging between 5% and 12%. The summits are broad and nearly flat with slopes of 0 – 4%. 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. The soils are of medium to low plant fertility levels and are liable to mostly moderate sheet erosion.

## Hydrography

### Water bodies

The Tain II FR owes its name to the Tain River that forms the northern boundary of the western half of the FR and runs in easterly direction. There are drainage grooves all over the area which drains northwards into the Tain River, like Kankama River, south of Dadease. There

are no permanently running streams in the western part of the Forest Reserve that fall under Form Ghana's management control.

### **Water quality**

The analysis of the hydrological samples showed that water in Tain II Forest Reserve is not suitable for drinking. Although turbidity per se does not have to be a risk for people's health, it is an indicator for possible presence of contaminants that do threaten health. Also, it interferes with disinfection of water. For effective disinfection, turbidity should be lower than 1 NTU (nephelometric turbidity units), and definitely not exceed 5 NTU. Turbidity in these samples ranges from 11.77 to 54.47 NTU. No health-based guideline value is proposed for colour in drinking-water. But commonly, values below 15 PtCo (Platinum-Cobalt scale) are acceptable to consumers. In the Tain II samples, apparent colour ranges from 82 PtCo to 388 PtCo.

pH lies well within the range of 6.5 – 8.5 recommended by the WHO. Calcium, magnesium, nitrate and chloride do not exceed recommended maximum levels. Hardness, conductivity and alkalinity are also within acceptable range.

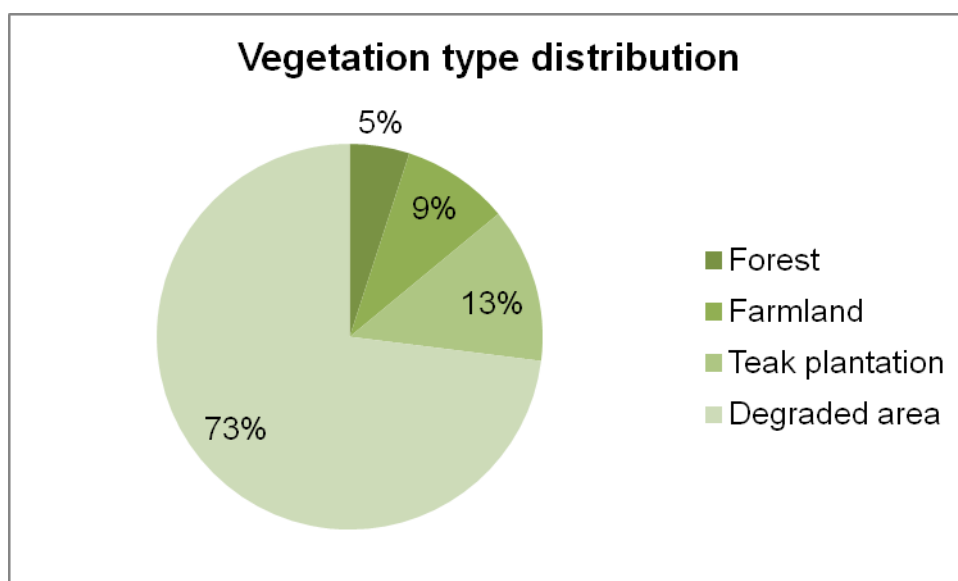
Copper and iron levels however are high. No health-based guideline value is proposed for iron by the WHO but it is recommended to maintain levels below 0.3 mg/l because iron promotes the growth of "iron bacteria", which derive their energy from the oxidation of ferrous iron to ferric iron and in the process deposit a slimy coating on the piping. At levels above 0.3 mg/l, iron stains laundry and plumbing fixtures. Iron levels in these samples reach up to 5.5 mg/l. The health-based guideline for copper is set at 2 mg/l by the WHO. Overall high concentrations can interfere with the intended domestic uses of the water. Staining of sanitary ware and laundry may occur at copper concentrations above 1 mg/l. At levels above 5 mg/l, copper also imparts a colour and an undesirable bitter taste to water. This level is exceeded in one of the samples (2.4 mg/l), located in the Kankama River, south of Dadease. In the other samples levels are generally low (0-0.63mg/l).

### **Vegetation**

Four main vegetation types were identified and classified as forest, teak plantation, farmlands and degraded areas (farm bush) (table 3.2).

**Table 3.2.** *Main vegetation types surveyed*

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



**Figure 3.4.** Vegetation types found on transects in the study area.

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. Some of these farmlands within the reserve boundaries still remain under the control of Ghanaian farmers and are excised from Form Ghana control, these are referred to as “Admitted Farms”. Degraded areas represented highly disturbed forests and grasslands with thickets of *Chromolaena odorata* (acheampong) and isolated trees (basal area of less than 10 m<sup>2</sup>/ ha). These areas also serve as active Fulani cattle grasslands and are constantly razed by fires in the dry season (figure 3.5).



**Figure 3.5.** Cattle grazing in Tain II FR.

Generally, forest patches are prevalent along the main water bodies, especially along the Tain River and its tributaries. These forests generally existed as riverine forests and occur along the northern and western fringes of the reserve. There are also smaller forest fragments dotted within the central portions of the reserve. There seems to be no clear pattern in the distribution of degraded areas and teak plantation, but 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 (farm bush) was more or less evenly distributed.



The main weeds are the species *Broussonetia papyrifera* (York), the shrub *Chromolaena odorata* (Akyeampong) and several grass species of which *Penisetum purpureum* (Elephant grass) is most abundant.

A number of scarlet star-rated species was found in the forest reserve (table 3.3). Most of these species are also planted by Form Ghana (see table 5.1 in chapter 5.3 of this document).

**Table 3.3.** Scarlet star-rated species found in the Tain II FR.

Local Name/Common name	Scientific name	Star-rated
Awiehfosamina	<i>Albizia ferruginea</i>	X
Edinam	<i>Entandrophragma angolense</i>	
Sapele/Efoborodidwo	<i>Entandrophragma cylindricum</i>	
Utile	<i>Entandrophragma utile</i>	
Krumben	<i>Khaya anthotheca</i>	X
Dubini	<i>Khaya ivorensis</i>	
Odum	<i>Milicia excelsa</i>	X
Kusia	<i>Nauclea diderrichii</i>	
Kokrodua	<i>Pericopsis elata</i>	
Wawa	<i>Triplochiton scleroxylon</i>	X

## Fauna

### Mammals

Previous mammal surveys conducted in the Tain II by Attuquayefio (2008) and Oduro and Danqhwa (2012) yielded 6 and 13 species respectively such that the known species richness prior to this survey was 19 species. The 2021 wet season survey (five days) yielded 24 species (including 11 previously unrecorded species), increasing the known avifauna species richness of the Tain II Reserve by 61% to 30 species.

The 2021 wet season survey revealed the presence of four red-listed mammal species within the Tain II reserve. Of these three were recorded by means of direct evidence (in the form visual observation, capture or signs) while one was confirmed through multiple, independent, anecdotal accounts given by interviewed locals. Red-listed species recorded by means of direct evidence included African White-bellied Pangolin (*Phataginus tricuspis*) (this was observed through signs in a single site, indicating the potential of a single specimen), Brown Pipistrelle (*Neoromicia brunnea*) (a single specimen was captured at the office complex), and African Straw-coloured Fruit Bat (*Eidolon helvum*) (there is a large colony in one of the natural forest blocks) while anecdotal reports centred on the sporadic presence of Forest Buffalo (*Syncerus caffer nanus*). Patas Monkey (*Erythrocebus patas*) and Large-headed Forest Shrew (*Crocidura grandiceps*) have previously been recorded in the reserve.

### Herpetofauna

The 2021 wet season survey (five days) yielded ten species (two from Asukese Forest). The findings of the current survey raise the total reptile inventory for Tain II to 16 species. Of these the Ball Python and African Rock Python has been observed historically in the FR as species of conservation significance.



### **Amphibians**

The 2021 wet season survey yielded 13 species. The findings of the current survey raise the total amphibian inventory for Tain II to 20 species. No amphibians of conservation significance have been recorded in Tain II nor where they found during the surveys.

### **Avifauna**

Results from the 2021 Biodiversity study report that previous avifaunal surveys conducted in the Tain II by Attuquayefio (2008) and Oduro and Danqhwa (2012) yielded 32 and 59 species respectively such that the known species richness prior to this survey was 76 species. The current (2021) wet season survey (five days) yielded 78 species (including 33 previously unrecorded species), increasing the known avifauna species richness of the Tain II Reserve by 43% to 109 species. No bird species of conservation significance were observed within the Tain II Reserve during the 2021 survey, nor have any been recorded during preceding surveys (Attuquayefio, 2008; Oduro and Danqhwa, 2012). This suggests localized extirpation of all regionally occurring conservation significant avifauna.

### **Hotspots**

The areas under natural forest restoration along the Tain River and natural forest patches set aside for conservation show the highest potential for existing and returning natural biodiversity.

## **Socio-economic environment**

The socio-economic data were collected at 18 villages located near Tain II FR: Akrofro, Ampenkrom, Arkokrom, Asantekrom, Dadease, Domeabra, Kojoakokrom, Kotoa, Kutre 1, Kutre 2, Meremano, Mpatapo, Mpatasie, Namasua, Nfodwokrom, Oforikrom, Pepaase and Tainso.

The information in these paragraphs was gathered from questionnaires filled out by household heads in the selected communities and from group discussions held with a number of focal people and village representatives in each community.

### **Household size, age and occupation**

#### **Household size**

Average household size is 8 people, usually consisting of the household head, his wife and their children. On average, a household had 4 children living in the village.

Most households were reduced in size because part of their children had moved out of the village, either temporarily or permanently. There were often other relatives included in the household, such as parents of the household head, brother/sisters, uncles/aunts or family in law.

#### **Age**

The average age of the household members was 22, but the most frequently occurring age was 4. The distribution in age classes shows a peak for ages 10 and 25 and a rapid decline above the age of 25 and again above 50. It is remarkable that the youngest age classes are less abundant than the teenagers. This may be explained by a decline in population growth or by migration of children into the communities after primary school (age 10-15).

### **Occupation**

Approximately 14% of the respondents were a child before school attendance, ca. one third was student. Over half of the respondents were working (52%) or unemployed (2%). Of the working respondents, the vast majority was farmer (76%). The next most frequently occurring occupations were trader (5%) and mason (3%). Other professions included tailor, taxi driver, hairdresser and teacher.



**Figure 3.6.** Tailor in her atelier.

## **Housing and transportation**

### **Housing**

Approximately half of the houses is built from clay, some of them plastered, some of them uncovered. The other half is 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.

### **Transportation**

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.



**Figure 3.7a.** Proud biker.



**Figure 3.7b.** Proud cyclist.

## *Ethnicity and religion*

### **Ethnicity**

Overall, most respondents were born in the village that they currently lived in (23%). Between the different villages, there was a large difference in the percentage of migrants. The highest migration rates were found in the communities bordering the forest reserve, where it is easier for settlers to find a piece of farmland. These villages are located at the most remote locations with the largest distance to facilities like markets, school or hospitals. The communities with the lowest number of migrants can be found closer to Berekum. Most of the migrants interviewed in this assessment migrated in the past decade. Migrants are defined as non-native to the village where they resided at the time of the interviews.

Most of the migrant respondents originated from another village within Bono Region (35%). Most of the people from outside the Brong Ahafo Region came in from the Northern Region (29%), followed by Upper West (15%). In total, 11 different ethnicities were interviewed in this assessment. The largest ethnic group is the Bono (81%), the original inhabitants of Bono Region. The largest ethnic minority are the Dagarti (12%).

### **Religion**

Religion is mainly Christian, combined with traditional customs and worship. Only a small percentage indicated that they were Muslim.

## *Village facilities*

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

### **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.

### **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 the 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 3.8.** Women pumping water from borehole.

### **Communication**

None of the villages had a computer and/ or internet connection. Telephone reception was generally low or absent, except in the villages close to the towns of Seikwa and Berekum. Despite of poor reception, most of the prominent village members owned a mobile phone that they used to make phone calls in nearby towns.

### **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.

### **Roads**

A paved road runs from Berekum to Mpatapo, Kutre 1 and Kutre 2 and to Mpatasie. After this, the roads are all unpaved and often in poor condition. Dadease, Arkokrom, Kojoakokrom and Asantekrom are especially inaccessible in the rainy season.

### **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 as permanent staff respectively.

### **Schools**

All villages have a primary school within 3 miles radius and most also have at least one Junior High School (JHS), although some students have to travel up to 16 miles (Dadease). 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 their education after JHS. They commonly stay with relatives in the town where they attend school and come back to their village in weekends or during holidays, depending on the distance.



### **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 as they then cannot sell their farm produce.

### **Fire service**

Bushfires occur frequently in Tain II Forest Reserve. In the winter of 2011-2012, 38 bushfires occurred in the period from December to March. This is a great pain for the farmers that risk losing their crops, but 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.

### **Level of education**

Illiteracy amongst the population >11 years of age at the national level is 26%, according to the 2010 Ghana national population and housing census report (Ghana Statistical Service, 2012). In Brong Ahafo Region this percentage is higher: 30%. The 20% illiteracy amongst the respondents of this assessment is hence below the national as well as the regional average, possibly because a large part of the respondents in this study lived in the vicinity of Berekum. Literacy in urban areas is commonly higher than in rural areas. This trend is visible in the national census report as well as in this study.

The communities located in Berekum district have the lowest level of people without education (13%). The highest level of people without education is in the communities in the east of Seikwa district (50%). Only 5% of the people in these communities went to JHS and 3% to SHS or higher level education. This coincides with the longest distance to the nearest JHS School for these communities: 12 and 16 miles for Nfodwokrom and Dadease respectively. The level of highly educated people (SHS and higher) is relatively low throughout Seikwa district, with 7% in Seikwa compared to 15-17% in the other three districts bordering Tain II FR.

The education level of people above the age of 25 is different from the people aged 25 or younger. The percentage of people without education is considerably higher amongst the older generation (28%) compared to the younger generation (8%), and more children attend primary school in this generation: 41% against 16%. However, the share of students that continue after primary school to do JHS or higher education is not that different, even a little bit higher for the older generation: 56% compared to 51%.

### **Health**

Malaria is the most frequently occurring disease in the area. According to interviewed community members, over 30% of all hospital visits were for malaria treatment. This reflects the statistics of the Berekum Holy Family hospital, where malaria is the number one reason for admission (10% of all admissions). Other frequently encountered complaints in the interviewed communities are stomach ache, headache, injuries from accidents and skin rashes. The main cause of death in the Berekum Holy Family hospital is HIV/AIDS.

## *Farming*

### ***Main agricultural crops cultivated***

Households commonly have some acres with their main bulk food crops (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. Cocoa was the most frequently grown perennial crop, followed by cashew and palmnut.

### ***Farm location***

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 acres and 3.1 acres respectively.

### ***Use of herbicides/ pesticides and fertilizers***

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.

### ***Farm production***

The average yield for maize is 18 bags per year. The production of maize per ha is much higher within the forest reserve than outside of the forest reserve: 2.8 bags/acre/year compared to 1.9 bags/acre/year. This can be explained by the conditions in the forest reserve or by the farmers that farm in the FR. It is likely that the soils within the reserve haven't been exhausted yet, and that abiotic conditions are more favourable 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.



## PRACTICAL INFORMATION

### Road infrastructure

A paved road runs from Berekum to Mpatapo, Kutre 1 and Kutre 2 and to Mpatasie. After this, the roads are all unpaved and often in poor condition. Dadease, Arkokrom, Ko-joakokrom and Asantekrom are especially inaccessible in the rainy season.

There is one feeder road that connects the Form Ghana plantation in Tain II FR with the national road network. This road leads over 22 kilometres from the highway at Berekum to the boundary of the Forest Reserve. The road between the highway and the forest reserve is improved and maintained by Form Ghana.

A number of main roads that run through or along the edges of the plantation are planned and will be constructed. From the main roads into the plantation in-roads will be created by profiling old roads or following contour lines when new roads are constructed. Main roads and in-roads are built and maintained by Form Ghana. In total, roughly 280 km of road will be constructed.

### Communication

Watchtowers will be placed at strategic locations, overseeing the entire plantation. Communication is organised via radio contact (Motorola) at a specific channel. Form Ghana management, foremen and fire squad have radios at their disposal.

### Organisational structure

In Tain II, Form Ghana has a work force that consists of up to 573 people. The number varies with the season as the seasonal weeding and pruning work makes it necessary to attract extra people. Form Ghana is managed by the Chief Executive Officer, with a Forest Manager overseeing forest management across the two forest reserves under Form Ghana's control. The Tain II site is managed by a team consisting of a plantation manager, a forester, supervisors, a head of security, storekeeper, a nurse and mechanics. These in turn direct teams or team leaders who are each responsible for a team. The organogram of the organisation can be found in Annexure 3.

### Plantation structure

The plantation is organized based on stands, compartments and blocks. Stands are homogeneous management areas, unique in forest type, plant year and location. Stands are subdivided in compartments. Compartments are the former logging coupes and measure 128 hectares. The compartments are subdivided in blocks of 64 hectares.

Stands are named according to the tree species planted and the plant year. For example: Teak 2001, Teak 2008, or Terminalia 2010. In principle, management regimes are defined per stand. In case tree growth is very heterogeneous within a stand, different areas within the stand will be managed according to different regimes.

Exceptions to this are the stands of natural forests or areas planted with indigenous trees. The stands of natural forest will not be harvested and the stands of indigenous species which fall within buffer zones along rivers will also be exempt from harvesting.

## Field planting program

The soils in most of the area are suitable for planting teak (84%). The field planting program is structured on the basis of the compartments, which are the land units as received from the Forestry Commission, and the projected progress each year. To date 7190.80 hectares of teak has been established, 62.28 hectares has been planted with gmelina, 1378.2 hectares has been planted with indigenous species as part of the restoration program while 375.82 hectares has been set aside for natural ecosystem regeneration. From 2023, the aim is to plant 150 hectares per year of teak plantation, indigenous plantation and buffer zones will also be set aside in the areas of establishment as the restoration project moves forward.

As soon as the in-depth soil research has been carried out, a field planting program will be elaborated stipulating which compartment will be planted in what year with teak or indigenous tree species. The Management Plan will be updated subsequently.

**Table 5.1.** Annual planning of the plantation activities.

Activity/ Month	7	8	9	10	11	12	1	2	3	4	5	6
Staking out & final mapping of area to be planted												
Final layout of road network												
Road construction												
Tilling of terrain suitable for plantation												
Pegging 3x3 meter planting grid												
Pegging planting grid in buffer-zones												
Road maintenance												
Digging of holes at pegs												
Transport to planting site and planting												

## SUSTAINABILITY CONCEPT

Tain II Forest Reserve have been declared 'degraded' by the Forestry Commission in the 1980's. The original natural ecosystem has changed into a mosaic of degraded ecosystems (farm bush), agriculture and remnant natural ecosystem patches, although these are considered to be in a highly degraded state. Many of the plants and animals typical for the original ecosystems had disappeared from the Forest Reserve areas.

Forest reserves were originally established by the national government of Ghana to secure a sustainable timber supply. Extraction of timber was allowed but strictly regulated. Unfortunately, most forest reserves are now degraded due to illegal activities. Therefore, the government initiated a policy in the 1990's to actively restore the ecological, social and economic values of the degraded forest reserves, allocating some forest reserves for strict ecological conservation, with heavily degraded reserves being allocation for strategic national timber production. International investors were attracted for reforestation and restoration of the reserves. Form Ghana operates within this framework for the restoration of strategic timber production in Asubima, Afrensu Brohuma and Tain II forest reserves, also providing rural social upliftment and conservation benefits in areas deemed either sensitive or critical for the provision of ecosystem services.

Form Ghana plants high quality timber trees in the degraded forest reserves and manages the natural forest and other ecosystems. The main tree species planted on the plantation is teak (*Tectona grandis*), with a maximum cover of 90%. The remaining 10% of the plantation is planted with a mixture of indigenous species.

Form Ghana aims to contribute significantly to the environment and to the Ghanaian economy and to the livelihoods of communities in the direct vicinity of the company. The sustainability concept designed by Form Ghana is a unique tool to ensure responsible management in all pillars of sustainability: society, environment and economy. This concept is applied to all the plantation units managed by Form Ghana.

### Economical sustainability

Form Ghana aims at the long-term production of high-quality timber, thereby meeting the steady national and global demand for sustainable roundwood. Since the remaining natural forests in Ghana are in a deplorable state, plantation forests will become even more critical to meet this demand in future. To bridge the time until the first harvest of roundwood, expected in 2032, Form Ghana generates income from carbon credits sales and commercial thinning.

The uneven age character of the plantation due to annual planting will assure periodical revenues from sales of forest products from the Teak areas and provision of ecosystem services from the indigenous forest areas. Harvesting of the teak areas will be distributed over a sustainable harvesting regime during the first rotation of felling to ensure a more even spread of harvesting and revenue generation.

### Ecological sustainability

Form Ghana believes that the mixture of teak, various native tree species and buffer zones is beneficial for the restoration of ecological and economic values of the forest reserve. Restoration of the tree cover will create a forest climate where carbon is stored above and below

ground, nutrient cycles are restored and water quality is improved. Form Ghana plants the teak trees mainly on deep, fertile and level soils that are relatively insensitive to erosion. Buffer zones or ecologically valuable areas are preferably planted with indigenous species. Erosion is therefore limited to an absolute minimum.

Corridors of natural, riparian forest, “buffer zones”, are established alongside water bodies to create habitats for flora, birds and wildlife. Buffer zones break the teak monoculture stands and are specifically designed for biodiversity conservation. The buffer vegetation will develop into a network of mixed native vegetation, providing corridors and refugia of suitable habitat for native flora and fauna. Birds and other wildlife will help plants and trees to spread their seeds, further enhancing vegetation cover (see Parotta, 1992). Organic matter and water retention capacity of the soil will be restored when fungi, bacteria and micro fauna recover their natural balance (Montagnini, 2001).

The buffer zones also function as green belts for fire protection. Buffer zones are suitable for fire control because of the moist nature of the riparian forests (Pettit and Naiman, 2007).

In Tain II FR several blocks of degraded natural forest that has been assessed as having potential to recover to natural forest. These blocks have been left and are protected in a natural state to enable natural regeneration to occur to restore these areas back to natural ecosystems.

Form Ghana makes no use of genetically modified (GMO) planting material of any kind and will introduce no new species into the area, in order to avoid introducing pests or invasive species.

As part of Form Ghana’s sustainability policy, chemical use in the plantation is maintained at a minimum. Mechanical weeding is preferred to chemical weeding but before the canopy is closed this method is very costly and not effective enough by itself. Further to this, many invasive exotic species require chemical control in the initial phases of weed eradication. Therefore, in addition to mechanical weeding, herbicides are used during land preparation to control regrowth of weeds and eradicate remaining stumps of York and Teak. After canopy closure, herbicides are no longer used. One type of insecticide and one type of fungicide are used in the nursery when necessary. Form Ghana has specific internal protocols for the use and storage of these chemicals.

For Tain II FR, a High Conservation Value Forest (HCVF) analysis was originally conducted, with reassessments against High Conservation Value (HCV) criterion. HCV are areas with environmental, socioeconomic, biodiversity or landscape value, as used within forestry management certification systems. It was concluded that that forest reserve is highly degraded and cannot be classified as having high conservation values. Ongoing High Conservation Value (HCV) Assessments are conducted every five years to assess and update these assessments based on ongoing monitoring and periodic biodiversity assessment. Results of these assessments are available on the Form Ghana website (<https://www.formghana.com/hcvf-analyses>). Form Ghana’s management objectives include the restoration of natural ecosystems, activities to achieve this objective have been implemented, mainly in the form of indigenous planting, conservation and protection provide enabling environments for the return of HCV elements as the natural ecosystems recover.

## Social sustainability

Labour conditions for Form Ghana employees naturally comply with national legislation and meet all FSC™ standards. The First Aid Procedures & Emergency Evacuation Protocol (P8) provides guidelines for ensuring health and safety of all Form Ghana employees. Form Ghana has developed good relations with the surrounding communities and will continue to maintain them. In the benefit sharing agreement accompanying the land lease, it has officially laid down how the community benefits from Form Ghana's activities. Form Ghana developed their own social plan describing how Form Ghana deals with employment, training of personnel, intercropping and extension services (see chapter 12). The collaboration with surrounding communities and local farmers is evaluated every year and if necessary, adjusted to meet the social goals of Form Ghana.

Although farming is not allowed within forest reserves according to Ghana's national law, there were many smallholders farms in Tain II when Form Ghana started their activities. Form Ghana gives these farmers the opportunity to sign an intercropping agreement with the company, enabling them to farm legally in between the young teak trees. This benefits the farmers and also the company because the farmers weed around the young teak trees, promoting their growth. After every final felling, land will become available for intercropping.

The collection of Non-Timber Forest Products (NTFPs) is restricted to allow regeneration of the severely degraded natural forest areas of the FR. Harvesting of locally rare materials such as rattan is prohibited until these species have increased their stocking. Fruits and nuts can be collected freely.

The integration of social sustainability in Form Ghana's management is documented in Form Ghana's Corporate Social Responsibility policy that can be uploaded from the website ([CSR Policy | Form Ghana | Bono Region](#)).

## Consequences on land-use

Form Ghana will establish a new forest estate in Tain II Forest Reserve that contributes to sustainable timber production, yields ecological and social benefits and is therefore in line with the national land use plans issued by the Forestry Commission of Ghana.

The fact that Tain II Forest Reserve will gradually be reforested means its availability for agriculture will be reduced. Fortunately, the number of farmers in the Forest Reserve is limited and no major obstacles are foreseen since all farmers can be linked to the intercropping system if they wish. The way the management is envisaged is that after every final felling, land will become available for planting of agricultural crops together with the new trees. This enables a continued agricultural use which is compatible with the timber plantation.

## PLANTATION MANAGEMENT

Planting started in 2013 and is ongoing. A total area of 8631.28ha has been planted (7190.80ha of teak, 62.28ha of gmelina and 1378.20 ha of indigenous). The total area also contains some natural areas, and all together covers 9007.10 ha.

80.53% of the planted area was planted with teak and gmelina and 19.47% with indigenous tree species, or left for natural regeneration. Teak was planted on the best quality sites, selected based on research by the Soil Research Institute in Kumasi (CSIR). Characteristics are:

- pH > 5
- Soils depth > 1.20m (4 ft)
- Good drainage
- Flat to slightly undulating surface to avoid erosion of the topsoil
- High soil fertility

In areas deemed to have conservation potential, a mix of indigenous species was planted. Buffer vegetation was conserved and/or enhanced in 30m strips alongside rivers and water bodies.

The management objectives can be summarised as follows:

1. Establishment and management of sustainable timber plantations;
2. Conservation and regeneration of natural riparian forest in accordance with the land lease requirements and relevant national legislation;
3. Generate sustainable income from round-wood and carbon sequestration;
4. Provide social benefits for employees and surrounding communities.

Current land use is described in table 2 below.

Table 2: Land area allocation by land use and year of restoration activity commencement

FOREST RESERVE	YEAR of planting (ha)	TOTAL AREA (ha)	Planted with INDIGENOUS (Ecological Restoration) (ha)	Planted with TEAK (Pro-ductive Restoration) (ha)	Natural Area (ha)	Planted with Gmelina (Productive Restoration) (ha)
Tain II	2013	644.79	26.73	573.78	44.28	
	2014	2,097.45	194.19	1,849.91	53.35	
	2015	1,325.31	93.25	1,098.14	130.32	3.60
	2016	120.69	-	87.63	33.06	
	2017	694.27	82.56	566.99	44.73	
	2018	1,934.21	306.51	1,597.50	25.20	5.00
	2019	1,293.25	363.06	863.17	42.02	25.00
	2020	606.01	302.36	272.74	2.23	28.68
	2021	148.77	9.55	138.59	0.63	
	2022	142.35		142.35		
<b>TOTAL</b>		<b>9,007.10</b>	<b>1,378.20</b>	<b>7,190.80</b>	<b>375.82</b>	<b>62.28</b>



## Teak: justification of plantation species

Teak (*Tectona grandis*) is the principal species planted by Form Ghana. Because of the physical and aesthetic qualities of teak wood, it is a much-desired timber species with a good commercial value. The production of teak has been successfully adopted in West Africa, with a better economic performance than indigenous tree species and other exotic species (Maldonado and Louppe, 2000; Dupuy and Verhaegen, 1993; Keogh and Pentsil, 2001; Behaghel, 1999). The price of Teak can be more than €300/m<sup>3</sup> for saw logs. For plantation saw logs of Wawa (*Triplochiton scleroxylon*) or Ofram (*Terminalia superba*), this price is around €50/m<sup>3</sup>. With an unrivalled growth rate of 14 m<sup>3</sup>/yr/ha, teak is currently the only commercially viable option.

Teak silviculture has been practiced since the 19<sup>th</sup> century (Behaghel, 1999). This long history of experience with teak silviculture resulted in elaborate management guidelines and accurate yield prognoses, providing a solid technical basis for plantation establishment today. There is a number of risks associated with plantation establishment, e.g. erosion, invasive species, pests and diseases. How these risks are dealt with by Form Ghana is discussed below.

As an exotic tree species in Ghana, teak is less prone to diseases than local species. Disease risk is further reduced by selecting proper sites for plantation establishment, where tree health is good (Keogh and Pentsil, 2001). Therefore, no chemical treatments are required for pest control. More information on pests and diseases is provided in section 7.3.

The risk of teak spreading outside of the plantation is low because of two reasons: 1) the dispersal capacity of the teak seeds is limited, and 2) teak is a light demanding species so it cannot invade the densely vegetated grasslands surrounding the Forest Reserves. Buffer zones and fire strips around the plantation further inhibit the spread of teak outside plantation boundaries. Most areas surrounding the plantation are in agricultural use for which teak poses no threat.

### ***Climate and soil conditions***

The optimal climate conditions for teak are a mean annual temperature between 22 and 27 °C, and an annual precipitation between 1200 and 2000 mm per year (Keogh and Pentsil, 2001). With temperatures between 23.6 and 26 degrees Celsius (Orgle, 1994) Tain II FR has the required temperatures for teak. The mean annual rainfall of 1200mm (Orgle, 1994) is the minimum of the recommended rainfall range. Actually, having rainfall a little less than the amount that is needed for maximum growth is good for the health of the trees and the quality of the timber.

### ***Provenances***

Form Ghana has acquired a lot of experience with teak planting through its reforestation activities in Asubima FR and Afrensu Brohuma FR. Anno 2012, 3,500 ha have been reforested of which 84% with teak. Systematic selection during plant production and before planting will assure the transfer of only the best material to the field.

The seeds for Tain II are proposed to be harvested from selected plus-trees in the 2001 pilot plantation in the Asubima FR, that originate from the SODEFOR plantations in Bouaké, Côte d'Ivoire, and that have proved a very suitable provenance for teak.

The genetic quality of the SODEFOR plantation is very good and the trees are adapted to the climate there as well as that of Asubima FR. Its origin goes back via selections from Trinidad and India to Tenasserim (Burma), the provenance of the best teak. The teak in the 64 hectares 2001 pilot plantation is estimated to be of growth class 2 and to produce a mean annual increment of 14 – 16 m<sup>3</sup>.

Other provenances with improved qualities will be explored in- or outside Ghana.

### **Other commercial tree species**

Complementary to teak, a number of species native to Ghana will be planted in the buffer zones along rivers and in areas where the soil conditions are not favourable for teak. These indigenous species will be grown in mixed stands to resemble a natural forest. Indigenous species planted by Form Ghana are shown in table 6.1.

Table 6.1. Indigenous tree species planted by Form Ghana.

<b>Local name</b>	<b>Scientific name</b>
Awiefosamina	<i>Albizia ferruginea</i>
Bombax	<i>Rhodognaphalon brevicuspe</i>
Bonsamdua	<i>Distemonantus benthamianus</i>
Emeri*	<i>Terminalia ivorensis</i>
Kokrodua	<i>Pericopsis elata</i>
Kusia	<i>Nauclea diderrichii</i>
Mahogany	<i>Khaya anthotheca</i>
Mansonia	<i>Mansonia altissima</i>
Ofram*	<i>Terminalia superba</i>
Onyina	<i>Ceiba pentandra</i>
Potrodom	<i>Erythrophleum ivorensis</i>
Watapuo	<i>Cola gigantea</i>
Wawa*	<i>Triplochiton scleroxylon</i>

\* Fast growing species

The local species will be sourced in Ghana, in order to maintain the genetic integrity of the local forests. For the indigenous species this means that efforts should be concentrated on selecting trees in the region to function as seed trees. This procedure avoids genetic pollution. This is especially important as these species are to be used to restore buffer zones along rivers and on poorer soils. As far as possible, the project employs certified seeds for these species obtained from FORIG in Ghana.

### **Buffer zones**

Form Ghana strives to conserve vegetation strips of at least 30m on each side of rivers and streams. These “buffer zones” are restoring back to natural forest. In some areas of the buffer zones the stocking of trees was low, or trees were completely absent. In order to assist natural restoration of these areas, Form Ghana planted indigenous trees. The local species originate from Ghana and are in most cases locally sourced in order to maintain the genetic integrity of the local forests. This happened in collaboration with the Forestry Research Institute of Ghana (FORIG). No harvesting is permitted in the buffer zones.

Invasive weeds hampering the natural forest restoration are removed. The main weeds are the tree species *Broussonetia papyrifera*. (York), the shrub *Chromolaena odorata* (Akyeam- pong) and several grass species of which *Penisetum purpureum* (Elephant grass) is most abundant.

### **Environment**

Continuous overexploitation and wildfire attacks have taken their toll over the past decades in the Forest Reserve prior to Form Ghana assuming control over these areas: plant communities have changed dramatically from dense forest vegetation and savannah to degraded agricultural land and farm bush, wildlife declined in numbers and birds associated with human disturbance thrive at the cost of those birds characteristic for the forest.

Despite these drastic changes, a number of birds, mammals and reptiles still remain, as well as a few indigenous trees. Form Ghana intends to conserve remnant trees and enhance remaining wildlife populations by creating habitat in buffer zones and by controlling all hunting and poaching activities. By reforesting the land, Form Ghana expects to restore many of the ecosystem functions that were degraded or absent. The focus of environmental management is on managing biodiversity, water and soil.

The Social and Environmental Impact Assessment (Tollenaar, 2013) foresees many positive effects on biodiversity, soils, hydrology, local climate and carbon balance to result from reforestation. Positive effects can be understood in the light of the degraded state of the forest reserve with only little natural forest left at the start of the reforestation activities by Form Ghana. The plantation is expected to restore many ecosystem functions that are presently degraded or absent whereas negative effects on biodiversity, soil and water are expected to be low.

Sound environmental management will ascertain that positive impacts are optimized and negative impacts avoided or mitigated. The focus of environmental management is on managing water and soil, biodiversity and High Conservation Values.

### ***Water and soil***

To maintain and improve the soil and water quality, Form Ghana takes various measures concerning water quality management, soil management and use of chemicals.

#### **Water quality management**

Hydrological analysis showed high levels of turbidity in the streams and rivers of Tain II FR. Water courses and bodies have to be protected to restore water quality, regular water flow and aquatic ecology. By establishing buffer vegetation strips of 30 m along-side water courses and bodies Form Ghana intends to improve water quality, restore aquatic ecology and minimize negative impacts of plantation establishment and management.

Moreover, Cattle herding will no longer be allowed in the area managed by Form Ghana, 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.

As water from streams and rivers is used for drinking and other household purposes by a large share of nearby villages, the improved water quality will also benefit people's health.

#### **Soil management**

Care has to be taken with plantation establishment and management to prevent erosion, soil acidification, soil fertility loss and pollution with agro-chemicals. Form Ghana assures impact mitigation by following best practise guidelines (assuring compatibility with the FSC™ standard) for plantation establishment, forest management, road construction, soil fertility management and pollution control (see next section on use of chemicals). The construction of culverts in roads is an important measure to prevent soil erosion. Others include regular thinning (light allows soil vegetation to grow) and filling up gullies (with branches etc.). To maintain and enhance soil fertility. Dead wood, yearly shedding of leaves and crown biomass resulting from thinning and felling are left in the plantation for decomposition.

### ***Policy for use of chemicals***

As part of Form Ghana's sustainability policy, chemical use in the plantation is reduced to minimum. Mechanical weeding is a policy, but before the canopy is closed, this method is very costly and not effective enough by itself. Therefore, herbicides (glyphosate) are used during land preparation and to complement mechanical weeding during the first 3 years after plantation establishment to eradicate remaining stumps of teak and to control regrowth of weeds. Glyphosate is a permitted herbicide by FSC™ and not highly hazardous.

Personnel that will apply herbicides will receive proper training and equipment to minimize health and environmental risks.

One type of insecticide and one type of fungicide are used in the nursery when necessary. Both are FSC™ approved. Form Ghana has specific internal protocols (P05) for the use and storage of these chemicals.

### ***Biodiversity***

Concerning biodiversity, the reforestation activities of Form Ghana will mainly have an impact on the buffer zone vegetation, wildlife and on harvesting of non-timber forest products by surrounding communities.

#### Wildlife

The SEIA reported that forest wildlife in Tain II FR has been severely impacted by habitat loss caused by wildfires and over-exploitation by humans (Tollenaar, 2013). Form Ghana intends to maintain and enhance forest wildlife populations where possible. This is done in two ways: providing suitable habitat to house species native to the area and protect these species against hunting and poaching.

The buffer vegetation provides suitable habitat with various ecological niches, as well as shelter and food sources. The 2021 biodiversity assessment shows that as vegetation develops over time, the buffer zones are becoming richer and more attractive for forest wildlife. The contiguous network of buffer zone vegetation acts as corridors that alternates with open fields where young teak stands and savannah species grow. This heterogeneous landscape is the natural habitat for rodents, duiker, bushbuck and other wildlife species. Over time, the area is changing from modified ecosystems into a more natural ecosystems with varying structure, complexity and diversity. This will gradually change wildlife composition favouring natural ecosystem wildlife over species typical of modified habitat.

Poaching is strictly forbidden in the areas managed by Form Ghana. This is controlled by the security guards of Form Ghana.

#### Harvesting non-timber forest products

People living in the fringing communities of Tain II FR will need permission from the FC and Form Ghana to collect non-timber forest products within Form Ghana plantation grounds.

### ***Social management***

The purpose of the social plan is to share the benefits of Form Ghana with stakeholders and to safeguard their rights. Stakeholder meetings are held at least once a year with traditional landowners, farmers, NGOs, Forestry Commission members and Form Ghana representatives, as described in Protocol 6. Form Ghana's conflict management procedure is described in Protocol 7.

People living close to the plantation are given priority with the employment of skilled and unskilled workers. Majority of Form Ghana employees are from the fringe communities. Table 5.2 shows the numerical strength of Form Ghana as at the end of 2022. These numbers increase depending on the season and activities that need to be carried out such as

pruning, firefighting etc. All workers are employed under the national labour standards for the agricultural sector and the ILO standards. Personnel is trained according to Protocol 11. Young forestry graduates are engaged to be trained in advanced nursery and plantation techniques. These forestry engineers will promote reforestation in the region and train local landowners in forest plantation practices and nursery establishment and maintenance. There are several protocols and policies governing Form Ghana's human resource management including the Complaint Response Mechanism, Gender Policy and Harassment Policy to ensure that Form Ghana meet international expectations for management of people.

Farmers can sign an intercropping agreement with Form Ghana to plant their crops between the young teak seedlings. Restrictions apply to the type of crop, use of fertilizers and phytosanitary agents and the distance between the crops and the planted trees. The opportunity for intercropping is open for everyone and offered an intercropping agreement for 1 year, with the possibility for renewal. The location and size of the farmland is often determined by blocks earmarked for development by Form Ghana. No restriction is placed for the farm size however, consideration is given to all farmers who expressed interest by filling the intercropping agreement form. The project management will maintain its full right to remove any intercropping farmers from the plantation if they do not respect the agreement.

Status	Male	Female	Total
Permanent	158	53	211
Casual	223	149	372
Total	381	202	583

Table 5.2. Numerical strength of Tain II plantations

### **Monitoring and evaluation**

Form Ghana commits itself to different types of monitoring: Biodiversity, Forest Condition, Water Quality, Forest Production, Economic Aspects and Social Benefits. Applied methods of monitoring depend on the purpose of each monitoring activity. These methods are described in protocol 13, per monitoring type.

Every year, a monitoring plan is constructed by Form Ghana with analysis by external consultants, including all monitoring activities that are expected for that year. Included in the monitoring plan is a list of indicators and verifiers that Form Ghana adheres to. In addition, Form Ghana or an external consultant analyses the monitoring data on forest condition, measured in permanent sample plots (PSPs). These analyses are recorded in an annual PSP Monitoring Report. All other monitoring activities are recorded in an annual Monitoring Report. Results from the monitoring activities are processed and used as input to improve Form Ghana's management.

Monitoring reports are produced annually and loaded to the Form Ghana website.



## **7 OPERATIONAL MANAGEMENT**

### **7.1 Silvicultural system**

Form Ghana developed their silvicultural system based on tree species, performance and on the desired end product. Form Ghana aims at the production of high-quality teak saw logs, because of the high revenue prospects. A 20-year rotation cycle for teak was chosen to match this aim. Currently there is no intention to harvest indigenous tree species, and therefore no rotation length or harvest frequency for these areas has been developed. In (buffer zones) no timber harvesting is permitted. Where indigenous species have been planted as part of restoration, uneconomical thinning and other silvicultural activities might be necessary to ensure restoration of natural ecosystem. The system applied by Form Ghana requires intensive plantation management to produce high quality sawlog timber, these systems are implemented according to best practice.

### **7.2 Nursery system**

Form Ghana established a tree nursery close to the plantation site at Akumadan and Berekum. Form Ghana planting stock is produced in this nursery and sometimes, outsourced from private seedlings producers. There are three shaded irrigation sheds with sprinkling installations and six hectares of beds reserved for stump production, irrigated with sprinklers in Akumadan whereas Berekum has dry-land (un-irrigated) beds for the production of teak stumps. Water for irrigation in the Akumadan nursery is pumped up from a dammed creek close to the nursery. The nurseries are designed to facilitate cultivation of teak and several species of indigenous trees. Detailed nursery management is described in protocol 14.

Native tree species are mostly grown from seeds in poly pots. The nursery is equipped with greenhouses for treating seeds in order to break dormancy. As soon as germination starts, plantlets are pricked out and transferred to prepared poly pots in shaded irrigation sheds.

Teak is grown in two different ways:

- Stump production
- Cloning

Stump production is the main nursery practice for teak. For the production of stumps, seeds are sown directly in the field during the start of the rainy season (March-June) in the preceding year. When the planting season starts in April, the seedlings are uprooted and pruned, to form stumps that can directly be planted in the field.

Teak clones are produced from cuttings, planted in Non-Mist Propagators (NMPs). When rooted, the clones are transferred to polypots and after a period of 3 weeks, they are taken out of the NMP and transferred to specially prepared beds under shade netting.

Form Ghana retrieves high quality teak seeds from an Ivory Coast provenance that was planted in the pilot plantation in Asubima Forest Reserve. All planting material is therefore of high genetic and phenotypic quality and selected to suit the local conditions. In future, other good sites for seed harvest will be selected and managed as seed stands. Seeds for indigenous tree species are collected on the plantation as much as possible.

The transport distance from Akumadan to Oforikrom (northern boundary of the Tain II FR) is 146 km or max. 3 hour drive. A truckload of stumps is estimated at 80,000 stumps which is enough to plant 70 hectares.

At the entrance of the Tain II Forest Reserve Form Ghana has installed another nursery of about 6 hectares. This nursery will produce about 2 million plants annually.

From the nursery at the entrance of the forest reserve the transport distance is very short. This

allows the planting to proceed without delays.

**Table 7.1.** Annual planning of the nursery activities.

<b>Activity/ Month</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>12</b>	<b>01</b>	<b>02</b>	<b>03</b>	<b>04</b>	<b>05</b>
Seed procurement									
Sowing of native trees									
Sowing of teak									
Weeding and watering									
Hardening of the plants									
Cutting plants to stumps									
Transport to planting site and planting									



### 7.3 Silvicultural operations

This section summarizes the silvicultural operations applied by Form Ghana and the rationale behind them. Detailed technical plantation management procedures are outlined in protocol 15.

#### 7.3.1 Terrain preparation

The soil is prepared for planting between January and April to create optimal conditions for the seedlings. The area to be planted is ploughed and sprayed with FSC™ permitted herbicides if necessary. At this moment, Form Ghana does not apply soil fertility management. However, if soil monitoring results indicate that soil fertility declines, Form Ghana will take appropriate action.

#### 7.3.2 Plantation establishment

Teak trees are planted at a density of 1111 trees/ha (3x3m) on most of the plantation.

Planting takes place between April and June, starting in the second half of April when the rainy season has really set in, to avoid the risk of drought stress.

#### 7.3.3 Silvicultural treatments

After planting, beating up is the first operation to be done. Beating up improves stocking to increase efficiency, improves weed control because of early canopy closure, increase carbon storage and make better use of the land in general. The young trees are then singled to direct growth at an early stage, reducing efforts later on.

Before canopy closure, weeding is needed to prevent weeds from competing with the seedlings. Climbers are cut to prevent the planted stock from growing crooked or being smothered. Forest stands are checked every year to determine whether climber cutting is necessary. Only if this is the case the climber cutting is carried out.

Wood distribution between stem and branches can be influenced by thinning and pruning. By timely thinning and pruning, the trees can be directed to have optimal height growth and well formed crowns, with little biomass wasted on side branches in early life stages.

Pruning is undertaken mainly to clean part of the stem from branches, which leads to higher timber quality and better processing.

Thinning regime and harvest estimates are based on yield tables from teak plantations in Ivory Coast, where similar soil and climatic conditions apply. These tables provide growth data over a period of 20 years, based on a specific management regime, including thinning and final felling. The tables are divided in four realistic yield classes based on the dominant height<sup>1</sup> ( $H_{dom}$ ) of a stand. The difference between the yield classes in total production potential and mean annual increment is considerable (Table 6.1).

**Table 6.1.** Yield classes from Ivory Coast with main characteristics

Yield class*	$H_{dom}$ (m after 20 years)	Total production ( $m^3$ after 20 years)	Mean annual increment ( $m^3/ha/y$ )
1	28.0	350.3	17.5
2	24.9	283.9	14.2
3	21.8	201.0	10.1
4	18.7	153.8	7.7

<sup>1</sup> Dominant height is estimated by the average height of the five trees with the largest diameter in a permanent sample plot.

*\*The classes are based on an initial planting density of 1111 plants/ha., a 20-year rotation, and 2-4 thinnings before final felling.*

Table 8.2 shows the estimated number of stems that has to be removed in a thinning. The real number of stems to be removed in a thinning is determined in a standard methodology which makes use of crown and tree diameters. This methodology is worked out in the management procedure on thinning, P15.

**Table 8.2.** Thinning regime based on the yield classes from Ivory Coast.

Yield class	G (m <sup>2</sup> / ha) at moment of thinning	Estimated stand age (years)	Thinning intensity (N/ ha)	Thinning intensity (%)*
1	>12	3	361 (1,111 to 750)	20.4
	>15	6	350 (750 to 400)	32.1
	>18	10	150 (400 to 250)	23.8
	>20	15	85 (250 to 165)	21.7
2	>12	4	700 (1,111 to 750)	18.3
	>15	8	300 (750 to 450)	26.5
	>18	12	150 (450 to 300)	20.4
3	>12	5	700 (1,111 to 750)	18.3
	>15	10	300 (750 to 450)	27.1
	>18	16	150 (450 to 300)	21.1
4	>12	6	700 (1,111 to 750)	20.7
	>15	13	300 (750 to 450)	26.7

*Timing of thinning is determined by actual G as measured in PSPs. The age at which the targeted basal area (G) for a thinning is reached depends on the stand's growth, so given thinning ages are estimates.*

\* based on G

Stumps of thinned trees are cut off low to the ground and covered with soil and leaves so that it experiences lack of light. This will prevent the stump from coppicing which is not desired because of root competition.

It is essential that the Form Ghana tree stands are classified accurately according to their yield class. This categorization is done based on results from growth performance monitoring in Permanent Sample Plots (PSPs), as described in protocol 13. The expected average yield class for Tain II FR is class two. This expectation is actualized regularly with results from an intensive monitoring program.

The thinning regime suggested for yield class two consists of three thinnings and a final harvest. The first thinning is non-commercial. The expected volumes of the commercial thinnings and the final harvest according to the yield tables are presented in table 6.2.

**Table 6.2.** Expected harvestable volumes of Teak from the Tain II FR plantation

Planting year	Surface (ha)	Yield 14 yrs (thinning) m <sup>3</sup>	Yield 20 yrs (clearcut) m <sup>3</sup>	Total yield
2013	573.8	14344.50	77420.71	91765.21
2014	1849.9	46247.75	249737.85	295985.60
2015	1098.1	27453.50	147150.76	174604.26
2016	87.6	2190.75	11830.05	14020.80
2017	567.0	14174.75	76543.65	90718.40
2018	1597.5	39937.50	215662.50	255600.00
2019	863.2	21579.25	116527.95	138107.20
2020	272.7	6818.50	36819.90	43638.40
2021	138.6	3464.75	18709.65	22174.40
2022	142.4	3558.75	19217.25	22776.00
<b>Total</b>	<b>7190.8</b>	<b>179770.00</b>	<b>969620.27</b>	<b>1149390.27</b>



Harvestable volumes are calculated with values from the yield table of yield class 2 (Annex 4). Commercial thinning volumes are approximately 40m<sup>3</sup>/ha, final harvested volume is 207m<sup>3</sup>/ha, total 247 m<sup>3</sup>/ha. Assumed in this table is that 90% of the plantation area will be planted with Teak.

The tables are used as a calculation and estimation tool for plantation management. As soon as the plantation has reached an age at which enough data is available, Form Ghana intends to create their own yield table starting in 2023 with specialist input.

#### **7.3.4 Final harvesting**

After 20 years, all remaining trees are harvested. This may change depending on market development. Establishment of the new plantation will be done by planting new seedlings/stumps, not through coppicing. Therefore, the terrain preparation section above will apply for all rotation cycles to come.

#### **7.3.5 Maintaining the positive effects of plantation establishment**

To safeguard against the potential significant reversal of the accrued environmental and climate change benefits from forest restoration, the following activities are important:

- i) minimizing fire risks;
- ii) no harvesting of trees in the restored buffer zones;
- iii) avoiding erosion and pollution during harvesting
- iv) ensuring a timely replanting after the final harvest

A mosaic of buffer-zones and indigenous plantation will ensure that key parts of the forest land scape remain in place.

## **8 RISK MANAGEMENT**

### **8.1 Prevention of illegal activities**

Form Ghana is determined to prevent illegal activities, e.g., intrusion, hunting, trapping, felling, burning, planting food crops without Form Ghana's consent from taking place on the plantation. Protocol 2 describes the different ways Form Ghana adopts to realize this goal.

### **8.2 Fire management**

Fire is the greatest risk for the plantation. Mature teak can withstand some fire but young plants are not yet resistant. Most of the native forest species cannot withstand fire at all. Fire management is employed to reduce fire risk, focusing on four main axes: fuel load reduction, fire breaks, establishment and training of a fire squad, and awareness raising on the risks of fire for local people. The detailed fire procedures are described in Protocol 21.

#### ***Awareness raising***

As laid out in the PPP, the Forestry Commission will fulfil the task of awareness raising or sensitization of surrounding communities regarding fire use and risks. The principles of fire management will be explained to the people in the surrounding villages in cooperation with agricultural extension agencies. Aim is that people will see how they can profit from developing agricultural systems which focus on soil organic matter, fire prevention and improved fallow. If successful, the overall risk of fire will be greatly reduced. Cooperation will also be sought with the district fire office in the sensitization of the local communities.

The farmers in the surrounding villages will be advised to inform Form Ghana beforehand in case they decide to set fire to their farms, so that the fire squads can control the fire and protect hearth and home of the farmers.

### **8.3 Control of pests and diseases**

Pests can cause considerable damage to forest plantations, especially monocultures. It is therefore of great importance to prevent diseases from entering the plantation and to take quick and appropriate action if a disease has been identified.

Teak, an exotic species in Ghana, is not very susceptible to pests and diseases (Gibson, 1975). Stem rot occurs occasionally in Ghana (Keogh and Pentsil, 2001). A number of fungi that cause white and brown rot in West Africa were listed by Gibson (1975). Form Ghana reduces the risk of these infections by planting teak only on appropriate sites, keeping a healthy nutrient balance and preventing damage from fire, pruning or harvesting (Keogh and Pentsil, 2001).

There are some pathogens and insects known to affect indigenous species. Infection and attacks can be avoided by planting a mixture of different species and abiding by proper hygiene measures, especially in the nursery. In some cases, pesticide may be needed to protect the crop. This will only be used as a last resort because pesticides are costly and may damage the environment.

Termites can be a problem for some of the tree species. However, since termites are important in keeping the soil open and fertile no action will be taken against them.

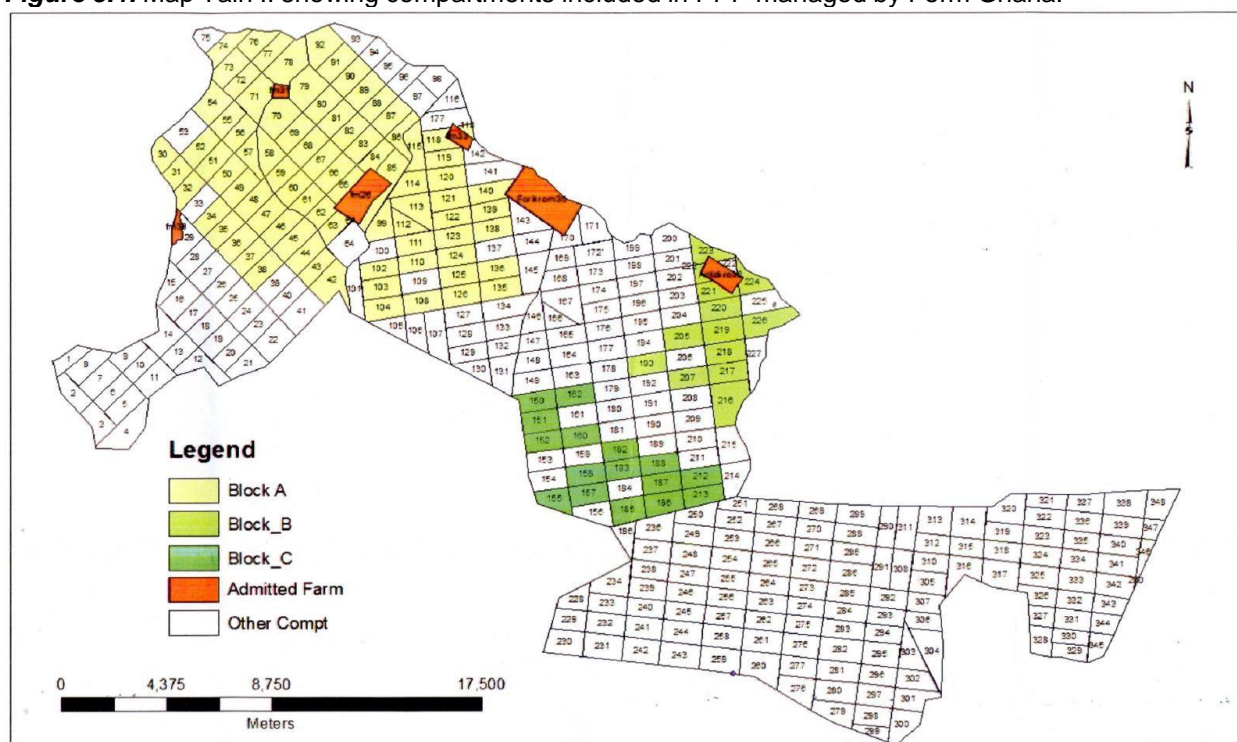
## ORGANISATION OF MANAGED AREAS

### Localisation and limits

The Tain II Forest Reserve is situated in the dry semi-deciduous forest zone at about 10 km north of Sunyani and 6 km north-east of Berekum in the Bono Region (see Annex C). It falls under the authority of the Sunyani Forest District. Total surface of Tain II FR is 50,906 ha. This comprises 49,262 ha of productive forest, 1,062 ha of admitted farms, 65 ha of roads and waterways and about 518 ha of grassland. Ownership is vested in the stools of Berekum, Odumasi and Nsoatre (Kosoe, 2012).

The selected site for plantation establishment comprises 3 blocks. Block A is the largest and consists of 81 compartments located in the north-western part of the Tain II FR, numbered: 30-32, 34-38, 42-52, 54-63, 65-74, 76-92, 99, 102-104, 108, 110-115, 118-126, 135, 136 and 138-140. Block B consists of 13 compartments located in the mid-northern part of Tain II FR, numbered: 193, 205, 207, 216-224 and 226. Block C consists of 16 compartments located in the mid-southern part and numbered 150-152, 155, 157, 158, 160, 162, 182, 183, 185-188, 212 and 213. Selection of this area was done on the basis of availability. In total, Form Ghana manages 14,576 ha of the Tain II Forest Reserve.

**Figure 5.1.** Map Tain II showing compartments included in PPP managed by Form Ghana.



## SOCIAL PLAN

The purpose of the social plan is to share the benefits of the plantation company with stakeholders and to safeguard their rights.

### Oversight body

An oversight body consisting of two individuals from Form Ghana Ltd and two individuals from FSD/FC meet quarterly to discuss and advice upon progress of the PPP project. After the initial implementation year, the meeting frequency may be reduced.

### Stakeholders' Management

It is important for the company to build a relationship with stakeholders that is characterized by clear, transparent, two-way communication to build trust and support for its activities. Stakeholders need to be informed on planned activities and ways this may impact the natural, social and economic environment. Also, the ideas, expectations and concerns of stakeholders must be heard and incorporated in the project plans.

#### ***Stakeholder meetings***

The stakeholder meetings are a very important means of communication between the company and its stakeholders. Per plan at least one stakeholder meeting is held every year, and in these meetings various stakeholder groups are represented. If the need arises it is possible to organize additional meetings. Every stakeholder on the list for whom the stakeholder meeting has been identified as being relevant, is invited prior to the meeting. The company will facilitate the attendance of all invited stakeholders.

The meeting is held in a neutral venue (e.g. church or town/village hall). Inviting stakeholders on the Form Ghana premises may be distracting and may cause people to feel intimidated. Invitation letters are sent (brought) to the stakeholders. Communication on the meeting and the venue is channelled through the community contact persons. For some stakeholders that have trouble coming to the meetings, transport may be arranged (e.g. groups of farmers).

The agenda of the stakeholder meeting is prepared based on topics are identified that need to be discussed with the stakeholders, as well as by listing of new information that has become available since the last meeting (new reports, new developments, events in the field).

The main stakeholder group is in charge of the following:

1. Inform the population on the management plan of Form Ghana
2. Facilitate the exchange and distribution of information between nearby villages
3. Identify and formulate projects for the region for which funds are available
4. Arbitrate conflicts in cooperation with the plantation management
5. Plan diverse activities and evaluate them

After every meeting, minutes are prepared and sent to the Forestry Commission and the District Assembly.

During the meetings, people are encouraged to share their views. Views are then discussed during the meeting, and this is explicitly captured in the meeting minutes. Minutes of the stakeholder meetings are kept at the Form Ghana office. The minutes are discussed in management meetings.

### Complaint Response Mechanism Procedure

Although due care is taken to avoid that grievances arise, it should not be forgotten that all the work is done by people, and conflicts and grievances may arise. Form Ghana has a special procedure to deal with grievances and conflicts (see P7 Complaint Response Mechanism (CRM)). This protocol is leading in all dealings with conflicts or grievances with stake- holders, but also with other parties such as workers. The working of the CRM and the way people can use it will be a recurrent topic during stakeholder meetings.

## Benefit sharing

The benefits accruing from the commercial thinning and harvesting of timber and other benefits, after deduction of project costs, will be shared among the different PPP partners according to the following key:

The Forestry Commission shall receive 12% of the Standing Tree Value (STV) of commercial thinnings and of the final harvest obtained from the Project, and shall receive the same percentage of other Benefits less the costs of Form Ghana Ltd. that would accrue from the project. Form Ghana Ltd. shall receive 80%, the Landowner shall receive 6% and the Local Community shall receive 2%.

## Intercropping

Form Ghana is committed to their targets for social sustainability, that include meaningful benefits to the fringing communities and an extensive stakeholder engagement plan.

The intercropping farmers are offered an intercropping agreement for 1 year, with the possibility for renewal (P 30 Annex A – Intercropping Agreement). The short-term duration of the agreement ensures that the farmers are flexible to move their farm when necessary, for instance when the canopy closes, or when new sites are planted. The agreement gives the farmer the opportunity to farm on Form Ghana land for free. The opportunity for intercropping is open for everyone, except for persons that demonstrably did not comply with Form Ghana farming and intercropping rules in the past. ***However, farmers will not be allowed to intercrop when Form Ghana leased areas are completely developed and canopy fully closed. Thus, potential and existing intercroppers will no longer have the opportunity to engage in any intercropping activity within the reserve.***

The location and size of the farmland can be selected by the farmers, in agreement with the company. No restrictions apply for the size of the farms, as the company promotes intercropping in the Form Ghana plantations.

A number of conditions apply for (intercropping) farmers to ensure that the farming activities do not hamper the growth of the trees and/or form a risk to the plantation or the surrounding villages. These conditions are defined in the intercropping agreement (P 30 Annex A– Intercropping Agreement).

## Employment and training

### **Employment**

For the employment of skilled and unskilled workers priority is given to inhabitants of the area surrounding the FR. For casual employment, intercroppers are given priority to ensure their livelihood throughout the year. The workers are employed under the national labour standards for the agricultural sector and the International Labour Organization (ILO) standards.



### **Safety**

Safety is of the utmost importance to Form Ghana. To ensure that everybody works in a safe manner in a safe environment three approaches are used:

- the workplace is periodically monitored to assess its safety
- personnel are trained in the safe use of equipment and in safe working techniques
- personnel use individual protective gear

The use of protective equipment is based on the ILO Health and Safety in Forestry work standard, although this can be modified to fit local conditions.

### **First aid**

Form Ghana has a clinic on site with a qualified nurse on duty.

Every year, training in first aid is given to all first aiders and relevant staff. A more intensive training is given to plantation manager, plantation supervisor, nursery supervisor and chief mechanic. The first aid kits must always be available at the working site: one in every car and truck and one with each supervisor or foreman of every team in the field.

In order to be able to rapidly evacuate any injured or gravely ill person a vehicle will always be available either in the plantation or at the nursery. Serious accidents are called using the radio to alert the nurse.

### **Training**

Training of personnel is essential for the safety on the work floor and the quality of the work. Trainings are given on various subjects and some types of training will be periodically refreshed to assure the highest level of capacity. Some types of training are specific to certain posts (chainsaw operator) whereas other trainings concern everybody (Health and safety and FSC™ certification) and other trainings are for individual (personal/self-development).

### **Planning of training**

A training schedule is designed every year according to relevance of the specific trainings. Relevance is determined based on assessments of management staff and internal audits. An assigned Form Ghana senior staff member maintains this schedule.

Professional training in nursery and plantation techniques is given to promising workers. For this purpose, subjects are selected and short courses given both in the plantation and at the nursery.

Training also covers the elements of the FSC™ certification scheme which are important to workers and to the local population. The objective of this training is to inform the workers on the implications of FSC™ for the people.

## OPERATIONAL MANAGEMENT PLAN

Operational management is organised based on homogeneous forest areas, or stands. A stand is unique in forest type, plant year and location. Specific management regimes (e.g. timing of thinning) are defined per stand. In case tree growth is very heterogeneous within a stand, different areas within one stand are managed with different regimes.

The operational management plan follows the general guidelines of the silvicultural system and/ or management for buffer vegetation. In addition, for each stand a stand sheet is drawn up at the end of the planting year. This stand sheet gives a clear overview of the general stand characteristics, management information and history, expected management regime and a map of the stand. A standard stand sheet has been developed.

All stand sheets are kept together for the management planning to be based upon.

### Annual planning

The stand sheets provide the information to make a detailed annual planning of activities and use of machines and personnel.

The annual planning is made in September/ October for the next calendar year.

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## ANNEX A. LIST OF PROTOCOLS

### Legislation and document management

- **P 01 Follow-up of Legislation and Conventions**  
This document describes how Form Ghana follows up on new legal texts that appear in Ghana and new conventions that are signed internationally. It also describes how texts are evaluated for applicability to Form Ghana.
- **P 02 Security**  
This document describes how Form Ghana avoid illegal activities on the lands it manages.
- **P 03 Periodical Review of Documentation**  
This document describes the system of annual evaluation of all management documents to include new information and assure continued relevance and actuality.

### Waste management and environmental protection

- **P 04A & B Waste Management**  
This document describes how Form Ghana deals with waste produced on its various sites.
- **P 05 Responsible Use of Pesticides**  
This document prescribes how pesticides need to be handled. It also describes the necessary safety measures.
- **P 16A & B Storage of Fuel, Lubricants and Toxins**  
This document prescribes how hazardous substances must be handled and stored across the two sites.
- **P 18 Machine Maintenance**  
This document prescribes maintenance of machines to assure their continued functioning.

### Stakeholder engagement

- **P 06A & B Stakeholder Management**  
This document describes how personnel and the local population are informed on Form Ghana activities, and how stakeholders can engage with Form Ghana across the various sites of operation
- **P 07 Complaint Response Mechanism**  
This document describes how grievances are dealt with and how grievances are redressed.
- **Resettlement Action Plan**  
This document describes the resettlement activities that Form Ghana undertakes for people that need as a consequence of Form Ghana activities.
- **P28A & B Community Development**  
This plan describes the community development activities that Form Ghana undertakes across the two sites.
- **P 30 Intercropping**  
This document describes Form Ghana's approach to intercropping farmers.

### Health and safety management

- **P 08A & B First Aid Procedures & Emergency Evacuation**  
This document prescribes how to deal with cases of emergency across the two sites.
- **P 09 Transport**  
This document prescribes how personnel can be transported.
- **P 10A & B Personal Protection**

This document assesses the risks related to the various work places and prescribes the safety gear people need for various jobs.

- **P 23 Envenomation by snakes and insects**

This document describes the possible snakes and insects that may harm people and how to act in case of bites and stings.

- **P 27 Information on Contagious Diseases**

This document serves as a basis for sensitization on contagious diseases.

#### Personnel management and training

- **P 11 Training of Personnel**

This document presents the general recurrent planning for training

- **P 17 Management Requirements Responsibilities Senior Staff**

This document describes the capacities need for senior functions

- **P 20 Meeting Schedule**

This document describes the management meetings

- **Training register**

This document is an up-to-date list of training provided to all workers

#### Certification management

- **P 12 Internal Audits**

This document prescribes internal audits to be conducted at Form Ghana to assure the continued high level of performance at the company.

- **P 22 Chain of Custody**

This document describes the system of tracking and tracing of logs and timber at the company.

- **P 19 FSC™ Logo Usage**

This document prescribes how the FSC™ logo can be used by the company.

#### Technical work prescriptions

- **P 14A & B Technical Performance in the Nursery**

This document describes all the activities in the two nurseries and presents quality standards

- **P 15 Technical Performance in the Plantation**

This document describes all the activities in the plantation and presents quality standards

- **P 21A & B Fire Prevention and Fire-fighting**

This document describes how fires will be prevented and when needed combatted across the two sites.

- **P 24 Road Construction and Maintenance**

This document prescribes how roads are to be constructed and maintained.

- **P 25 Harvesting**

This document describes the system for extracting and preparing logs during forest harvesting.

- **P 29 Integrated Pest Management**

This procedure describes how to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.

#### Monitoring

- **P 13A & B Monitoring**

This protocol describes the various monitoring activities across the two sites

- **Monitoring Plan**

This document describes the planning of the various monitoring activities

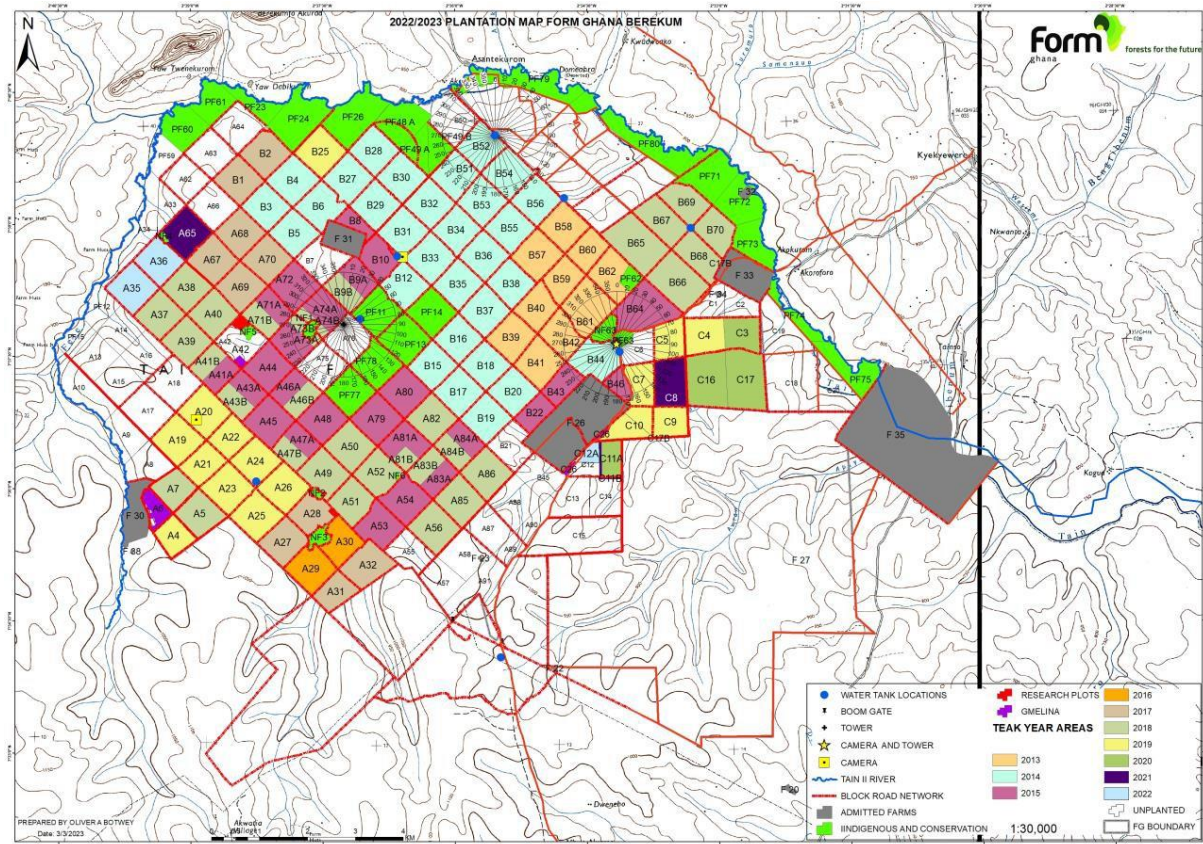
### **Human resources policies, procedures and labour relations.**

Form Ghana HR department has developed a number of policies and procedures in addition to the protocols which are part of the Environmental and Social Management Plans (ESMP). These include:

- **Absenteeism Management Policy** which serves as a guidance to implement rules and regulation governing the company to maximize employee attendance at work.
- **FG Visitor's Emergency form** (linked to Protocol 27) which informs visitors of necessary medical precautions and collects emergency information.
- **HEALTHCARE POLICY 1 update** sets out principles and procedures so as to create and promote best service of healthcare to all employees.
- **HIV/AIDS Policy** is to ensure a consistent and equitable approach to the prevention of HIV/AIDS among employees and their families, and to the management of the consequences of HIV Aids, including the care and support of employees living with HIV/AIDS.
- **Industrial Attachment Policy** is a training program designed to enable students/graduates placed with the company to acquire practical technical skills and knowledge through on-the-job training under the mentorship of company supervisors with vast experiences in forest rehabilitation for development.
- **Internal Rules and Regulations FMGH** presents the general rules relating to Employment, Discipline, Sanctions, Provisions as to the rights and defence of the workers
- **LEAVE POLICY** seeks to allow flexibility for employees to meet personal, family, work and community commitments without compromising the achievements of business objectives.
- **LETTERHEAD USE POLICY** describes officially the rules and regulations governing the use of company's letterhead, logo and stamp.
- **RECRUITMENT POLICY AND PROCEDURES** aims at enabling the company find and recruit people with the necessary qualifications, skills, and expertise to deliver on its strategic objectives and goals.
- **SHORT TERM- Workers** policy seeks to reach and promote decent work irrespective of employment arrangement, Form Ghana has formulated principles and procedures. These principles and procedures, in conjunction with Form Ghana's internal rules and regulations, grievance protocol and disciplinary action policy, will ensure good labour standards and protection of workers employed by Form Ghana.
- **TRAINING AND DEVELOPMENT POLICY** is to notify Form Ghana employees of the ways and means of training and developing workers that have the skills needed or career path.
- **Company Procedure Appendix 2019** informs on phone numbers and allowances
- **Procedure Manual Update 2019** describes part of the company's procedures.
- **Section 3 – Finance** explains financial rules
- **Section 4 – Accommodation & Car Policy** describes some of the benefits of FG workers.
- **Section 5- Communication** lays out the rules for communication efforts by the company.
- **Section 6 - IT Policy** regulates the use of the company's IT equipment and services.
- **Section 7- Human Resource Management** describes the HR management of Form Ghana.
- **Section 8 - Gender Policy** formulates principles and procedures that address the need for gender equality, rights, responsibilities and opportunities for all employees of the company.



## ANNEX B. FG PLANTATIONS IN TAIN II



## ANNEX C. STAND SHEETS

### General Information

FOREST RESERVE	YEAR of planting (ha)	TOTAL AREA (ha)	Planted with IN-DIGENOUS (Ecological Restoration) (ha)	Planted with TEAK (Productive Restoration) (ha)	Natural Area (ha)	Planted with Gmelina (Productive Restoration) (ha)
Tain II	2013	644.79	26.73	573.78	44.28	
	2014	2,097.45	194.19	1,849.91	53.35	
	2015	1,325.31	93.25	1,098.14	130.32	3.60
	2016	120.69	-	87.63	33.06	
	2017	694.27	82.56	566.99	44.73	
	2018	1,934.21	306.51	1,597.50	25.20	5.00
	2019	1,293.25	363.06	863.17	42.02	25.00
	2020	606.01	302.36	272.74	2.23	28.68
	2021	148.77	9.55	138.59	0.63	
	2022	142.35		142.35		
<b>TOTAL</b>		<b>9,007.10</b>	<b>1,378.20</b>	<b>7,190.80</b>	<b>375.82</b>	<b>62.28</b>

### Management information

Forest management and silvicultural treatments are performed as described in the management plan and management procedures.

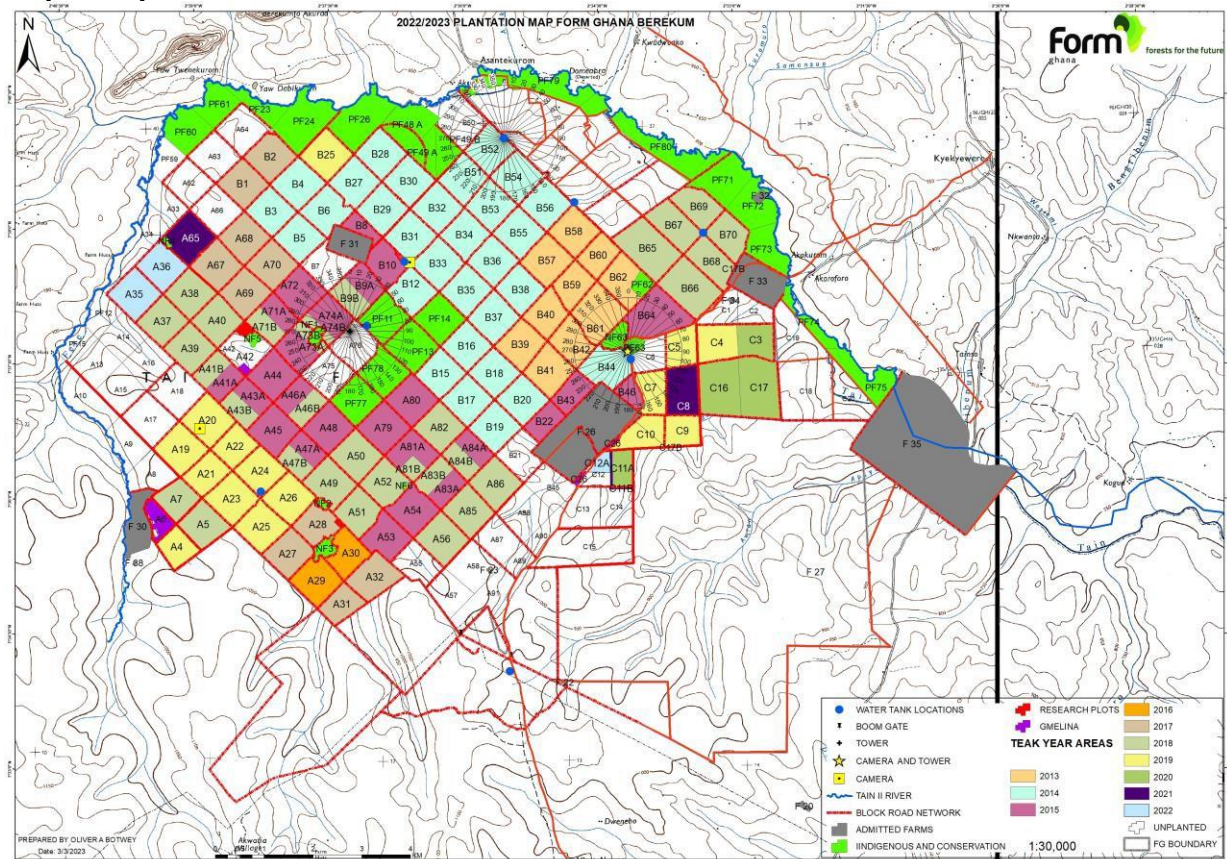
Expected rotation: 20 years  
Expected yield class: 2

Management history  
2013: Planting started

### Expected management regime

Year	Beating up; singling	Weeding	Climber cutting	Pruning	Thinning	Harvest
2013		x	x			
2014		x	x			
2015		x	x			
2016		x	x	x		
2017			x	x	x	
2021			x	x	x	
2025					x	
2033						x

## Map area planted 2013-2022





## ANNEX D. YIELD TABLES IVORY COAST

Yield tables for teak in Ivory Coast at initial stock density of 1,111 trees per ha and final felling after 20 years for 4 yield classes (adapted from Dupuy, 1990)

### Legend

N: number of trees per ha

H dom: dominant height of forest stand

D before: mean diameter before thinning

D after: mean diameter after thinning

G before: basal area before thinning

G after: basal area after thinning

**Table 1.** Yield table for class 1: thinning at 3, 6, 10 and 15 years.

Yield class 1									
Age (years)	N	H dom (m)	D before (cm)	D after (cm)	G before (m <sup>2</sup> / ha)	G after (m <sup>2</sup> / ha)	% thin-ning*	Volume (m <sup>3</sup> / ha)	Volume thin-ning (m <sup>3</sup> / ha)
1	1,111	3.4	3.5		0			0	
2	1,111	6.8	7.0		4.3			10.2	
3	<b>750</b>	<b>10.2</b>	<b>10.5</b>	<b>11.4</b>	<b>9.6</b>	<b>7.7</b>	<b>20.4</b>	<b>34.6</b>	<b>4.6</b>
4	750	12.2	12.8		9.6			41.0	
5	750	14.1	15.0		13.3			65.8	
6	<b>400</b>	<b>15.7</b>	<b>16.4</b>	<b>18.5</b>	<b>15.8</b>	<b>10.8</b>	<b>32.1</b>	<b>100.3</b>	<b>29.3</b>
7	400	16.9	18.3		10.5			71.5	
8	400	18.0	20.2		12.8			93.0	
9	400	19.2	22.1		15.3			118.5	
10	<b>250</b>	<b>20.3</b>	<b>24.0</b>	<b>26.5</b>	<b>18.1</b>	<b>13.8</b>	<b>23.8</b>	<b>150.1</b>	<b>33.1</b>
11	250	21.2	25.7		12.9			111.9	
12	250	22.0	27.4		14.7			132.2	
13	250	22.9	29.0		16.6			154.8	
14	250	23.7	30.7		18.5			179.7	
15	<b>165</b>	<b>24.6</b>	<b>32.4</b>	<b>35.3</b>	<b>20.6</b>	<b>16.1</b>	<b>21.7</b>	<b>205.3</b>	<b>40.3</b>
16	165	25.3	34.0		15.0			153.7	
17	165	26.0	35.7		16.5			173.4	
18	165	26.6	37.3		18.0			194.7	
19	165	27.3	39.0		19.7			217.6	
20	<b>165</b>	<b>28.0</b>	<b>40.6</b>	<b>0</b>	<b>21.4</b>	<b>0</b>	<b>100</b>	<b>243.1</b>	<b>243.1</b>
<b>Total production (m<sup>3</sup>/ ha)</b>									<b>350.3</b>
Mean annual increment (m <sup>3</sup> / ha/ year)									17.5

\* based on G

**Table 2.** Yield table for class 2: thinning at 4, 8 and 12 years.

<b>Yield class 2</b>									
Age (years)	N	H dom (m)	D before (cm)	D after (cm)	G before (m <sup>2</sup> / ha)	G after (m <sup>2</sup> / ha)	% thinning*	Volume (m <sup>3</sup> / ha)	Volume thinning (m <sup>3</sup> / ha)
1	1,111	2.8	2.8		0			0	
2	1,111	5.5	5.5		2.6			5.2	
3	1,111	8.3	7.3		4.7			13.8	
<b>4</b>	<b>750</b>	<b>11.0</b>	<b>11.0</b>	<b>12.1</b>	<b>10.6</b>	<b>8.6</b>	<b>18.3</b>	<b>41.5</b>	<b>3.5</b>
5	750	12.6	13.6		10.9			49.0	
6	750	13.8	14.7		12.7			62.7	
7	750	15.0	15.8		14.7			78.8	
<b>8</b>	<b>450</b>	<b>16.2</b>	<b>16.9</b>	<b>18.7</b>	<b>16.8</b>	<b>12.4</b>	<b>26.5</b>	<b>109.0</b>	<b>25.0</b>
9	450	17.2	18.9		12.6			86.6	
10	450	18.1	20.9		15.4			111.8	
11	450	18.9	21.8		16.8			127.0	
<b>12</b>	<b>300</b>	<b>19.7</b>	<b>22.7</b>	<b>24.8</b>	<b>18.2</b>	<b>14.5</b>	<b>20.4</b>	<b>143.5</b>	<b>25.5</b>
13	300	20.4	24.3		14.0			114.0	
14	300	21.2	26.0		15.9			134.5	
15	300	21.9	27.6		17.9			157.2	
16	300	22.5	28.4		18.9			170.4	
17	300	23.1	29.1		20.0			184.4	
18	300	23.7	29.9		21.0			199.0	
19	300	24.3	30.6		22.1			214.4	
<b>20</b>	<b>300</b>	<b>24.9</b>	<b>31.3</b>	<b>0</b>	<b>23.1</b>	<b>0</b>	<b>100</b>	<b>229.9</b>	<b>229.9</b>
<b>Total production (m<sup>3</sup>/ ha)</b>									<b>283.9</b>
Mean annual increment (m <sup>3</sup> / ha/ year)									14.2

\* based on G

**Table 3.** Yield table for class 3: thinning at 5, 10 and 16 years.

<b>Yield class 3</b>									
Age (years)	N	H dom (m)	D before (cm)	D after (cm)	G before (m <sup>2</sup> / ha)	G after (m <sup>2</sup> / ha)	% thinning*	Volume (m <sup>3</sup> / ha)	Volume thinning (m <sup>3</sup> / ha)
1	1,111	2,2	2.2		0			0	
2	1,111	4,4	4.4		1.7			2.7	
3	1,111	6,6	6.6		3.8			9.1	
4	1,111	8,8	8.8		6.8			21.6	
<b>5</b>	<b>750</b>	<b>11,0</b>	<b>11.0</b>	<b>12.1</b>	<b>10.6</b>	<b>8.6</b>	<b>18.3</b>	<b>42.2</b>	<b>4.2</b>
6	750	12,0	12.2		8.8			38.3	
7	750	13,0	13.4		10.6			50.0	
8	750	14,0	14.6		12.6			63.9	
9	750	15,0	15.8		14.7			80.2	
<b>10</b>	<b>450</b>	<b>15,8</b>	<b>16.6</b>	<b>18.3</b>	<b>16.2</b>	<b>11.8</b>	<b>27.1</b>	<b>103.4</b>	<b>13.4</b>
11	450	16,5	17.7		11.0			73.3	
12	450	17,1	18.8		12.4			85.9	
13	450	17,8	19.8		13.9			99.7	
14	450	18,4	20.9		15.5			115.0	
15	450	19,1	22.0		17.1			131.7	
<b>16</b>	<b>300</b>	<b>19,7</b>	<b>22.7</b>	<b>24.7</b>	<b>18.2</b>	<b>14.4</b>	<b>21.1</b>	<b>145.3</b>	<b>27.3</b>
17	300	20,2	23.9		13.4			110.0	
18	300	20,8	25.1		14.8			124.2	
19	300	21,3	26.2		16.2			139.6	
<b>20</b>	<b>300</b>	<b>21,8</b>	<b>27.4</b>	<b>0</b>	<b>17.7</b>	<b>0</b>	<b>100</b>	<b>156.1</b>	<b>156.1</b>
<b>Total production (m<sup>3</sup>/ ha)</b>									<b>201.0</b>
Mean annual increment (m <sup>3</sup> / ha/ year)									10.1

\* based on G

**Table 4.** Yield table for class 4: thinning at 6 and 13 years.

Yield class 4									
Age (years)	N	H dom (m)	D before (cm)	D after (cm)	G before (m <sup>2</sup> / ha)	G after (m <sup>2</sup> / ha)	% thinning*	Volume (m <sup>3</sup> / ha)	Volume thinning (m <sup>3</sup> / ha)
1	1,111	1.7	1.8		0			0	
2	1,111	3.5	3.6		1.1			1.4	
3	1,111	5.2	5.4		2.5			4.6	
4	1,111	6.9	7.1		4.4			11.0	
5	1,111	9.1	9.4		7.7			24.9	
6	750	10.4	10.7	11.6	10.0	7.9	20.7	37.1	5.1
7	750	11.2	11.7		8.0			32.0	
8	750	12.0	12.6		9.4			40.1	
9	750	12.8	13.6		10.8			49.4	
10	750	13.6	14.5		12.4			60.2	
11	750	14.2	15.0		13.3			67.5	
12	750	14.8	15.6		14.3			75.4	
13	450	15.4	16.1	17.8	15.3	11.2	26.7	96.0	24.0
14	450	15.9	17.6		10.9			70.6	
15	450	16.4	19.0		12.8			85.4	
16	450	16.9	19.5		13.4			92.5	
17	450	17.3	20.0		14.1			99.9	
18	450	17.8	20.5		14.9			107.8	
19	450	18.2	21.0		15.6			116.0	
20	450	18.7	21.5	0	16.3	0	100	124.7	124.7
Total production (m <sup>3</sup> / ha)									153.8
Mean annual increment (m <sup>3</sup> / ha/ year)									7.7

\* based on G

**Table 5:** Management history of tree stands in Tain II forest reserves.

Tree Stand	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Teak 2013	Pl	Bu		Pr	Th (550)	Pr	Pr			
Teak 2014		Pl	Bu		Pr	Th (550)	Pr		Pr	
Teak 2015			Pl	Bu		Pr	Th (550)	Pr		Pr
Teak 2016				Pl	Bu		Pr	Th (550)	Pr	
Teak 2017					Pl	Bu		Pr	Th (550)	Pr
Teak 2018						Pl	Bu		Pr	Th (550)
Teak 2019							Pl	Bu		Pr
Teak 2020								Pl	Bu	
Teak 2021									Pl	Bu
Teak 2022										Pl
Indigenous TAIN II FR	Pl	Pl	Pl		Pl	Pl	Pl	Pl	Pl	Bu

Pl	Planting	Pr	Pruning
Bu	Beating up	Th (550)	Thinning (trees/ha)