

Sugar cane to ethanol project, Sierra Leone

PROJECT DESCRIPTION

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October 2009

This Report should be cited as follows: Coastal & Environmental Services, March 2009: *Sugar cane to ethanol project, Sierra Leone, Project Description*, CES, Grahamstown.

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1 PROJECT DESCRIPTION

This section provides a detailed description of the project, as assessed in the ESHIA. The description here represents a project that has, where appropriate, included mitigation strategies and recommendations that flowed from the EIA process. It therefore represents the “post mitigation” project.

1.1 The proposed project

Addax Bioenergy intends to develop a Greenfield integrated agricultural and renewable energy complex in Sierra Leone producing ethanol and electricity including a large scale sugarcane estates and an ethanol processing factory. Food production through a small scale farmer support programme is included in the project. The project development area is located approximately 15 km west of the town of Makeni in the Makari-Gbanti Chiefdom of the Bombali District, Northern Province of Sierra Leone. The surveyed area is a large, gently undulating plain limited to the north by the Lunsar-Makeni highway and to the south by the Seli/Rokel River. The factory feedstock will consist of sugar cane and cassava. Over 90% of the sugarcane requirements will be sourced from the company plantation. The 10% balance, and most of the cassava will be purchased from local and regional outgrowers.

The project will be developed in an area covering about 13,500 hectares made up of a total planted area of 12,500 ha, consisting of an annual harvested area at full development of 10,500 ha and 2,000 ha lying fallow every year for a rest period, and an area of 1,000 ha for factory, residential areas and road and irrigation infrastructure. In addition, an estimated 2,000ha will be required for ecological corridors and buffer areas.

The plantation is divided into several estates which have been selected on criteria of agricultural suitability, proximity to factory and irrigation sources, avoidance of villages and food-producing areas. Therefore economic and physical resettlement is kept to a minimum.

The project will comprise a sugar factory capable of processing 4000 tonnes of cane per day, producing sugar syrup as the primary feedstock for a 350 kilolitre per day fermentation distillery and a 30 MW co-generation plant. The factory, distillery and the sugarcane estates irrigation system will be powered by the factory’s own power-plant, which will be fuelled with cane residues (bagasse and trash), plus biogas produced by the anaerobic digestion of the fermentation effluent and waste-waters. The additional electricity produced by the factory will be sold to the national grid through the nearby Bumbuna dam power line. The de-natured anhydrous ethanol will then be transported to the Petroleone port terminal in Freetown by road, for export to Europe.

The factory will be designed and built as a “multi-feed” factory which will be capable of utilizing both sugar based feedstocks (sugarcane and sweet sorghum) and starch based feedstocks, such as cassava. This will allow the factory to operate for up to 300 days per year instead of the usual ± 200 days on sugarcane alone. A maximum of approximately 20% of the factory’s feedstock requirements will be sourced from smallholder farmers.

This chapter describes the various components of the project. The section below describes the site and plantation area selection process. Following this, a detailed description of the plantation estate development is provided. The irrigation scheme is discussed, as well as the fertilizer requirements for the fields. The cane planting schedule is then presented, and the techniques used to harvest the cane described. The next section explains how the harvested sugar cane will be transported to the ethanol factory, and briefly describes the infrastructure associated with this. A detailed description of the ethanol factory and co-generation plant is then provided, which includes all the associated infrastructure and wastes streams associated with this. The transportation route between the factory and the Addax terminal in

Freetown is detailed in the section following this, and the chapter finishes off with a discussion about the other project elements such as staff housing etc.

1.2 Site description and background to the plantation area selection

The proposed development site is situated on a large, gently undulating plain in the Bombali district in between the towns of Makeni and Lunsar. The site has been previously degraded through human activity, and scared by former tobacco plantations ending in late 1980, and most of the original vegetation has been cleared or burnt a long time ago to make way for irregular use as pastures and for subsistence farming.

The Mabole and the Seli/Rokel rivers delineate the northern and southern boundaries of the site. The site has a number of villages on it and the villagers practise scattered agriculture across some of the site. The villagers use small areas for annual staple crops such as rice and leave the remaining areas fallow for a pre determined period. These fallow lands are periodically burnt and used as new planting areas (slash and burn agriculture). Forested areas are generally limited to areas directly adjacent to the villages, and many of these are plantations of mangoes, oil palms, cashews etc. Riparian vegetation occurs along small river courses and in areas close to villages.

As is common with projects of this scale, the project description and particularly the site selection have gone through four phases. This section describes the process the project has been through to explain to the reader how this project has evolved from its initiation, and how the results of various studies, included this ESHIA, have influenced the project.

1.2.1 Phase 1

The original gross project boundary was set around an area of approximately 87,000 ha (Figure 1.1). The rough boundaries include the Seli/Rokel and Mabohe Rivers in the south and north respectively, the town of Makeni in the east and Yankisa town and Belia River to the west. The Tabai River bisects the study area.



Figure 1.1: Map indicating the broad area considered during phase 1

1.2.2 Phase 2

During Phase 2 Addax originally identified and surveyed an area of about 45000ha. Six potential areas suitable for estates were identified, including both uplands and bolilands and were considered suitable for further detailed development (Figure 1.2). However, during the January 2009 scoping phase site visit by CES, and based on remote sensing techniques, two of the plots (plots 4 & 5) were excluded as potential development areas. This was mainly due to two factors:

1. The areas are very populated; therefore developing estates in these areas would require too many people to be resettled.
2. The area has relatively high forest cover, and is therefore considered too bio diverse for the purposes of this project (in line with the EU RED).

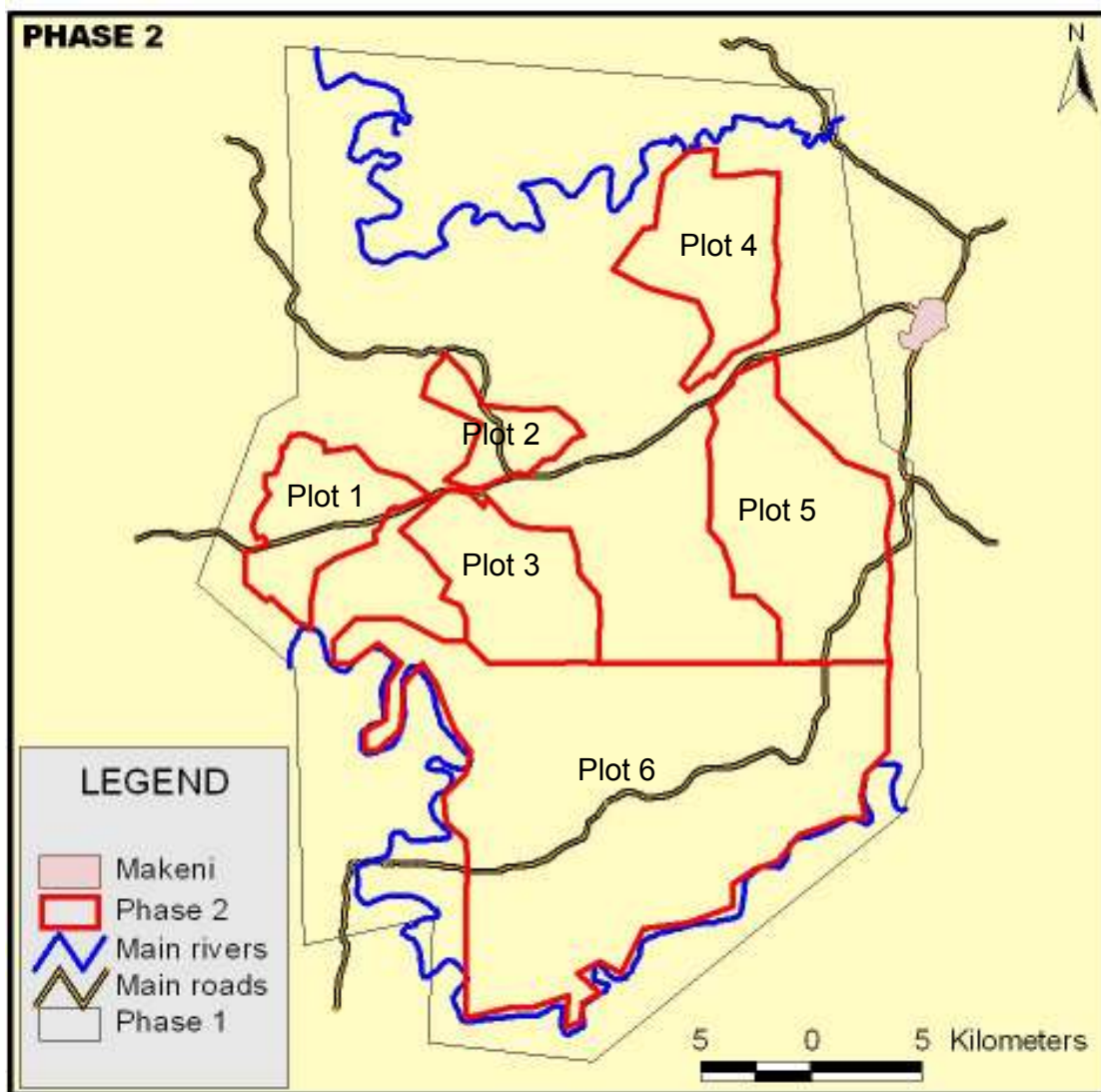


Figure 1.2: Map indicating the 6 broad estates considered in phase 2.

1.2.3 Phase 3

Due to the exclusion of plots 4 and 5, and due to logistical considerations, the area south of the Makeni to Freetown road was then considered. This was because it was recognised at this stage of the project that in order to minimise traffic impacts on the Makeni to Freetown road, the estates should ideally all be located on the same side of the road. Thus Phase 3 considered areas below (south) of the road (Figure 1.3).

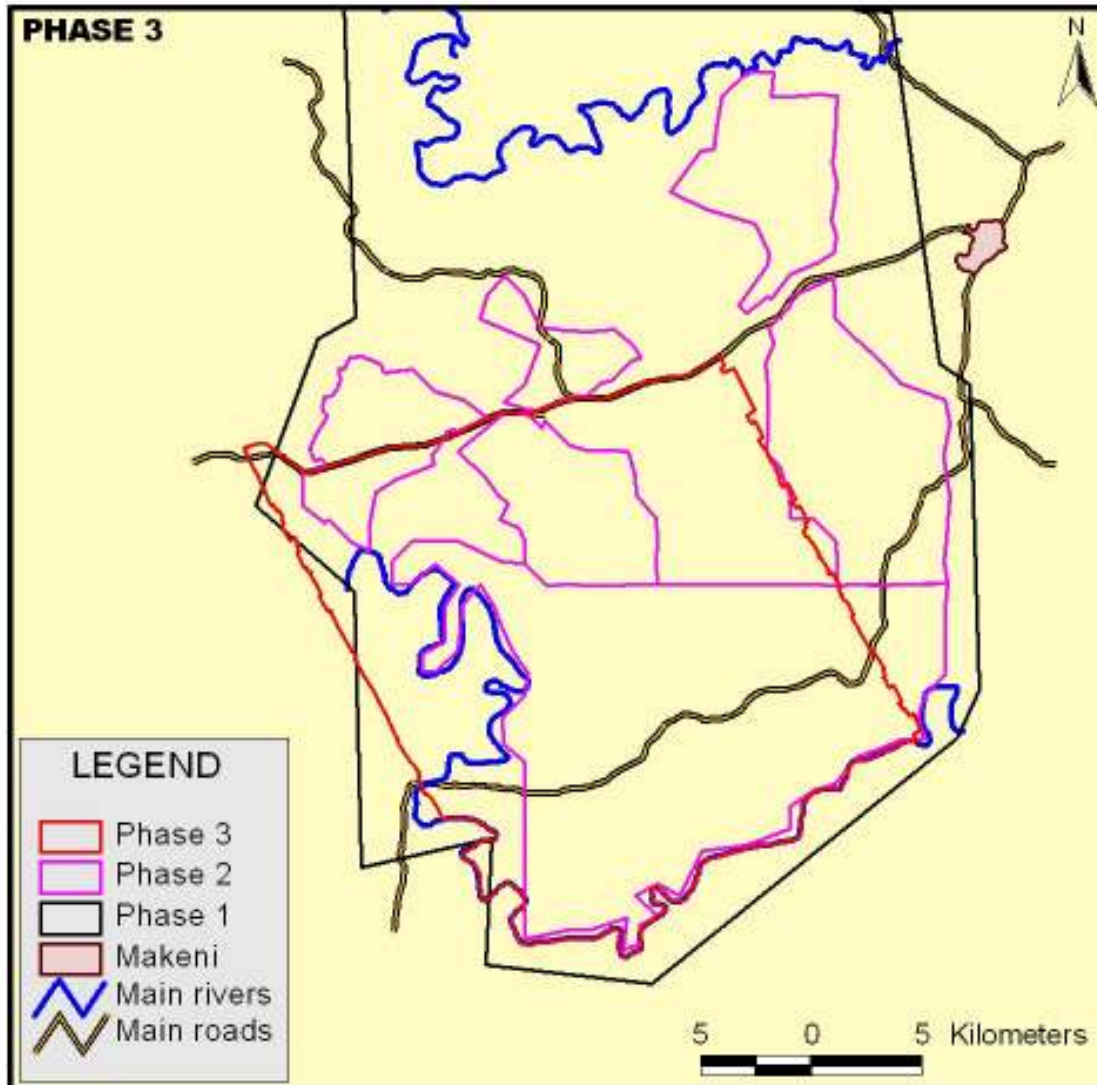


Figure 1.3: Map showing the area considered during phase 3.

Based on Phase 3, and with the help of detailed aerial imagery, tentative field layouts were identified within the greater boundary area of Phase 3 (Figure 1.3). There are several reasons for which these areas in particular have been selected as potential planting areas including:

1. There are no villages within these plots.
2. There is very little or no forest in these plots. Note: any forest that does occur in the plots will not be removed since this would be in conflict with the EU RED.
3. The soils in these areas are considered to be suitable to grow sugarcane in an economical way.
4. The slopes in these areas are considered suitable for the type of planting and irrigation Addax intends to use.
5. Proximity to water (primarily the Rokel/Seli and Tabai Rivers).
6. Agricultural and infrastructure requirements.

7. Sustainability criteria.

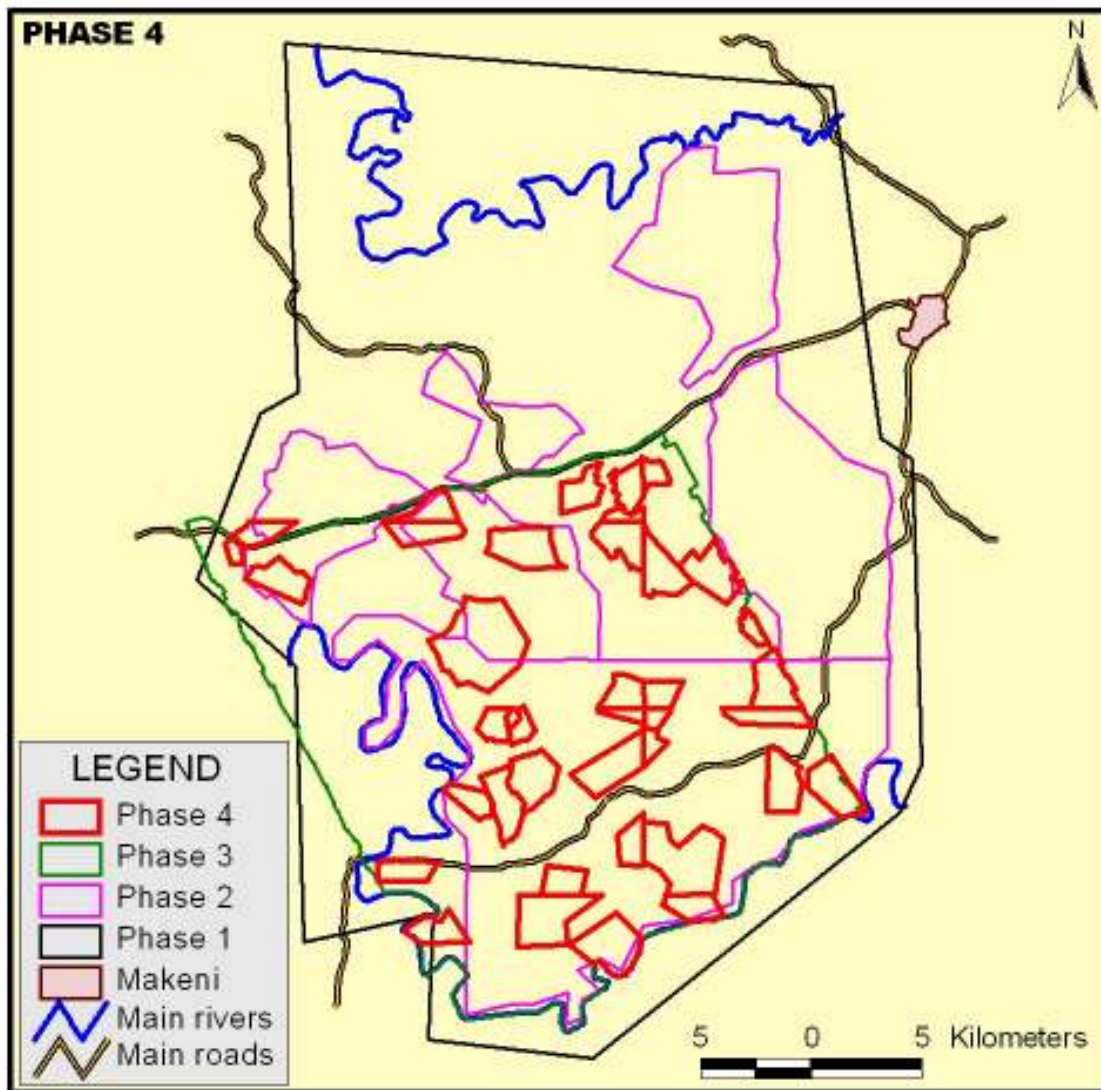


Figure 1.4: Proposed fields for the Addax project

Thus the scattered nature of the fields depicted in Figure 1.4 is a result of the different criteria used to select potential planting areas. A detailed contour mapping of the project area is under way which indicates elevations and depressions with a precision of 300 mm. Thus it is likely that the layout shown in Figure 1.4 will change as the implementation of the project begins. Addax will only develop lands which will have been legally leased and as this process is still to be finalised, the layout depicted in Figure 1.4 may be subject to change for this reason as well. It is important to point out that Addax land selection strategy is based on avoiding any physical resettlement.

However, for the purposes of this ESHIR the proposed layout depicted in Figure 1.4, referred to as phase 4, will be used in order to identify environmental impacts, detail proposed mitigation measures and rate all impacts associated with the project. In instances where impacts are site specific, the specialists have made recommendations for further study once the final layout of the fields has been determined.

As is common with projects of this magnitude, the plots have changed significantly from the time of site visit and disclosure of the scoping report to the writing of the ESHIA. The areas that were excluded during phases 1-3 will no longer be developed for the project, but they could be considered for smallholder development.

1.3 Proposed sugarcane estate development

1.3.1 Sugarcane plantation establishment

The plantation will be slowly expanded, beginning with a pre-nursery. The varieties will be grown out for 9 to 10 months to provide disease free varietally pure seedcane to plant a 10 times larger 2nd stage nursery. The 2nd stage nursery will in turn multiply the seedcane by a factor of 10 in order to provide the large quantities of seedcane necessary for planting the commercial sugar cane lands. This 3 year bulking up process will become a permanent feature of the production cycle, with a fresh pre-nursery being established each year from selected varietally pure and disease free sugarcane or imported tissue cultured “in-vitro” plantlets. This is necessary to ensure the best quality and up to date varieties of seedcane are available for the commercial cane growing operations.

There are no local sources of high quality sugarcane varieties therefore suitable international varieties of sugar cane will need to be used. All importations of plant material for the project will be done under strict international protocols generally as envisaged in the Cartagena Protocol and in accordance with international regulations for the movement of fauna and flora across international frontiers. This rules out the transfer of vegetative material or rootstocks and all imports will be in the form of certified tissue cultured in-vitro plantlets. These will require specialised and quarantined growing out facilities to establish and harden off the plantlets prior to planting in the pre-nurseries for bulking up of commercial seedcane.

A pre-nursery has already been planted using cane varieties Q88 and S13 from a nearby sugarcane plantation and about 6 hectares have already been established. The pre-nursery will be expanded to 40 hectares in October/November 2009 and will provide the seedcane necessary to keep pace with the expansion of the plantation.

This existing pre-nursery area will also serve for the planting and bulking up of break-crop seeds like soya beans, rice and as a test plot for trials of imported cane varieties and for cassava.

1.3.2 Rationale for irrigating the estates

The study area is characterised by a distinct dry and wet season (please see Chapter 6 for a description of the climate in the study area). The average rainfall in the study area is 3000mm and this quantity of rainfall is more than double the amount needed to produce a reasonable crop of sugarcane. However the distinctive wet and dry season results in an excess of water for part of the growing period and a deficit for the remainder of the usual 12 month sugarcane production cycle.

The long dry period will result in substantial water deficits occurring during the sugarcane crop growth period therefore supplementary irrigation will be used to optimize yields. The fresh sugarcane will be planted in the different estates over a period of 4 to 6 months, therefore the various plantings and subsequent ratoons will be at widely different growth stages. This means that different agronomic and irrigation practices will need to be conducted on different fields throughout the growing period. Newly germinated or re-sprouting ratoon cane has a shallow rooting zone and low water requirements and due to this, relatively little irrigation will be needed in the early growth stages. As the cane grows, its root mass will increase and spread, the above ground foliage will also increase and the plant will transpire more water into the atmosphere. Due to this, the need for irrigation water will increase as the crop matures. The diagram below (Figure 1.5) graphically illustrates this sequence of growth and water use.

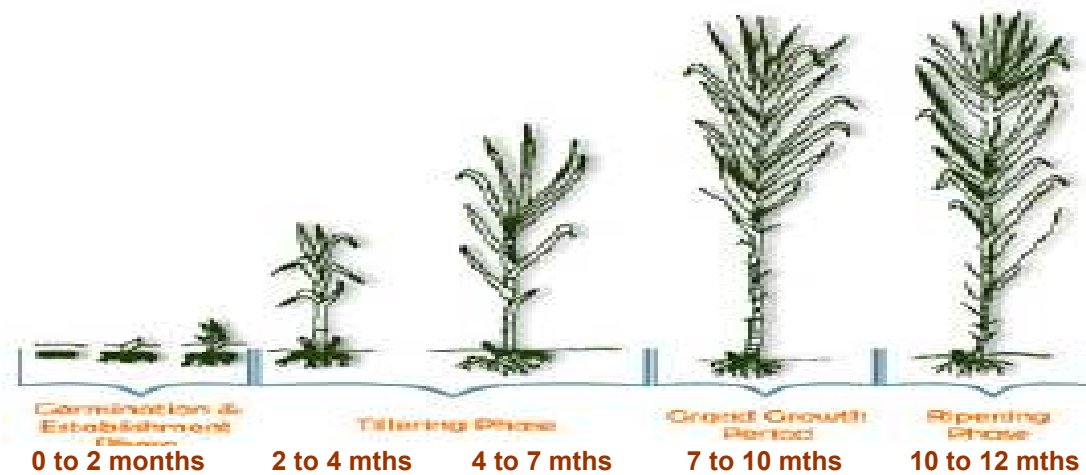


Figure 1.5: Diagrammatic Illustration of the Typical Growth Phases of Sugarcane over a 12 Month Cycle

Irrigation will not be required during the wet season, but the establishment of properly planned and constructed water control and drainage structures in the sugarcane fields to cope with the large quantities of rain water will be an important prerequisite to land preparation and planting of the sugarcane. Soil erosion will be a potentially serious constraint if adequate conservation measures and controls are not implemented. The Bolilands in the study area will require suitable water diversion and flood control measures to be put in place to manage the inevitable seasonal inundation which will occur during the peak rains.

In order to counter the large volumes of water on the fields during the wet season, Addax will ensure that all fields are surveyed and that the necessary land forming and erosion control structures are implemented. This will ensure that stormwater is rapidly removed from the cropping areas without causing erosion or ponding in the fields.

In order to achieve this, Addax propose to implement a “broad based” contour ridge system which will be built at right angles to the crop rows at intervals determined by the gradient of the fields. Contour ridges are commonly used to divert water flows from cultivated lands. Generally one of two types are employed: broad based / wide bottom ridges or narrow based ridges. Broad based ridges shown below (Plate 1.1) are used on flat lands and can allow machinery to pass over them. Narrow based higher ridges are used on steeper slopes, and are usually planted with grass on their downslopes. They are designed to withstand the faster flowing water emanating from the steep rows. Conventional farm machinery cannot pass over these narrow based contour ridges (Figure 1.6).



Plate 1.1: An Example of Broad Based Contour Ridges

Broad based contour ridges allow the exit and entry of machinery along their shallow and wide drainage channels during the dry season, and are therefore of use in the harvesting process. This is because the infield harvesters can get in or out of the fields at regular intervals without having to travel the entire length of the field every time their trailer is full. The broad based contours also allow the mechanical harvesters to travel non stop from end to end allowing them to operate more efficiently.

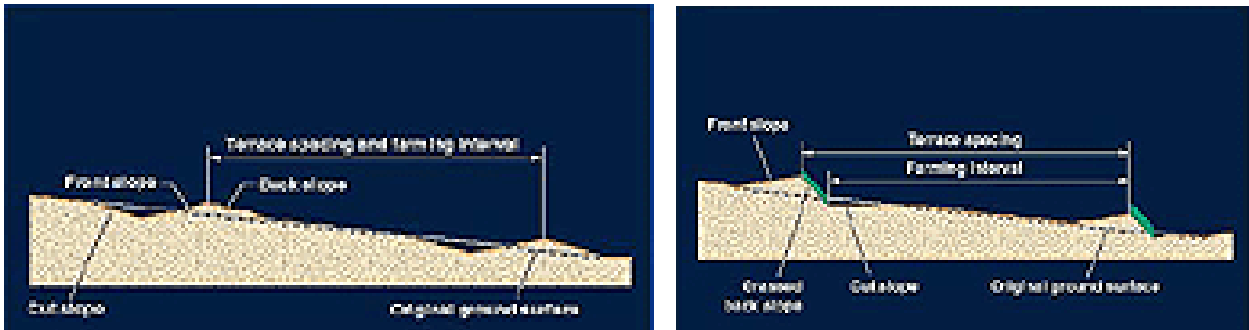


Figure 1.6: Broad (left hand side) and narrow (right hand side) based contours

The field borders will be levelled and suitable grasses will be planted to hold the soil together and reduce susceptibility to erosion from water and mechanical forces. Mechanical harvesters and infield transporters are large heavy machines and adequate turning room is required on the headlands (the area at each end of the field) to allow them to turn without stopping and reversing or ploughing up the soil. All headlands will be at least 10 metres wide for this purpose. The edges of fields will also be at least 5 metres wide, cleared of trees, debris and other obstacles in order to facilitate the regular mowing of grass and to allow fast access by fire fighting vehicles in the event of fires breaking out in the canefields or adjoining areas.

The control and dispersal of stormwater flows once they exit the field areas will also receive attention in the planning and land preparation stages. The diversion of water by means of contour ridges necessarily results in concentrated flows of water at the exit points. This can lead to serious erosion problems at these “point load” areas. If not dealt with properly, they soon grow into large gullies and this eventually leads to stream or riverbank erosion. The water leaving the fields must be spread out and its flow velocity reduced as soon as possible.

Contour ridges are designed to maintain adequate water flows without eroding the soil, but the very high water flows caused by heavy rainstorms tends to load the contour furrows to their limits and thus increases the flow rate, causing erosion to occur. Several methods can be used to dissipate and slow down water flows, including grassed waterways. Grassed waterways are designed to accept high flows from the contours discharging onto them, and to channel them down towards natural watercourses or wetlands for safe dispersal.

Grassed waterways (Figures 4.7 and Plate 1.2) are specially graded areas planted with suitable grasses to counter the erosive forces of the water and to slow down the speed of flow. The waterways get larger as more subsidiary waterways feed into them in order to accommodate the increasing flows of water running off the croplands during heavy rainfalls (Figure 1.7). A good grass cover is essential in order to prevent erosion of the soil in the waterways. The indigenous riverine trees are left intact and a wide area of at least 75 metres is left uncultivated and undisturbed along the banks of the river (Plate 1.2). The water is then discharged into suitable wetlands or swamp areas or into watercourses which are adequately protected to receive these periodic high water flows.

If the watercourse does not have natural features such as rock outcrops which can accept the water flows, artificial stabilization may be required. This can either be a hard engineering structure (e.g. rock filled gabions and in extreme cases concrete) or a soft engineering structure (e.g. planting suitable tree or swamp species along the affected riverbanks to hold

the soil together and protect the banks from undercutting and collapse).



Figure 1.7: Illustration showing contours discharging into grassed waterways



Plate 1.2: Well Planned and Laid Out Field Contours and Waterways

Depending on the circumstances and topography of individual lands, it may be necessary to construct other water control structures such as sediment traps or artificial wetlands, or even underground pipe drains. Each field will be evaluated and developed as a separate entity based on its own unique characteristics regarding soil type, slope, adjacent areas and other natural features. These evaluations and remedial measures will all be implemented as part of the overall field preparation.

1.3.3 Land selection criteria

Aerial photographing of pre-selected areas has been undertaken and these photographs were used to identify suitable areas for further detailed ground surveying and soil sampling. These preliminary areas are shown in Figure 1.8 below, which also shows the irrigation and electricity infrastructure. It is important to note that these field locations may still change since the land lease process is not yet complete.

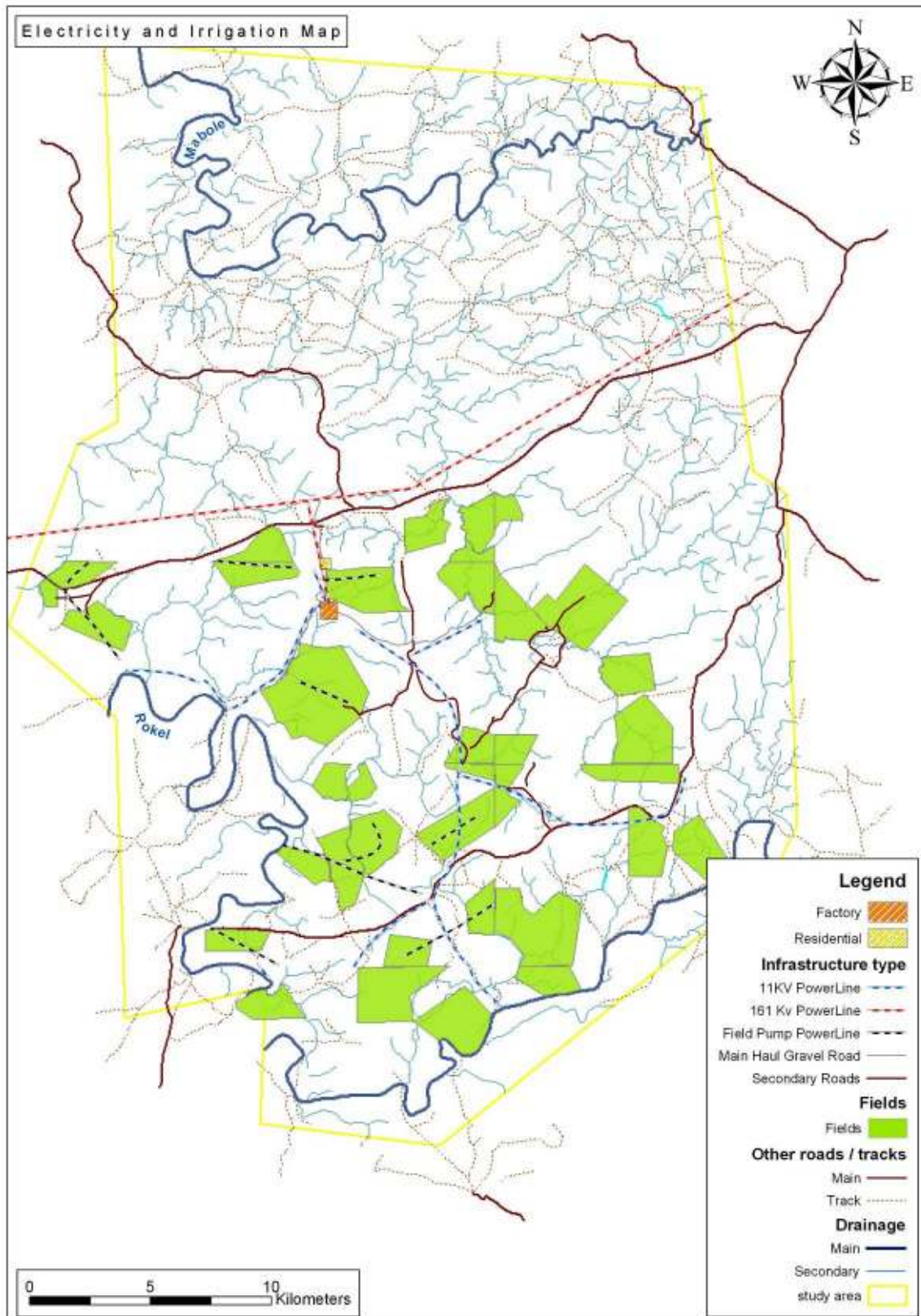


Figure 1.8: Proposed plantation estates land layout including the electricity and irrigation infrastructure.

Detailed ground surveys were carried out in conjunction with the aerial photography and these were used to develop accurate contour maps and digital terrain models. These will be used to design the necessary waterways, contours and land forming required to ensure the

adequate controlled removal of storm waters and to laser level the ground to the required gradients for flood irrigation. Whilst laser land levelling will not be absolutely essential for efficient operation of overhead irrigation systems, accurate contour mapping and designing of field layouts to optimise water movement will be necessary wherever furrow irrigation is the preferred method of irrigation (for an explanation of the irrigation methods to be used please see section 1.3.6 below).

Land selection will be based on choosing suitable areas for estate sugarcane production which do not require the physical re-settlement of people or villages. All detailed planning of selected lands will be carried out in accordance with current International BMP's and with due cognisance of the need to develop sustainable long term agricultural operations.

1.3.4 Land clearing

In accordance with the EU regulations on renewable fuels, no areas of forested land will be cleared for the planting of sugarcane. Most of the pre-selected land areas are savannah grassland with relatively little tree cover, and will require minimal heavy equipment to prepare them prior to heavy discing and ripping before land forming takes place.

Relatively large quantities of tree stumps remain in certain, previously cleared areas which will require heavy equipment to clear the land prior to heavy discing and ongoing land preparation operations. Addax will use conventional heavy Caterpillar bulldozers, Excavators and Traxcavators to remove the tree stumps (Plate 1.3). Articulated Dump Trucks (ADT's) will be used to carry off the stumps and roots to designated areas outside the selected land areas. Once de-stumped, heavy discing and land forming will take place in accordance with the overall land preparation plans. Initial land preparation is based on root grubbing or raking with heavy Caterpillar equipment to a depth of approximately 360 millimetres. This will be followed by a single heavy discing, prior to the broadcast application of lime and/or basic phosphate fertilisers which will then be incorporated by a second lighter cross discing operation.

Thereafter, land forming will take place as required according to the detailed land surveys and the type of irrigation to be employed. Flood or furrow irrigated areas on the heavier clay soils will require precise land forming involving accurate levelling to produce the uniform gradients needed (Plate 1.4). Overhead irrigated areas will be levelled sufficiently to ensure good storm water dispersal using only land planning operations rather than laser controlled cut and carry work (as is required for the flood irrigation areas).



Plate 1.3: (from left to right) Cat ripper equipment, heavy discing equipment and light discing/ finishing equipment



Plate 1.4: Laser controlled land forming equipment

1.3.5 Proposed cane field design

Addax proposes to use a raised beds system incorporating minimal tillage (Plate 1.6). Minimum tillage refers to the practice of minimising the amount of cultivation or soil disturbance necessary for crop production. This involves the establishment of raised beds and implementing controlled traffic on the sugarcane fields. Controlled traffic is the practice of permanently separating the crop growth zone from the traffic zone and matching the row-spacing with the machinery wheel spacing (Plate 1.5).

Minimum/zero tillage leads to reduced costs of soil preparation and a significant reduction in sediment run-off (up to 30%) due to reduced soil compaction and less soil disturbance. It is a recognised international BMP.



Plate 1.5: An example of controlled traffic. The machinery only passes in the inter row area, leaving the growth zone intact.

International experience has shown that controlled traffic is a vital new concept in sugarcane production. Until recently, the combination of random axle lengths on in-field machinery and mismatched row spacings caused widespread soil compaction in the growth zone of cane rows. Thus, all tractors, trailers, harvesters and wheeled implements will be built or modified to match the crop row spacing chosen. This will ensure that the row is only for growing plants and the inter-row becomes a hard and permanent wheel track. Furthermore, low ground pressure flotation tyres or tracks in very wet areas will be fitted to the harvesters and infield transporters. Using this system, the tractors will be able to access to fields during wet weather.



Plate 1.6: Forming Raised Beds in New Lands

As described earlier, water flows must be controlled both within the cane lands and also once the water exits the lands on its way to its final destination in a natural water course or wetland area. The fields will also be designed to enable the practise of flood irrigation (Plate 1.7). In this case, water is flooded along the cane rows at a controlled rate ensuring optimal irrigation of the root zone of the sugarcane.

The raised beds which will be constructed for planting the seedcane will run at right angles to the contour ridges. This will allow the excess water to run down the furrows between the beds and end up in the contour channel. From here it will in turn be guided off the land into the grassed waterway and ultimately into the nearby river.



Plate 1.7: an example of well made and graded beds that can be used for flood irrigation

1.3.6 Sugarcane irrigation - Plantation operation

Based on the soils and topography in the study area, Addax intends to use surface and overhead irrigation techniques according to the soil types and topography of the sugarcane fields. Addax will use modern techniques to apply computer controlled amounts of water to the plants.

Surface or flood irrigation is the application or distribution of water over the surface of a field by gravity flow. Furrow irrigation avoids flooding the entire field surface by channelling the flow along the primary direction of the field using furrows, raised beds or corrugations. Water infiltrates through the wetted perimeter and spreads vertically and horizontally through the ridges or raised areas to refill the soil water profile.

One of the main items of consideration in surface irrigation design and planning is soil type. Sandy and coarse grained soils are usually unsuitable for surface irrigation due to the high infiltration rates which allows the water to percolate downwards rather than spreading across the surface to evenly cover the whole field. Finer textured clays and silty loam soils are better suited to surface or flood irrigation regimes as they allow the application of controlled amounts of water over relatively large field areas.

The implementation of modern surge controlled surface irrigation methods will entail detailed topographical surveying in order to develop a computerised “cut & fill” programme. The cut and fill programme will use satellite monitored laser controlled land forming equipment to move the soil where it is required. This will enable Addax to establish highly accurate gradients and levels. Once these gradients are set up on the field, Addax will be able to apply irrigation water in the field in a controlled manner using gravity.

Addax anticipates that they will use surge valves on the bolilands (Plate 1.8). Surge irrigation using computer controlled surge valves will switch the water flow in the distribution pipeline from one section to another. These irrigation systems can increase the application efficiency of a furrow irrigation system by 10% to 40%. Surge Valves reduce infiltration rates, decrease advance time, reduce tailwater at the lower end of the field and reduce deep percolation at the upper and lower ends of the field.



Plate 1.8: Surge valve controllers operating on layflat gated irrigation pipes



Plate 1.9: Installing layflat piping

Layflat Tubing will be used to transport the irrigation water around the estates (Plate 1.9). Layflat tubing is a thin wall polyethylene tube and it can increase system efficiencies by 5% to 20%. Lay flat tubing is a good cost effective substitute for earthen ditches and aluminium surface or gated pipes. It is a disposable product lasting five years which has a very low pressure rating and, therefore, is not suitable for pressured irrigation systems.

Gated pipes will be used to control the infield distribution of water into the furrow (Plate 1.10). Traditionally, surface irrigation was based on open furrows and manually operated siphon tubes, or by physically opening and closing the earthen walls of the main furrow into the field distribution furrows. Gated Pipes are now the commonly used approach on commercial farms.



Plate 1.10: Flood irrigation control: manual versus gated pipes.

The upland areas of the study site are unlikely to be suitable for surface irrigation due to their steeper slopes and their gravelly nature which makes them extremely free draining. In order to control leaching of water and nutrients through these soils, irrigation water applications will be at low rates and relatively frequent intervals. Some form of sprinkler or drip irrigation will be required for these areas. Drip irrigation is viewed by Addax to present too many management problems under large scale sugarcane production scenarios. Travelling reels would be too expensive to run on large areas of commercial cane. Various forms of overhead irrigation are under study. Addax proposes therefore to install permanent set floppy irrigation or center pivot systems in the upland areas.

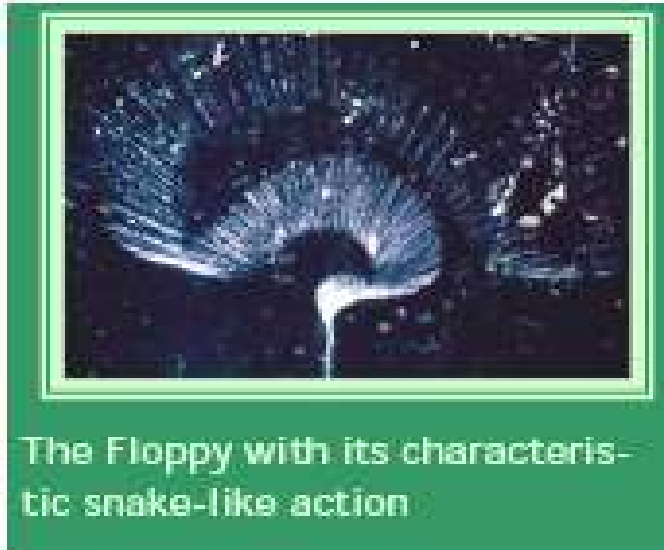


Plate 1.11: The floppy sprinkler system.

The floppy Sprinkler system essentially comprises a thin flexible silicon tube and will be used wherever surface irrigation is not possible (Plate 1.11). “Permanent set” floppy irrigation systems have proved to be ideal on many cane farms for irrigating sandy soils at low application rates and fast turnaround times.

The floppy risers are attached to relatively small bore underground polythene pipes which are buried well below the surface in the canefields, which in turn connect to larger distribution lines which will be independently controlled either manually or electronically. This will allow for virtually 100% automation if desired. The ability to automate the floppy irrigation system using relatively cheap and simple computer controls and telemetry linked to automatic weather stations is a major benefit for large scale irrigation projects.

Central pivot irrigation is a form of overhead (sprinkler) irrigation consisting of several segments of pipe (usually galvanized steel or aluminium) joined together and supported by trusses, mounted on wheeled towers with sprinklers positioned along its length. The machine moves in a circular pattern and is fed with water from the pivot point at the center of the circle. The outside set of wheels sets the master pace for the rotation (typically once every three days). The inner sets of wheels are mounted at hubs between two segments and use angle sensors to detect when the bend at the joint exceeds a certain threshold, and thus, the wheels should be rotated to keep the segments aligned. Centre pivots are typically less than 500m in length (circle radius) with the most common size being the standard 1/4 mile machine (400 m). In order to achieve uniform application centre pivots require a continuously variable emitter flow rate across the radius of the machine. Nozzle sizes are smallest at in the inner spans to achieve low flow rates and increase with distance from the pivot point.

Most center pivot systems now have drops hanging from a u-shaped pipe called a *gooseneck* attached at the top of the pipe with sprinkler heads that are positioned a few feet (at most) above the crop, thus limiting evaporative losses and wind drift, (Plate 1.12). There are many different nozzle configurations available including static plate, moving plate and part circle. Pressure regulators are typically installed upstream of each nozzle to ensure each is operating at the correct design pressure. Drops can also be used with drag hoses or bubblers that deposit the water directly on the ground between crops. This type of system is known as LEPA (Low Energy Precision Application) and is often associated with the construction of small dams along the furrow length (termed furrow diking/dyking). Crops may be planted in straight rows or are sometimes planted in circles to conform to the travel of the center pivot.



Plate 1.12: Ground View of Center Pivot Systems

Originally, most center pivots were water-powered. These were replaced by hydraulic systems and electric motor-driven systems. Most systems today are driven by an electric motor mounted at each tower.

For center pivot to be used, the terrain needs to be reasonably flat; (Plate 1.13) but one major advantage of center pivots over alternative systems is the ability to function in undulating country. This advantage has resulted in increased irrigated acreage and water use in some areas. The system is in use, for example, in parts of the United States, Australia, New Zealand, Brazil and also in desert areas such as the Sahara and the Middle East.

Potential specific impacts of the use of center pivot irrigation versus floppy irrigation have not been assessed by CES at the stage of the draft ESHIA report and will be included in the final ESHIA report.



Plate 1.13: Aerial View of Sugarcane Fields Irrigated with Centre Pivots.

Addax intends to use soil moisture monitoring and irrigation scheduling to optimise their irrigation operation. Soil moisture monitoring helps irrigators to utilise their irrigation water efficiently by preventing over or under irrigation. This technique is most effective when used with an irrigation scheduling program. Scheduling is the practice of applying irrigation water to the crop in amounts that the crop can efficiently utilize, when the crop needs it, and in amounts that are not in excess of the soil water holding capacity. Proper irrigation Scheduling also maintains a storage deficit in the soil profile to make room available for rainfall when it occurs, thus maximizing the utilization of natural rainfall as well as irrigation water.

1.3.7 Sugarcane irrigation- Pre nursery operation

The pre-nursery operation at Makeni uses travelling reel irrigators, as these lands are not prepared with precision levelling equipment and therefore have relatively uneven surface areas unsuitable for flood irrigation. In addition, the seedbed areas are used in a relatively fast rotation system to prevent the carry over of pests and diseases to subsequent seedcane crops. Mobile diesel pumps are stationed at the nearby river to pump the necessary water for the seedcane crop.



Plate 1.14: Travelling Reel Irrigator in Operation

Travelling reel sprinkler systems are a sophisticated combination of portable pipeline and dragline systems. They utilise a strong flexible hose attached to a mechanically operated reel (Plate 1.14) which in turn is mounted on a 2 or 4 wheeled trailer chassis. In operation, the reel is placed in position in the centre of the area to be irrigated. Once in position, the sprinkler carriage, which is attached to the end of the flexible hose, is pulled out to the end of its run and the water pump is then opened. This supplies pressurised water through the turbine mechanism to the sprinkler head or “big gun” mounted on the carriage at the end of the hose (Plates 4.14 and 4.15). The turbine automatically begins to reel in the hose, dragging the sprinkler carriage with it. Powered by water under pressure, the sprinkler “travels” the length of the field. A mobile diesel engine pump with portable pipelines can be used to supply the necessary water under pressure to the hose reel. In permanent systems, an underground high pressure motherline with hydrants at the correct spacing can be installed to supply the water.



Plate 1.15: “Big Gun” sprinkler

1.3.8 Proposed water abstraction, transport and storage for irrigation

The provision of sufficient water for the irrigation needs of the proposed estate will require further detailed investigation and accurate surveying of the entire area. Addax will need to establish where main and secondary canals can be routed at least cost and where river offtakes can be sited with minimal environmental consequences. They will need to estimate pumping requirements in terms of access to electrical power and energy consumption. Cost estimates comparing open canals and pipelines will have to be considered in order to select the most cost effective alternatives. A preliminary layout of the canals, pipelines and river offtakes is shown in Figure 1.8 above.

Addax is currently proposing two alternative options for water abstraction and transportation at the Makeni site:

1. The use of canals and pipelines, where water will be pumped via pressurised pipelines, to high points above field areas from the Seli/Rokel. This water will be transferred to open channel lined canals for further distribution to adjacent lower lying fields. The infield distribution will be operated by means of surge controlled layflat gated pipe systems. Upland areas will be irrigated using floppy sprinklers with field pumps drawing water from the gravity canals.
2. Diverting controlled amounts of water from the Seli/Rokel into the Tabai River via a flapgate and buried gravity pipeline. The water volumes will be controlled using manually operated flap gates to ensure that only the required amount of water is abstracted to minimise abstraction from the Seli/Rokel River.

The second option involves connecting the Tabai and Mabole Rivers to the Seli/Rokel River. Since the Tabai and Mabole Rivers are not in any manner connected to the Seli/Rokel River and since there was insufficient information regarding the fauna of either of these rivers an additional specialist study (not anticipated in the Scoping phase of the project) was undertaken. This inter catchment transfer study identified the risks associated with this proposed irrigation scheme (Refer to Specialist Report no. 13, volume 2) for more information on this study.

1.3.9 Sugarcane planting

The physical planting of the sugarcane will be undertaken using semi mechanised planting of whole stalk cane. Double disc furrow openers mounted on the toolbars of mechanised stalk cutters will open the furrows, and chopped lengths of seedcane will be continuously planted into the ground (Plate 1.16). Double disc opener planting is a technique that enables minimum tillage to be practised. The planter contains two coulter discs that meet at a point to slice through the sugarcane stubble (which is the remaining sugarcane after harvesting) and part the soil to allow the billet (the short piece of sugarcane left in the ground) to be placed in a position that will allow good soil to billet contact.

The seedcane will be simultaneously sprayed with fungicide and/or termite control chemicals and immediately covered before being compacted by the planters press wheels.

Within 24 hours of planting, herbicides will be applied to the cane by boom sprayers. Shortly thereafter, the sugarcane will be irrigated using overhead spray irrigation techniques to initiate germination and ensure that the herbicide previously applied is adequately incorporated into the soil surface to optimise the chemicals' effectiveness. Flood irrigated areas will receive this initial irrigation by means of portable travelling reel irrigators, as normal flood irrigation will not provide the necessary overall water application necessary to incorporate the herbicides.



Plate 1.16: typical mechanised billet planters in operation

The commercial cane crop will be grown in accordance with the latest internationally accepted BMP's on a 5 year cycle of 1 year "plantcrop" (the 1st year's crop from planting seedcane) and 4 years of "ratoon" crops (ratoon crops are the crops which regrow after the cane is cut and harvested). Depending on variety, agricultural conditions and the estates policy, cane can be rationed for anything from 2 to as much as 11 or 12 years before declining yields necessitate replanting with fresh seedcane. At Makeni a 5 year rotation followed by a full years leguminous "break crop" is anticipated.

A leguminous break crop (probably soya bean) will be allowed to grow until it reaches maturity. This is done because it breaks the monocrop cycle of sugarcane and can supply nitrogen to the soil by a process known as nitrogen fixation. This is of great value to future sugarcane as it requires nitrogen in the soil to grow, and reduces the fertilizer requirements. It also slows the spread of sugarcane disease, because legumes are often resistant to diseases and pests that affect sugarcane. The presence of the legume instead of the sugarcane effectively removes the host or habitat of the disease or pest, thereby greatly reducing its abundance. A legume fallow also leads to improved microbial soil health. Implementation of legume fallows can lead to a reduction in sediment runoff, as less soil disturbance occurs over time while improved cane growth leads to a larger canopy cover and high trash levels for mulching operations. This is especially relevant in areas such as Sierra Leone with a high rainfall. This approach is based on the findings of Australian research which has shown that this cropping regime maintains yields and enhances the sustainability of the sugarcane crop (Garside *et al.* 2005, Sugarcane production Best Management Practices, Louisiana State University). Additionally, a 5 year crop cycle will allow the introduction of improved varieties faster than, for example, an 8 or 10 year cycle.

Leguminous break crops will be planted directly into the dead cane stubble and grown out to maturity. In some cases, the legume seeds may be harvested either to supply seed for further plantings or for sale. Harvesting of the seed significantly reduces the amount of Nitrogen which is fixed in the soil by the legumes and consequently affects the fertilisation regime of the following cane crop. By the end of the wet season the legume crop will either be left to die or killed by spraying with Glyphosate herbicides and, in turn sugarcane will then be re-planted.

Most of the pre-preparation work for the following cane crop under minimum tillage consists of either slashing (but not incorporating) the legume crop and the application of a chemical spray to control weeds. The seedcane is thereafter planted directly into the leguminous crops stubble using suitable double disc furrow openers.

1.3.10 Application of fertilizers, herbicides and pesticides

Significant quantities of nutrients are required in order to achieve the high yields expected from commercial crops of irrigated sugarcane. Agriculturists in developed countries generally make use of inorganic or so called “artificial” fertilisers to provide the necessary elements for optimal plant growth and top yields. The application of inorganic or organic fertilisers and manures can result in unintended negative consequences if care is not exercised in the application of these fertilisers. Excessive application rates can result in nutrients being washed off the surfaces of fields by stormwater or being leached downwards through the soil by over irrigation or rainwater. These nutrients can end up in natural watercourses and ultimately accumulate in deposits in the estuarine environments of these rivers. Nutrients can have severe negative impacts on aquatic environments because they can cause imbalances in nutrients inputs (See the Hydrology and Surface Water, Assessment, Specialist Report no. 2, Volume 2 ESHA, for more details).

Growing awareness of these problems over the last few decades has focused attention on methods of preventing or drastically reducing the potential for agricultural crop nutrients to contaminate the surrounding environment and watercourses. Trials on alternative methods of fertilisation and land preparation has resulted in several BMP's, which shows that it is possible to drastically reduce production costs and fertiliser usage while maintaining or increasing yields. The adoption of minimum or zero tillage as described earlier in this document reduces tractor use without affecting yields. Reduced fertiliser use, particularly nitrogen coupled with leguminous break crops cuts costs and has been shown in Australia to eliminate nutrient runoff or leaching of nitrogenous and phosphate fertilisers.

In addition, another very positive and important factor for ethanol producers has been the development of more environmentally friendly, profitable and sustainable methods of utilising the vinasse which is produced in very large quantities by fermentation distilleries and which in the past has often been a major source of pollution. Vinasse (stillage or distillery effluent) is one of the co-products which is produced in the manufacture of anhydrous ethanol from sugarcane juice using conventional yeast fermentation technologies

Once considered a major environmental problem for the sugar production industry, modern technology has enabled growers to utilise this product after suitable processing and modification, as a valuable fertiliser for their sugarcane and other crops. An additional benefit is that the main method of processing vinasse to reduce the Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) is anaerobic digestion, which in turn produces a methane rich “biogas”. This biogas can be used as a combustion fuel in boilers to raise steam and electricity. It can also be used as a gaseous fuel in internal combustion engines to drive electrical generators or power trains, tractors or vehicles which adds further monetary value and additional environmental benefits to the utilisation of vinasse

In the case of sugarcane juice vinasse, the high levels of potassium and lower levels of phosphorous and nitrogen makes the Anaerobic Digester (AD) effluents very valuable liquid fertilisers for use on the cane fields. Addax will return these residues to the fields and will add extra nutrients (commonly known as “spiking”) to balance the three main nutrients: Nitrogen, Phosphorus and Potassium (NP&K) which are required by all growing plants. Plant requirements of NP&K vary according to the crop and the soil in which the crop is growing.

In the case of the Addax project, the AD residues will be pumped or transported daily back to the fields where harvesting has taken place. They will then either be sprayed directly onto the fields or held in lined dams close to the irrigation water supply points, until required for application to the fields in accordance with the planned irrigation and nutrient program for each field. Many sugar growers use heavy tankers to drive through the fields spraying the AD effluent onto the land at relatively high and uncontrolled rates which often leads to compacted soils, damaged cane stools and also increases the risks of runoff of significant quantities of the applied liquid fertiliser (Plate 1.17).



Plate 1.17: Typical heavy slurry tankers, expensive and the cause of soil compaction

The irrigation systems proposed at Makeni allow for the addition of controlled amounts of fertilisers or crop chemicals in the irrigation water in a process known as “fertigation or chemigation”. This process ensures that the fertiliser or chemical is applied evenly over the entire area at measured and controlled rates. The application rates and concentrations are determined to ensure maximum absorption into the upper rooting zone of the plants, which greatly reduces potential runoff or leaching of the applied products.

Vinasse will be spiked and used as the startup irrigation directly after harvesting in a “once a year” application, (refer to Section 1.3.1 above: sugarcane planting). To achieve this, Addax will implement a system where dedicated rail tankers or pipelines will transport the vinasse effluent after bio-digestion to the fields where it is required (generally the fields just harvested). The rail tankers will discharge into “short haul” road tankers for transfer of the vinasse to the field’s edge where the tanker will discharge into one of the small (± 500 cubic metre) temporary holding dams which will be established in strategic positions on the perimeters of all the cane fields.

These holding dams will act as surge or buffer storage for the vinasse before being pumped onto the fields. The travelling reel irrigators will operate on a continuous 24 hour basis spraying the vinasse in controlled amounts at relatively low application rates to prevent any runoff occurring. However, the tankers will deliver intermittent large amounts of vinasse from the factory, therefore some means of absorbing the “ups & downs” of the delivery system is required. The holding dams will in effect prevent tankers standing waiting to be offloaded at the slow rate of application the travelling reel irrigators.

Alternatively, the vinasse will be pumped back to the fields via pipe-lines into the overhead irrigation system and applied to the fields together with water for irrigation.

Given that harvesting and ratooning (regrowth after harvesting) of sugarcane will only take place in the dry season and that an application of irrigation water is necessary to start the cane growing again as a normal or routine agronomic practice, this system imposes no extra work or application of liquids than would occur without the AD effluent. In the absence of the liquid AD effluent as a nutrient base, conventional practice would use commercial dry or granular fertilisers to provide the “kickstart” nutrients needed to boost early cane growth. The probability of heavy rain falling during this period is extremely low and therefore minimal runoff or leaching of the liquid nutrients which will be applied is expected.

Prior to delivery and application, the nutrients in the AD effluent will be analysed as will the soils of the lands on which they will be applied and varying amounts of liquid N & P will be added to produce a balanced NPK fertiliser in accordance with the requirements of the particular crop and soil type.

It should be noted that as with most conventional practice and current BMP's, further crop nutrients will need to be applied as the cane grows. These are usually applied while mechanical cultivation or ridging up takes place. At Makeni the choice of methodology for the later fertiliser applications will be decided on a site by site basis and could include fertigation via the irrigation water or possibly application of dry fertilisers by more conventional means. In all cases nutrients and chemicals will only be applied at pre-calculated rates in accordance with the crops requirements and internationally accepted BMP's.

1.3.11 Harvesting and Sugarcane yield potential

Sugarcane harvesting will take place during the dry season over a period of 200 days (6 to 7 months). The cane will be mechanically harvested once a year.

Yields of sugarcane in Sierra Leone over the proposed 5 year cycle are estimated to average about 85 tonnes per hectare over the cycle, with plantcane and 1st ratoon crops achieving 90 to 94 tonnes per hectare. The following ratoons are anticipated to drop approximately 4 to 5% per year with Ratoon 5 just before plough out probably yielding in the region of 80 tonnes per hectare (Table 1.1).

Table 1.1: Plantation development schedule (Ecofys August 2008)

Year	2009	2010	2011	2012	2013	2014
	-1	0	1	2	3	4
	Pre-nurs	Nursery	Planting	Harvest 1	Harvest 2	Harvest 3
		Pre-nurs	Nursery	Planting	Harvest 1	Harvest 2
			Pre-nurs	Nursery	Planting	Harvest 1
				Pre-nurs	Nursery	Planting
					Pre-nurs	Nursery
Total Area (ha)	40	500	5,400	10,400	12,100	12,500
Total Harvested Area (ha)			3,900	7,400	9,900	10,100
Average Yield (tonne/ha)				85	83	81
Total Estate Cane Yield (ktonne)			32	279	570	837
Estimated Smallholder Cane (kt)					11	29
Delivered to Mill (kt after Seedcane)				244	559	861
Ethanol Production (kilolitres)				20,000	45,000	69,000
Potential Extra Ethanol from Cassava (kilolitres)				8,000	16,000	20,000
Potential Total Annual Ethanol Production				28,000	61,000	89,000

1.4 Transportation of sugarcane from the field to the factory

In field transport refers to the transport of harvested cane, agricultural requisites and materials within the estate, and most especially to the ethanol plant. Transport is a key factor in the overall production of ethanol from sugarcane, mainly due to the very large tonnages of bulky sugarcane which must be delivered to the plant, 24 hours a day for 7 days a week during the 200 day "oncrop" or processing season.

A large number of roads will be required. Road surfaces will be compacted lateritic gravel

sourced from existing local quarries. Due to the high rainfall characteristics of the area, these roads will require well designed and maintained drainage systems, mainly mitre drains designed to remove all stormwater from the vicinity of the road to adequately grassed discharge areas which feed into the natural drainage patterns of the surrounding area. The road surfaces will deteriorate rapidly during the wet season despite the relatively low traffic volumes at this time, and resurfacing will have to be carried out at the end of the rainy season each year. This will involve additional laterite to replace washaways, followed by grading and compaction to produce a level and hard road surface. Culverts will need cleaning and clearing of grass or flotsam caught in the pipes. Drains may need cleaning if considerable amounts of sediment have built up.

During the dry season, the traffic volumes and the mass of the vehicles will increase substantially, especially the “main haul roads” being used for delivering sugarcane to the factory (Figure 1.9). These will require regular grading at least weekly to remove the surface irregularities (corrugations) which are formed by high speed wheeled traffic.

Some resurfacing will inevitably be needed during this period as soft spots show up and potholes develop. It is anticipated that a dedicated road maintenance division equipped with the appropriate equipment (tipper trucks, road graders, front end loaders, Sheepsfoot, Padfoot and drum rollers plus access to bulldozers and concrete batching equipment if necessary) will be required.

Very high traffic areas such as the access road into the factory and the road from the factory to the main Makeni – Freetown highway will need higher quality surfacing in order to cater for the very high traffic concentrations on these roads, and it will be necessary to stabilize the laterite surfaces with suitable granite aggregates, cement and possibly in low lying areas specialist water repellent surfacing materials.

The transport of cane begins in the field, where modified heavy duty four or six wheel drive infield transporters (trucks) fitted with agricultural lugged tyres or even tracks in very wet conditions, follow the mechanical harvesters to collect the chopped cane as it is discharged from the harvesters delivery chute. In order to ensure that the harvesters do not stand idle waiting for infield transporters, two to three transporters are required per harvester. These infield transporters are not suitable for long distance high speed transport on hard roads, so they cannot be used to move material along public roads

The infield transporters will be used to deliver the chopped cane to a transloading zone situated close to the fields. A maximum field to transloading zone distance of 3 kilometers will be the norm for infield transport deliveries. At the transloading zone, the infield units which will be fitted with hi lift side tipping cane bodies, will transfer their load into waiting trailers or bins for onward transport by either road or rail trains to the factory.

Roadtrains will comprise a heavy haulage unit towing up to 5 x 15 tonne capacity trailers to give a gross train load of up to 90 tonnes of cane. Roadtrains are not suitable for use on public roads due to the restrictions imposed on numbers of trailers and gross vehicle mass allowed by legislation in most countries. At Makeni the use of roadtrains has been proposed for transport from fields in the estates situated close to the factory where private roads can be used and the haul distance will be less than 7 kilometres.

1.4.1 Rail vs. Road transport

In view of the very high tonnages of cane to be delivered annually to the factory (>1.5 million tonnes on completion of Phase 2), plus the large quantities of “backhaul” products such as vinasse and compost to the fields (also >1.5 million tones) Addax are considering implementing a railway transport system in preference to gravelled haul roads. A rail system requires fewer embankments (±2m wide compared to at least 8m wide for a main haul road) and far less maintenance than a gravel road, especially under the very high rainfall regime in

Sierra Leone. Washaways do occur on rail as for road systems, but rebuilding is on a far smaller scale, and the actual rail surface being steel requires virtually no maintenance. Ballast cleaning and sleeper re-alignment are the main recurring maintenance tasks for rail systems, again at far lower cost and frequency than for maintaining gravel road surfaces.

On large estates, where in excess of a million tonnes of cane has to be transported every year, rail transport presents an attractive alternative to road haulage in terms of operating costs due to the much higher hauling capacity of locomotives on steel rail compared to road trains on rubber and gravel roads (in round figures, 1kW of engine power can pull one tonne on steel but only 200 to 300 kgs on rubber/gravel). Trains also require far less input in terms of drivers, assistants, or maintenance and have a far longer operating life than road vehicles. Modern technologies allow trains to operate on almost any fuel and modern “new steam” locomotives have become far more efficient. Modern steam trains use gasification to combust biomass or coal to raise steam in high pressure boilers with more efficient steam chambers and piston rings, condensation recovery and no oil contamination of the boiler water. Smoke and soot are not produced in a gasifier and combustion is up to 30% more efficient than even a well designed open hearth combustion chamber. The potential for the use of biomass from a cane factory offers even more advantages as does the possibility of using “fireless” steam engines which draw their steam requirements from the large factory boilers to provide the power for all the yard and shunting operations.

In the event that rail was selected as the mode of transport for cane haulage, it would still be necessary to build and maintain a network of internal and field access roads to allow access to all areas by management, labour and land preparation machinery. This is because rail does not provide the necessary access for light vehicles such as pickups, tractors and motorcycles, which are an essential part of the overall estate management and production plan. These roads would however be relatively cheap to construct and maintain as they would not be required to bear the traffic of over a million tonnes of cane every year, and would be much smaller structures than would be needed for a main cane haul road infrastructure. Figure 1.9 below shows the preliminary layout of the roads and railway lines for the Addax project.

Thus, the building of a dedicated narrow gauge railway line to serve the outlying cane estates will only take place after the initial development of the estate areas close to the factory. These areas will be served by road transport due to their close proximity to the factory which allows for cost effective road transport to be implemented. However, none of the existing roads in the selected cane growing areas are currently suitable for cane haulage and these will need to be upgraded and maintained.

1.5 Sugarcane processing, ethanol production and factory layout

A sugarcane juice to ethanol plant will be built on site. The project will comprise an 4000 tonnes of cane per day sugar factory “frontend”, producing sugar syrup as the primary feedstock for a 350 kilolitre per day fermentation distillery and 40 MW co-generation plant.

The ethanol plant, located adjacent to field 8, covers 50ha and will similarly draw on the bulk services and infrastructure developed for the residential estate. This slightly elevated area lies between Kolisoko and Taiama villages. It provides road and, later, rail access from two directions to the agricultural areas, plus easy access to the main road for ethanol transport and is centrally located. An alternative site is envisaged about 5 km south-west of Kolisoko close to the Rokel River which is closer to the water source but slightly off-center. The entire plant area will be approximately 1000 ha. A site specific addendum study may be required for the alternative factory site, since only the first option has been considered in this ESHIA.

The factory will require continuous supply of cane 24 hours per day, 7 days a week for approximately 28 weeks (6 months) per annum during the “oncrop” season. During the “off-crop” season, ethanol will be produced from supplementary feedstock. Cassava - one of the

highest starch content crops available (capable of producing ± 420 litres of ethanol/tonne of cassava) is widely grown in Sierra Leone and, unlike sugarcane, can be dried and stored over long periods. Ethanol can be produced from cassava using the existing fermentation and distillation lines which are idle during the cane “off-crop” season, and process steam and electricity from the co-generation operation which will be running in any event. It will be possible to run the factory for a further 100 to 120 days of the year, depending on the cost of the storage facilities for dried cassava and the extra capital expenditures for front end cassava grinding. Furthermore, Addax intends to support smallholder farmers to grow cassava and sweet sorghum as an easy-to-grow rainfed annual crop with features similar to sugarcane for the production of ethanol.

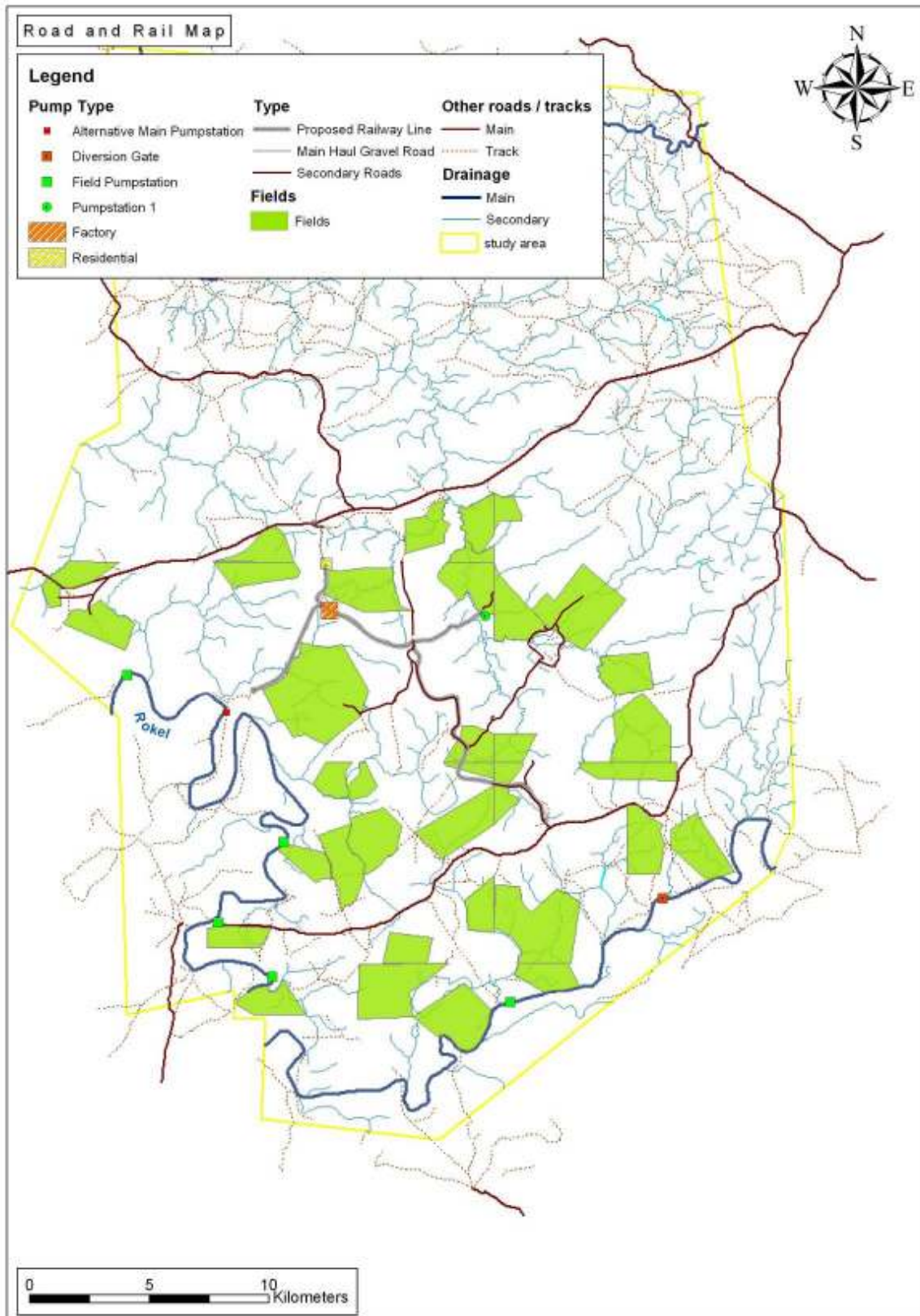


Figure 1.9: Map indicating the preliminary layout of roads and rail in the project area

The production of ethanol requires 6 steps:

1. Preparation: The sugar cane is chopped up and shredded for ease of handling
2. Extraction of sugar juice: the sugar is removed from the cane and a residue bagasse (the solid leftovers of the extraction process) is produced
3. Clarification: the sugar juice is cleaned of dirt and impurities
4. Fermentation: the sugar is converted by yeasts into ethanol $\pm 51\%$ and Carbon Dioxide $\pm 49\%$
5. Distillation: most of the water is removed from the ethanol liquid to produce 96% ethanol
6. Dehydration: the remainder of the water is removed to produce anhydrous ethanol (99.7% ethanol)

1.5.1 Preparation

Sugarcane is washed and shredded by a shredder (set of high speed rotating knives) to facilitate handling. The trend towards the use of green cane (i.e. cane that has not been burned prior to harvesting) and whole stalk cane harvesting results in significant quantities of extra biomass in the form of “trash” (cane leaves and tops) being transported to the mills where it is separated from the cane stalks prior to shredding and milling. Trash can be used to supplement the bagasse (see Section 1.6 below) as boiler fuel and can help extend the length of the electricity generating season beyond the normal 6 to 8 month on-crop period, thereby further increasing the income earning potential of the electricity production division.

1.5.2 Extraction of sugar juice

The shredded cane will then go through a diffuser for the extraction step. In the diffuser, hot water is percolated through the shredded cane and bagasse (i.e. the fibrous residue left over after the juice has been squeezed out of the sugarcane) until all the sugar has dissolved into the water. Following this step, the smaller bagasse particles (bagacillo also known as pith) and dirt are removed from the liquid in a hydrocyclone or by filtering the liquid.

Bagasse emerging from the diffuser must be dewatered to reach the approximately 50% moisture of mill-run bagasse and at this moisture, it can be fed as fuel to factory boilers.

1.5.3 Clarification

The juice from the diffuser (mixed juice) will still contain solids. The liquid is therefore allowed to stand to settle out all impurities (clarification). Lime and heat are used as clarifying agents and these neutralise the natural acidity of the juice, forming insoluble lime salts mostly (calcium phosphate). This mixing also stops the decay of sucrose into glucose and fructose and precipitates out some impurities. Heating the lime juice to boiling temperature or slightly above coagulates the albumin, some of the fats, waxes and gums. The precipitate formed traps suspended solids as well as finer particles (ECOFYS, 2008). These solids are referred to as mud and they separate from the juice by precipitation (gravity) and are later filtered on a rotary vacuum filter which is used to reclaim sugar from the underflow of clarification i.e. mud / sludge.

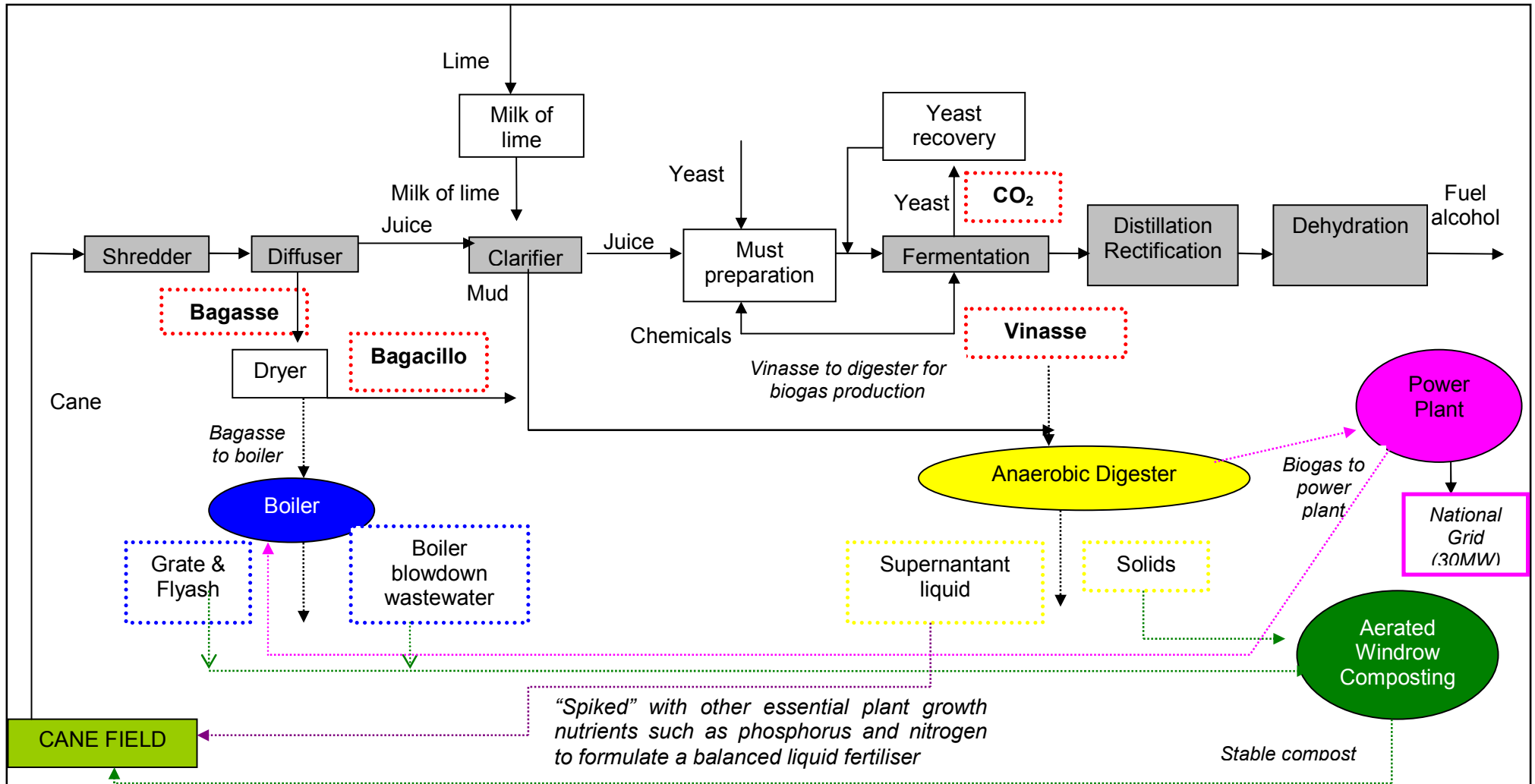


Figure 1.10: Major steps in ethanol production via diffusion of sugar cane indicating the steps at which co-products (in dashed boxes) are generated.

1.5.4 Fermentation

Yeast is added to clarified sugarcane juice (sucrose) and kept in an anaerobic vessel at 32°C to form ethanol. The carbon dioxide (CO²) produced from the fermentation process, represents approximately 49% of the original sucrose feedstock and in developed countries is often sold to beverage bottlers for use in their carbonated drinks or compressed to make dry ice for sale to ice cream vendors and other applications. In Sierra Leone, this may not be possible as the potential market is unlikely to justify the cost of equipment to purify and compress the carbon dioxide. However the factory may be able to use the CO² to “blanket” the ethanol storage tanks in order to reduce the risk of fire or explosions. In the event that cassava is used as a second feedstock for the factory, CO² can be used in the storage silos to control insect infestations. However most of the CO² will be vented to atmosphere as will the CO² emissions emanating from the boiler stacks. Due to the strain of yeast being used in the process, only a relatively small quantity of excess yeast will be produced each year.

The boilers will be fired with the bagasse and field trash. Given that all the factory derived CO² emissions emanate from the sugarcane crop itself, they are generally regarded as essentially carbon neutral on the premise that an equivalent quantity of carbon dioxide will be taken up by the growing crop.

1.5.5 Distillation

Fermented liquid now called ‘beer’ or ‘wine’ is then passed through a distillation system where the alcohol is boiled off at approximately 79°C and 96% ethanol is obtained.

Vinasse is the ‘wastewater’ which remains following the distillation step (see Figure 1.10). It is rich in organic nutrients, particularly potassium – an essential nutrient for sugarcane plant growth following harvesting. Addax will utilise vinasse to produce methane-rich biogas via anaerobic digestion. Biogas can be used to supplement boiler fuels or directly in suitable internal combustion engines to drive generators to produce electricity for the factory. The residues from the anaerobic digestion process comprise a supernatant liquid and solids in the form of a slurry. The liquid portion containing most of the potassium salts will be decanted or separated from the solids via centrifugation and mixed with other essential plant growth nutrients such as phosphorus and nitrogen to formulate a balanced liquid fertiliser which will be returned to the cane fields.

The solids (slurry) will be taken to a specially constructed composting area where they will be mixed with the filter sludge (filter sludge also contains some nutrients as well as high levels of calcium carbonate i.e. lime) from the sugar juice clarification process. In addition, the bagasse grate ash and flyash from the boilers will also be mixed into the compost (ash has value as a substitute for lime in counteracting the low pH of the soils at the site).

1.5.6 Dehydration

The 96% ethanol is dehydrated using modern molecular sieve dehydration techniques and the end product is 99.7% anhydrous ethanol. There are no significant co-products produced during this process step

1.5.7 Detailed process description: ethanol production from Cassava and/or sweet sorghum (“offcrop” season)

The production of ethanol from cassava or sweet sorghum involves six steps (ECOFYS, 2008).

These are:-

- Cleaning and Peeling: The cassava tubers are cleaned and loose dirt, sand and gravel removed and then the tubers are peeled for ease of handling;
- Milling
- Liquefaction
- Saccharification
- Fermentation
- Purification

Figure 1.11 below provides a flow chart of ethanol production from cassava (Nguyen et al., 2006).

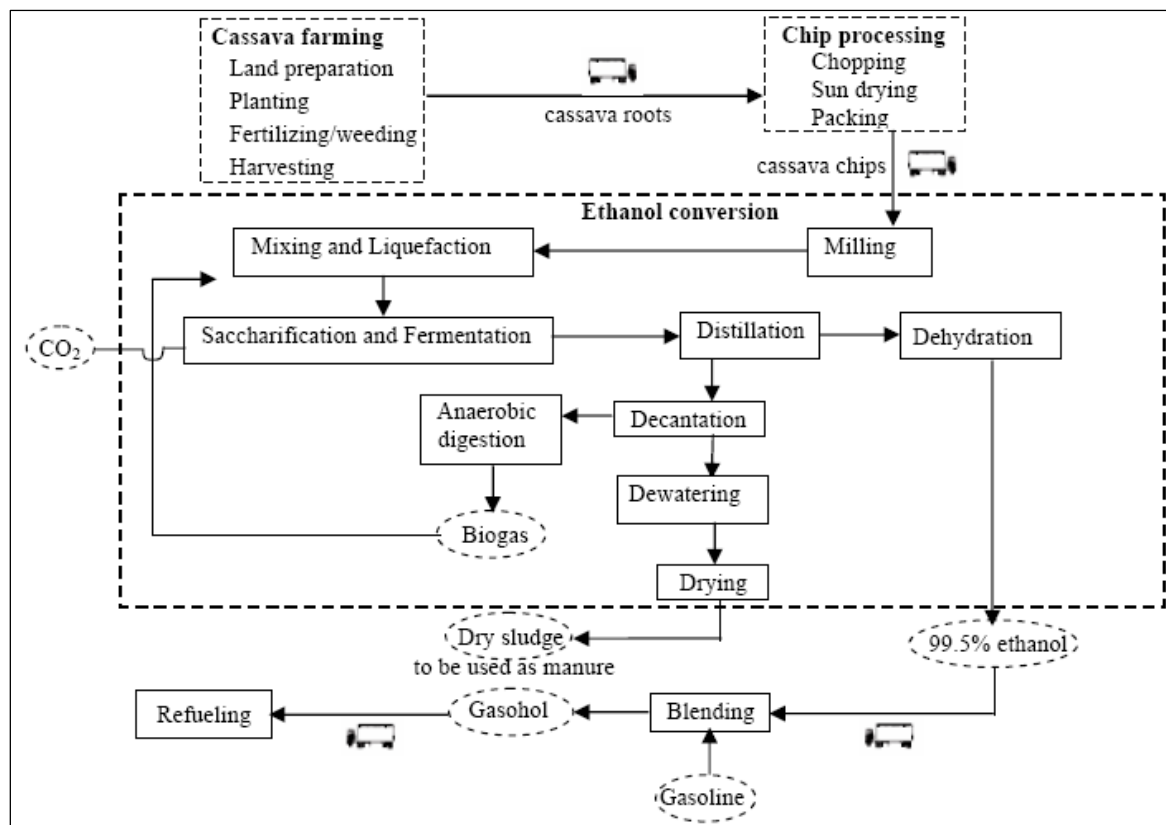


Figure 1.11: Flowchart of cassava ethanol production Source: Nguyen et al. (2006)

Cleaning and Peeling

Peeling will only be necessary if the cassava is bought as whole roots and involves the removal the outer peels of the cassava. Sand is a common contaminant of dried cassava chips and suitable machinery will be needed to pre-clean all incoming cassava feedstocks.

Liquefaction

It is necessary to grind the cassava in order to reduce the particle size prior to the saccharification step. Once ground and screened, the cassava will be mixed with water and heated by means of a steam injected 'jet cooker' to gelatinise the granular starch product. The cooked cassava is then pumped to a tank where the saccharification step takes place

Saccharification

During this step, the viscosity of the mixture is reduced and the starch is converted to sugars that can be fermented by the yeasts. The slurry is mixed with enzymes, which break down cellulose and other complex carbons into sucrose, and slowly stirred until saccharification takes place. This process can take place in the same reactor as the fermentation process discussed below.

Fermentation

This step is similar to that for production of ethanol from cane and will make use of the same fermentation vessels. This process also produces a vinasse co-product similar to that obtained from sugar syrup fermentation but the cassava vinasse contains residual solids emanating from the starch feedstock. In more developed countries using starch based fermentation feedstocks such as maize or wheat, these solids are separated from the liquid and dried for sale as an animal feed supplement known as Distillers Wet Grains with Solubles (DWGS). As there is no animal feed industry in Sierra Leone, Addax will either dry this product and add it to the bagasse for use as fuel in the boilers, or else use undried material as feed for the anaerobic digester.

Plate 1.18 below shows a typical layout of a rural ethanol factory.

1.6 Composting, anaerobic digestion and power production

The use of modern technologies coupled with the high prices of energy and fertilisers, has made the utilisation of all the residues, by-products, waste products etc., which arise from the sugarcane to ethanol process, an essential part of the overall production plan. Recycling, condensate waters, anaerobic digestion and bagasse fuelled co-generation plus the development of balanced liquid fertilisers and composts all contribute to the reduction of costs in the fields and factory. Although a truly 100% "zero discharge" factory operation is probably an unrealistic target, the quantity of materials or contaminated water, which will require disposal from the proposed project, will be negligible and relatively easy to manage.

The following section describes the fate of all these co-products at the factory.

1.6.1 Composting (sugarcane ethanol production)

Addax is considering the installation of a specially constructed composting area based on modern mechanised aerated windrow composting. Compost material will comprise of solids (slurry) from the distillation process, filter sludge from the clarification process and fly ash from the boilers. Composting in the specially constructed composting area will be carried out using windrow turning machines which regularly aerate the piles of compost by lifting and mixing the compost while more slurry and liquids are sprayed onto the windrows. The process takes approximately 50 to 60 days to produce homogenous well decomposed stable compost, a valuable soil conditioner and fertiliser.



Plate 1.18: A typical rural ethanol factory layout.

The compost will be used mainly on the fields which are due for planting or re-planting and will be applied by mechanical spreaders to ensure even and controlled application rates before the legume crop is planted prior to cane planting. The composting facility will be located in a suitable area away from residential areas and on elevated ground which will be levelled, compacted and graded to control runoff and percolation of contaminated water into the soil. Drainage will be established to direct any seepage or runoff into lined channels and storage dams from where the effluent will be recovered for spraying onto the compost windrows and ultimate drying off. Compost will be analysed to determine its nutrient levels. If deemed necessary, micro elements and possibly organic bacteria, specially selected for enhancing nitrogen production, will be added to the compost. Composting allows all the waste water from boiler blow downs, fermentation tank and factory washing to be disposed of in a controlled and value added operation which eliminates discharges of polluted products or water into rivers or streams and groundwater.

1.6.2 Anaerobic digestion

The designs for the proposed facility include an anaerobic digester based on the highly efficient upflow anaerobic sludge blanket (UASB) technology for the treatment of the vinasse. The UASB technology relies on the retention of microbial biomass within the 'blanket' in the lower portion of the reactor and a series of sloped baffles in the upper portion facilitate the separation of biomass from biogas and treated effluent. The biogas from this unit will be used to provide energy, while the treated vinasse will be applied to the fields as a liquid fertiliser.

Raw cane juice vinasse has a Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) that ranges between 17,000 – 30,000mg/l and 30,000 – 80,000mg/l respectively. This is reduced to 3,000 – 5,000mg/l and ±4,000 to ±9,000mg/l for BOD and COD respectively assuming an 80-85% reduction following Anaerobic Digestion (AD) and remediation.

This process allows Addax to produce significant quantities of valuable biogas (methane) which can be used to produce electricity and steam for use in the factory. Added to this is the allied benefit of reducing the potential for methane and/or CO₂ emissions which could occur if raw vinasse were to be applied to the fields.

1.6.3 Boilers and power generation

Addax will use the bagasse (the fibrous residue left over after the juice has been squeezed out of the sugarcane) as a boiler fuel to produce steam and electrical energy to run the ethanol factory. The operation will produce more electricity than is required for the operation of the factory, so the remaining energy will be sold to the national grid (15MW). The main power requirements of the Addax factory are large amounts of low pressure "process steam" and relatively small amounts of electricity during the harvesting (on-crop) period. Thus Addax will produce "green electricity" using high pressure boilers (45 to 80 bar) and steam turbo generators.

The production of electricity will necessitate a 30kV power line from the ethanol plant to the transformer station which will increase the voltage to 161kV for transmission on the national grid, and various 11kV power lines transecting the estate to provide power to the pump stations (see Figure 1.8 for the preliminary locations of the powerlines).

Trash (cane leaves and tops) can be used to supplement the bagasse as boiler fuel and can help extend the length of the electricity generating season beyond the normal 6 to 8 month on-crop period. The Addax project proposes to generate 30 megawatts of electricity on a continuous basis for up to 11 months of the year using bagasse, trash and biogas.

1.7 Transportation of ethanol to and from Freetown

The transport of up to 100,000 m³ per annum of anydrous ethanol from the estate at Makeni to the Kissy terminal in Freetown will rely on road transport. Road transport will use standard tanker trucks capable of carrying 65,000 litres (40 tonnes payload) of Ethanol, and with a combined axle weight at full load of 65 tonnes (<8 tonnes/axle). It is estimated that 8 to 14 tankers per day 7 days a week for the 200 days oncrop period will be required. There will be 6 to 7 trucks a day in the 150 day wet season. It is estimated that 7 or 8 light pickups/cars per day will travel to or from Freetown. The transport of 100 000 m³ of ethanol per annum will require a total of ±1400 trips per annum between the facility and Freetown during the 200 day processing season, with a further 600 during the off-crop periods due to reduced quantities of product being produced from alternative crops (based on one way, these figures double if the return trips are classed as another trip.

In addition, the same vehicles will return from Freetown to deliver various materials to the estate, such as agricultural requisites, pesticides etc. It is estimated that 50 to 60,000 tonnes per annum of diesel fuel, petrol for use as ethanol denaturant, lime, fertiliser, crop chemicals, building materials, machinery & spares etc. will be required. Addax are considering specially built dual purpose tankers for the ethanol transport, which will be capable of backloading most of the above materials except for possibly the machinery and Heavy Fuel Oil (HFO) for the generators, as this will require specialised transporters such as lowloaders and dedicated heated HFO tankers.

Dual-purpose 'platypus' units known as General Freight Liquid Tankers or GFLT's are being considered. These all-aluminium trailer sets offer significant advantages in the crucial areas of stability, payload, safety and versatility, yet are rugged enough to operate in countries where road systems are not necessarily as well developed. They are able to haul fuel to land-locked countries and then deck loads such as sugar or timber on return trips



Plate 1.19: General Freight Liquid Tanker

The route from the estate west of Makeni town will be along the Makeni-Freetown highway, a distance of approximately 150km. The road is generally in good condition, constructed of asphalt (chip and spray) with lanes well demarcated. There are a few portions in poor condition (pot-holed). The road passes through a number of villages (there are 15 towns adjacent to the road along the route) where slower vehicles are encountered and traffic hazards are more significant (vehicles pulling on or off the road, vehicles travelling at slow speed, pedestrians within the road reserve and vendors – Plates 4.20 and 4.21). In most cases reduced speed limit signs are present, but little enforcement is in place. There is a narrow bridge that the road crosses, (Plate 1.22). This bridge is 3,5 metres wide, road traffic regulations stipulate that a road tanker may not be more than 2,5 metres wide. It would be impossible to widen the current bridge structure economically and it would not be necessary in order to allow the passage of Addax's proposed tanker transport.

Transport of agricultural inputs such as lime, fertilisers, diesel etc will be \pm 20,000 tonnes per annum in 2011, up to 35,000 tonnes in 2012 and \pm 50,000 tonnes in 2013 onwards. Ethanol to port transport will commence in 2012 with \pm 30,000 tonnes over 6 months – March to July, followed in \pm 55,000 tonnes December to September 2013; and \pm 100,000 tonnes from December 2014..



Plate 1.20: A small village adjacent to the road within the project area.



Plate 1.21: Road Approaching a Small Village. Note pedestrians, lack of road signage and good condition of road surface.



Plate 1.22: Narrow Bridge Along the Makeni Freetown Route. The Conductor Rails Need Replacing.

In Freetown most of the roads are very congested with both vehicles and pedestrians. This seems to be the norm in the city, but will provide risks and challenges for large vehicles carrying hazardous substances negotiating these roads en-route to Kissy terminal (Plate 1.23).



Plate 1.23: For part of its length, but especially in the vicinity of the Parsonage intersection with Bai Bureh road, the road is congested, with the edges lined with street vendors operating within the road reserve.

1.8 Addax port terminal

Oryx, an affiliate of the Addax Bioenergy group, runs the "Petroleone" storage facility at the Kissy terminal in Freetown. The port facility comprises three storage tanks with a capacity of 12,000 m³ each. Oryx also leases two other storage tanks from NP with same capacity, thus the total Addax terminal has a capacity of 60,000 m³.

At present it is anticipated that one to two tanks from Petroleone will be converted to store the ethanol. This will require some internal coating and floating screens to ensure that they comply with environment, health and safety standards. A separate ethanol pipe-line will be connected to the Kissy Oil jetty, Plate 1.24. Addax are currently negotiating a Build Operate Train Transfer (BOTT) agreement with the Government of Sierra Leone to renovate the jetty which requires some structural reinforcements.

No additional materials handling facilities be required at the port, as the existing port facilities, including storage tanks and ships on-board cranes will be used for loading, (Current Layout Illustrated in Figure 1.9). No quays or load out facilities (e.g. a ship-loader or conveyor) are envisaged, as liquid ethanol will be loaded into bulk tankers through the existing petroleum outloading facilities. No other facilities linked to the storage, handling and transport of materials at the port are envisaged, as loading and transport will be direct from ship to road vehicle and delivered the same day to site.



Plate 1.24: Google image of the Addax facility at Kissy Terminal.

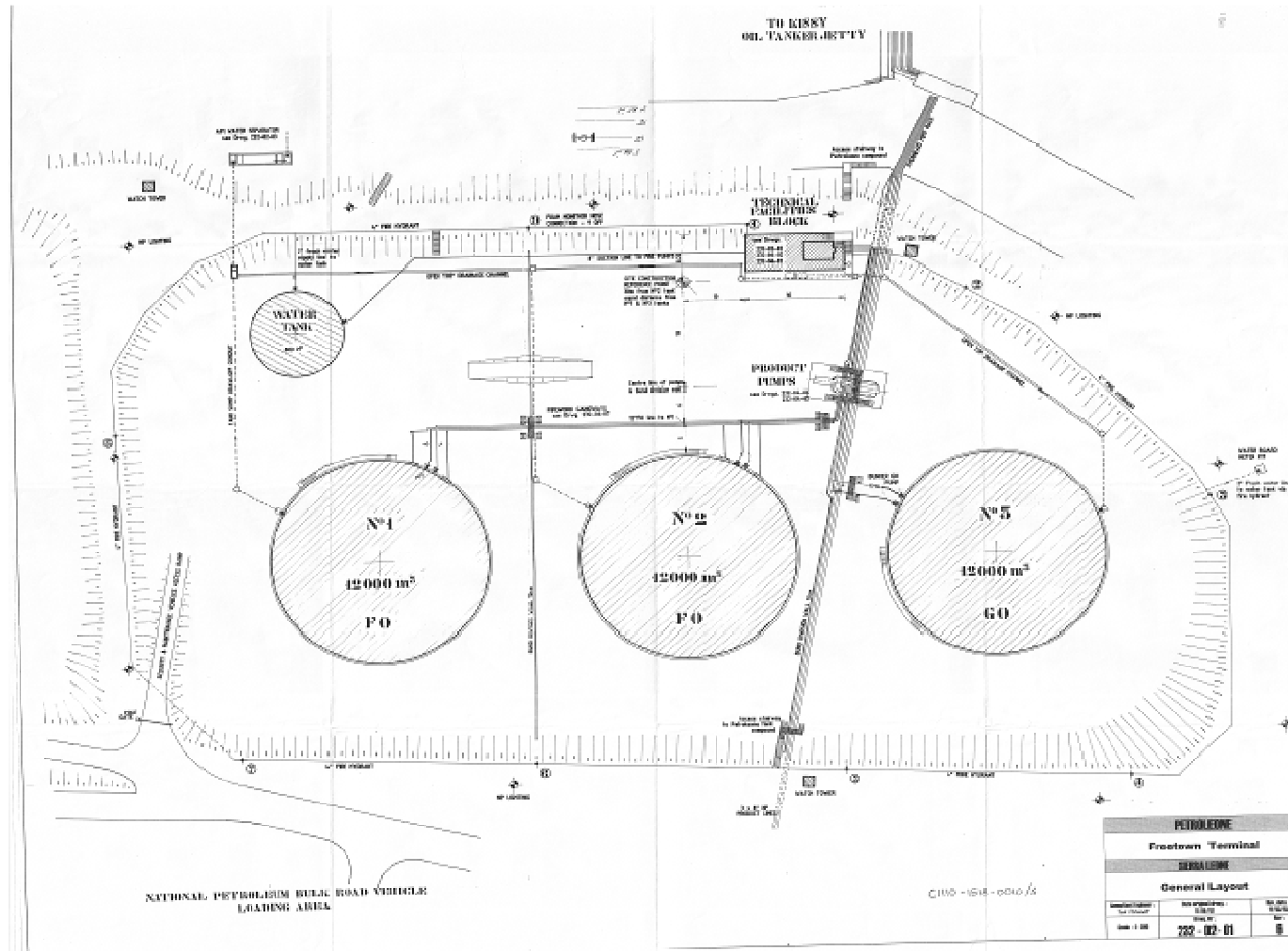


Figure 1.9: Layout sketch of the Kissy Petroleone storage facility in the Freetown Terminal.

1.9 Small Holder Outgrower Scheme

Addax are aware of the critical issue associated with the establishment of a large scale agricultural endeavour - the land required for planting and the associated pressure this might place on food production by local communities who subsist from this land by growing food crops. Hence, they will establish and manage a Smallholder and Outgrower development program (SHOG) at the Makeni project area, to develop farmer based production for food, as well as sugarcane, cassava and sorghum for the production of feedstock for the ethanol distillery. This will include training and agricultural support to third parties (i.e. community members) that will be separate and in addition to the Addax in-house training for its own staff. The SHOG program is a priority for Addax and will be used to support those farmers and communities who are directly affected by the project development; e.g. those landowners who lease land to Addax and other identified land users on these lands.

The objectives of the SHOG program are twofold;

1. To ensure that the farmer's leasing land to Addax and people resident within the selected project development areas are at the very least no worse off in terms of food resources than they are at present (mitigation) and
2. To enable local farmers who want to increase their food or cash crop production over time, to become outgrower contract farmers (commercial support operation).

Few farmers would today be able to participate in a commercial outgrower program considering the poverty levels, agricultural skills and associated food security issues. The objective is neither to create a dependency on the project company nor to substitute government responsibilities.

Addax will design and plan the SHOG program so that it is established and implemented in parallel with the rest of the plantation. The smallholder and outgrower development program will be an integral part of the overall business and operating scenario and will be run by a dedicated fulltime qualified expatriate manager equipped with the necessary monetary, mechanisation and management resources required to implement a commercially oriented and viable smallholder farming scheme. The SHOG will also consist of agricultural support such as machinery services, heavy equipment services and fertilizers. Addax will also set up an agricultural skills development programme with both classroom training and in-field training.

The Addax SHOG program will, as its first priority, take into consideration food security and will carefully consider the economic and social basis of the livelihoods of people in the project area, as well as agricultural capacity development at village, government and civil society level. Considering the low productivity currently prevailing in the Bombali District and Makeni area, the program will be developed and structured in a manner that ensures that the overall food security of the local farmers will not be negatively impacted by the implementation of cash crop production.

Addax's proposed mitigation is based on an understanding of the potential for very significant gains in yields from traditional rice and cassava crops merely by the application of the most basic soil amendments such as lime and phosphate. Additional improvements involving additional balanced fertilisers, assistance with mechanisation, timely weed control, water control and harvesting will in time produce further increases in yields.

Addax proposes an independent monitoring programme of the SHOG program be developed, to review and continually improve the establishment and management of the program. It will be undertaken by a social expert to ensure that the interests of the smallholders are fully taken into account, so as to ensure sustainable production, social cohesion and equitable distribution of benefits.

The implementation of the program will be synchronised with activities such as livelihood assessment, income restoration, land and soil management and agro-forestry programs. The agriculture support program will be implemented in the villages that are directly affected by the project, and will focus on households who are leasing land to Addax, or who are landless. It will provide the basis for stabilising the prevailing system of shifting cultivation by replacing it with a more stable and productive form of agriculture.

The Addax farmer training concept will include on the job training courses with participating farmers, by applying “learning by doing” training. The training of local farmers will focus on how to improve their existing skills in rice and cassava, sugar cane, fruits, legumes and other food crops. Other areas of interest are programs focusing on assistance in post-harvest and marketing arrangements and programs for establishing micro credit.

Addax will also implement a “pilot farmer train the trainers” approach, and will identify farmers who have the capacity to become farmer trainers in the region. Addax will develop a syllabus and the required training material for the farmer trainers in sustainable farming systems development with special emphasis on various food crops, feedstock and livestock, but also non-agricultural topics such as HIV/AIDS, gender, nutrition, adult literacy, group dynamics and leadership and market and business skills.

Addax will take into consideration lessons learned from well established programs organised by the Ministry of Agriculture and Food Security, Ministry of Education and FAO-UNDP such as the Farmer Field Schools (FFS) and Agricultural Business Centres (ABC) and also consider cooperation with existing agricultural institutions and NGO’s in Bombali District and Makeni as well as the Sierra Leone Agricultural Research Institute (SLARI) including the Institute of Agricultural Research at Njala University.

1.9.1 SHOG as Mitigation tool

Apart from developing the commercial outgrower operation the SHOG program will also be used as a mitigation tool for loss of access to land (i.e. those communities who lease land to Addax for its sugarcane operation). This could result in physical or economic displacement due to land acquisition, and it will be part of the Compensation Framework, to be developed as part of the Resettlement Action Plan (RAP) process to develop a “replacement property compensation strategy”. This will be used as a mitigation tool for targeted assistance and/or transitional support for vulnerable groups such as the landless, the elderly and disabled.

There are landless people in the villages that today are granted right to farm by the traditional landowners for a defined period (usually annual) on receipt of a ‘payment’. Also there are urban-based individuals (usually relatively wealthy) who are granted rights to farm land owned by rural families. Finally, there are Fullah cattle herders (pastoralists) who have agreements in place, with local traditional authorities and land owners, to enable them to graze in certain defined areas (waris).

The “replacement property compensation strategy” is briefly the establishment of community plots close to each village where people with no access to land (as the land they were leasing is now leased by the owner to Addax, and no “spare” land is available as the remaining land is used for their crops) can grow crops on a portion of the community plots. The mechanism of implementing this, including the developing of eligibility criteria will be detailed in the RAP.

In cases where the SHOG program is used as a mitigation measure (e.g. as part of the compensation to the land owner for leasing the land) the support will be subsidised until the compensation has taken effect (e.g. until the land owner has reached the stage at which he/she was prior to the implementation of the lease agreement). At this stage it is assumed that the communities retain adequate amounts of land for the production of their own food and as their skills and access to suitable crop inputs improves, land will become available for their development as outgrowers.

1.9.2 SHOG Management

Management of the production by the smallholders will be under the SHOG management team of Addax. This function, however, will not cover all the requirements of the smallholders. They will also require training in connection with the management of their business affairs beyond that of food and feedstock production. They are not accustomed to management of significant wealth, or of living within a community where responsibilities must be borne by individuals to ensure the sustained functioning of their business interests. It is therefore recommended that a needs assessment exercise be conducted by an NGO, such as CRS or CARE, with experience in such aspects of smallholder community development under these circumstances

Addax intend operating the smallholder and outgrower program as an integral part of its overall project with the necessary funding, machinery, experienced management and set targets/goals which will have to be achieved. The rationale for the commercial part of the program is that the small-scale farmers in and adjacent to the project area will be given the opportunity to enter into an enterprise that would provide them with scope for wealth creation by adaptation of their skills, application of their land and association with the neighbouring commercial ethanol production industry.

The local communities are financially poor but are not without the capability to engage in commercial agricultural enterprise. It is thus considered well worthwhile to provide them with the opportunity to engage productively in the national economy by using the Addax accompanying measures to facilitate their entry.

The SHOG program must be developed, implemented and managed within the overall project development profile of the Addax project. The entire smallholder and outgrower development program will be run by the Addax SHOG Manager, much like the other commercial estates (in fact this will be referred to as the “4th estate”). The SHOG manager will be an experienced expatriate agronomist who will be supported by a team of field extension officers, staff to operate the heavy equipment, training managers and demonstration farmers.

The SHOG Manager will be responsible for the implementation of the SHOG concept and the linkage of farmer producers to the processing plants and overall outgrower scheme. He will be responsible for the identification of the farmer trainers and farmers who are willing to join the outgrower scheme, and will assist in planning and implementation of the overall production scheme with the allocation of land for new farmer settlers. He will be responsible for outlining the farming systems development strategy and the provision of the required inputs and equipment for the farmers, as well as recruiting and supervising suitable field extension staff trainers and demonstration farmers.

The SHOG Manager will work in close cooperation with the HSEQ management and especially with the Resettlement and Community Liaison Officers. The HSEQ Manager (directly reporting to the company MD) will independently assess the impact of the SHOG activities on the communities and on market prices. They will recommend mitigation measures and remedial actions in cases of imbalances (socio-economic monitoring).

1.9.3 SHOG as Commercial outgrower program

The objectives of the commercial outgrower program are to ensure that the smallholders in the project area and in Bombali District are assisted, so that their participation in the sugarcane to ethanol project is viable in the long term, and that the legal structures and agreements that govern their participation are fair, equitable and secure, and that they have the skills to meet their obligation in the management of the project and usefully accommodate the increased wealth that will accrue to them as a result of their participation.

The conditions attached to the management of outgrower production by Addax will be in a contract that covers all aspects of management and the obligations of both Addax and the outgrower(s). The agreement is to be made between Addax and individual farmers but also with cooperatives and with the proposed “Bombali Association of Smallholders”.

The duration of the management agreement would need to be at least three years and more likely five years with a gradual diminution of the functions of Addax as skills and responsibilities are taken on board by the smallholders themselves and their associations. The details of the legal agreements governing the management will be reviewed by a legal expert in order to ensure that the interests of the smallholders are covered and that the agreement is secure. The same recommendation applies to the water supply agreement, buying feedstock and pricing agreements.

Trained and experienced farmers as well as farmer groups at around 12 to 14 people from the same village/community area will be encouraged and supported in the establishment of an outgrower association. It is proposed that outgrowers in the project area will be organised into the “Bombali Association of Smallholders” with a constitution drawn up with professional assistance and signed by relevant parties.

Addax intends to adopt a third party certification of sustainable production guaranteeing that its own and the outgrowers products are produced according to strict standards for environmental, social and economic management. Within the farming systems development process, Addax will ensure that land use changes are adequately considered and that the future defined EU standards for sustainability and certification are met.

Addax will develop a system to verify that the feedstock grown for producing the ethanol is sustainable and traceable. The verification process setup will be similar to a quality-management system. An independent international company will be performing monitoring, on-site checks and verification to make sure Addax is meeting the system's requirements. In case the third party finds non-compliance, procedures will be in place to ensure that this non-compliance is corrected and that it does not recur.

Addax will undertake long term purchase contracts with the out growers which will be benchmarked against below the plantation operating costs. The SHOG operation will be centrally managed as an integral part of the factory feedstock and it may be possible to offset the agricultural support costs against the feedstock delivery. Services and input supply and the associated credit will be managed under an agreement with Addax and would not be a part of the assistance provided under the programs support and mitigation measures.

For the SHOG program there will be an agreement between the out growers and Addax that a certain proportion of the financial returns from sugar cane sales are retained by SHOG who provide the inputs on credit and manage the crop, the harvesting and the marketing. Such an arrangement has the benefit of ensuring that there is an incentive for the out growers to optimise economic efficiency in production. Under this regime they would lose if they did not observe timeliness in applications for instance. The precise balance in remuneration to the smallholder and to the management company is obviously a matter of crucial importance, one where independent assessment and arbitration would play a useful role.

The proposed agreement between Addax management and the smallholders is that agri support services are done on a commercial basis, i.e. services and inputs will be paid at cost plus 10% either against cash or a credit retention scheme (for both food and cash crops). Addax management could provide administration services, water management, chemicals, replanting of cane, maintenance, cutting and hauling of cane at the same prices for everyone. They would not provide the fertilizer but deliver it to the field edge after it has been paid for directly by the smallholder. This arrangement has proven successful at other outgrower operations and it remains open to discussion to follow the same principles. The reason that fertiliser would not be provided for free by Addax is that the often poor smallholder tend to either resell the fertiliser or apply it to alternative crops unless they have paid for it directly.

The details of the legal agreements governing the management will be reviewed by a legal expert, as stated above, in order to ensure that the interests of the smallholders are covered and that the agreement is secure. The same recommendation applies to the water supply agreement and the cane buying and pricing agreements.

Marketing of the cane and cassava from the perspective of the smallholders in the project area is simply a matter of allowing it to be delivered to Addax factory some 10-20 km away. For cassava, which can be supplied as dried chips throughout the year from a wider region, storage and transport will be supported.

Cutting, loading, hauling and delivery of sugarcane according to schedules could be organised on the behalf of the out grower by Addax according to contracts and sub-contracts in well-practised fashion from other out growers operations. The cane is hauled from individual fields in loads of approximately 100 tonnes and is weighed at the factory such that the yield of each smallholder is known. Each smallholding will produce in the region of 68 tonnes per hectare, so there will be very little or no need to mix loads from different holdings and thereby confuse yield records of individuals.

The pricing mechanism between Addax and the smallholders and their associations is stipulated in a comprehensive agreement and depends on Estimated Recoverable Sugar (ERS) as a percentage by weight of the cane, which can vary seasonally, and the weighted average prices obtained for the final products in the markets. For cassava the pricing mechanism will depend on weigh and starch content.

All out growers are subject to the same pricing mechanisms and they would therefore all benefit from an independent review of this agreement by an independent legal expert. This will be put in place.

Since cassava is one of the main staple crops in Sierra Leone there is a risk of reduced market prices due to over supply, but profitability and cash generation will also be enhanced due to higher production per hectare and unit of labour input. Addax will set prices for surplus cassava at less than prevailing rates for food cassava in order to ensure that the food demand is satisfied before any cassava is sold for industrial use.

The fact that Addax will implement a proper storage system for very large quantities of cassava dried chips (20,000 tonnes increasing to 50 or 60,000 tonnes) will in itself provide the biggest form of food security anywhere in the country. Not only will producers benefit from receiving payment for their surplus produce but as the cassava will be processed only after the cane crop season ends (November to June), it means that in the event of a natural disaster or food shortage, large quantities of food would be available for ameliorating the shortage, particularly in July and August the traditional “hungry months”.

Recurrent costs to the outgrower are for fertiliser. This is funded from earnings from the sugarcane and transferred to them by Addax. In the first year they will have to take on credit from Addax or a bank for the fertiliser since they will not yet have earned any income. All other recurrent costs will be deducted from returns from the sale of cane by Addax or a bank or micro-credit institution willing to finance the supply of inputs and services until income is generated with the first harvest.

Addax is currently investigating the infrastructure development needed to support the SHOG program. Construction of canals and distribution of water to irrigate fields is considered as an important feature for the long term success of the outgrower scheme.

Until the layout of the fields is known it is not possible to determine the layout or the cost of the capital intensive canals, pump stations or pipelines. It is assessed that some of the fields will be able to benefit from the same infrastructure as Addax nucleus fields. The outgrower fields will be laser levelled to ensure efficient irrigation. Investment in infrastructure also needs discussion with micro-credit institutions and banks supporting the project.

Feedstock production can be accomplished by women in so far as weed control, irrigation and general maintenance is concerned since the heavy work of cultivation and hauling is outsourced to Addax or dedicated groups of men. Addax will have a number of female small-scale growers. There are also monitoring and administrative employment opportunities that would be open to women under the smallholder development scheme. Added household income will also ease the burden of female members of the household even if they are not directly involved in production.

The income earning opportunities provided by cash crop production will help to stabilise communities that are involved in it which will also benefit the women since their responsibilities towards rearing the family will be more easily accomplished in a stable situation.

The envisaged benefit to the economy is that it will earn foreign exchange and initiate multiplier effects in the locality to benefit the wider community. It applies resources of land, water and skills to sustainable economic development to the benefit of the nation as well as the local community. This benefit will be measured against the baseline survey information to hand to ensure that the benefits, as identified, do accrue.

Further detail on the SHOG can be found in the Land Use Report, Specialist Report no. 4, Volume 2, ESHIA.

1.10 Housing and associated facilities for managers, other personnel and workers

The factory would need a fully developed residential area with a range of houses to accommodate approximately 40 expatriate staff members plus their local counterparts and middle management staff (Figure 35). Addax Bioenergy plans to build construction houses (+/- 100 houses) which would become operating staff housing (for its managers and other personnel and its operations) once construction is completed, and if needed, to also add houses for estate and factory workers. The total size of the estate is 20ha, and it is located in centrally in proximity to Field 6.

Recreational facilities have been included in the design of the proposed project and would include:

- Clubhouses (one senior, plus one junior)
- Squash courts;
- Tennis courts, and;
- Football fields.

The design of the proposed Addax project also includes a number of service facilities including:

- Offices;
- A laboratory;
- A school;
- Workshops (vehicles and locomotives);
- Storage houses;
- Garages;
- Security facilities;
- One general and one factory clinic;
- Security and fire station;
- Full scale water reticulation;
- Electricity distribution systems, and;
- Sewage reticulation infrastructure.

Water, electricity, roads etc will be based on typical South African designs with power, water and sewer services running parallel to access roads in residential areas.

Schools will be built or existing schools upgraded on a case by case basis in or close to villages in the project development area. Clinics will be provided at the factory and at each estate headquarters. Mobile clinics operating from these bases will service local villages falling within the estate and factory supply areas. Sports facilities will be developed at the clubhouse and at estate headquarter areas plus some facilities in larger villages. Workshops will be grouped within the factory area. An example of an accommodation village is depicted in Plate 1.25.

The Office complex, to be located adjacent to the residential estate, will utilise the same services established for the estate.



Plate 1.25: Example of an accommodation village

1.11 Project alternatives

There are no site alternatives at present apart from the no-go option (i.e. do nothing). The study area is large, therefore a number of alternatives exist in terms of the location of individual sugarcane estates. The layout being assessed in this ESHIA is depicted in Figure 1.8.

There are a number of technological alternatives for the factory layout and designs. These include different options for the processing of the sugarcane (e.g. diffusers versus mills to extract the sugar from the sugarcane), and also different boiler options (there is a possibility of using more energy efficient boilers, but these have varying cost implications). Most of the technological alternatives are financially based, since more efficient technologies are substantially more expensive. The Addax team is still discussing what the maximum capital expenditure on the project is in this regard.

The specialist reports considered a number of specific alternatives which will not be discussed in this section.