Chapter 4

Impact Prediction and Evaluation

4.1 Introduction

This chapter identifies the key environmental issues and explains the impacts related to the development and the operations of the proposed Oil Palm Plantation (OPP) and Industrial Tree Plantation (ITP) Project. The scope of the assessment will focus on the following key issues:-

a) Soil erosion, Water quality and Hydrology

b) Terrestrial and Aquatic Fauna Ecology

c) Human-Animal Conflict

d) Flora Ecology

e) Socio Economics

f) Biomass and Waste Management

g) Green House Effects

h) Cost Benefit Analysis

i) Pests and Diseases Management

Other environmental issue that will be discussed in less detail is:

a) Forest Fire Management

All the issues above will be discussed from **Section 4.3 to Section 4.12** below. The SEIA matrix is presented in **Table 4.2.1**.

4.2 The EIA Matrix

Table 4.2.1: EIA Matrix for the Proposed OPP Plantation Project at Kalabakan and Gunung Rara Forest Reserves, Tawau District, Sabah

Activities and the related Environmental Impacts	Magnitude	Permanence	Reversibility	Cumulative
Pre Development Phase – Feasibility Studies, Forest Inventory, Demarcation of high risk area and boundary survey				
Loss of flora along the trails or access route	1	2	2	1
Surface erosion	1	2	2	3
Employment and business opportunities	2	2	2	3
Logging Operation and Land Preparation Stage – Establishment of infrastructure, log harvesting and land clearing				
Increase in soil erosion and sediment load	2	2	2	3
Loss of flora, terrestrial and aquatic fauna diversity	2	3	3	2
Flood hazard due to increased runoff	2	3	3	3
Soil damage (compaction & removal of organic matter, topsoil & nutrients)	2	2	2	3
Benefit from employment and business opportunities	3	2	2	3
Influx of foreign workers	2	2	2	3
Dust pollution	1	2	2	2
Fire hazard	2	2	2	3
OPP Plantation Maintenance Stage – Maintenance of plantation, infrastructure and oil palm harvesting				
Benefit from employment and business opportunities	3	2	2	3
Removal of soil nutrient	2	2	2	3
Water pollution	2	2	2	3
Human-animal conflict	2	3	3	3
Fire hazard	2	2	2	3
Abandonment Phase – Rehabilitation with indigenous species				
Flora biodiversity	2	3	2	3
Loss of business and employment	2	2	2	3
Note:				
Magnitude – a measure of the importance in relation to the spatial boundaries. (1) Change/effect only within the project site (2) Change / effect to local conditions and /or to areas immediately outside (3) Regional/ National / International change / effect				
Permanence – defines whether the condition is temporary or permanent (1) No change / not applicable (2) Temporary (3) Permanent				
Reversibility - defines the condition can be changed and is a measure of the control over the effect of the condition. (1) No change / not applicable (2) Reversible (3) Irreversible				
Cumulative – a measure of whether the effect will have a single direct effect or whether there will be a cumulative effect over time, or a synergistic effect with other conditions (1) No change / not applicable (2) Non cumulative / single (3) Cumulative				

Adopted from the "Handbook for EIA in Sabah", EPD Sabah, February 2001.

4.3 Soil Erosion, Water Quality and Hydrology

4.3.1 Soil Damage/ Erosion, Nutrient Loss and Slope Stability

Soil damage and erosion due to oil palm and forest plantation development can affect the environment either directly or indirectly. The direct impact is on-site accelerated soil and nutrient loss, soil compaction and slope instability, while indirect impact is water pollution as a result of sediment runoff and agrichemicals or fertilisers usage from the proposed Project site as well as palm oil mill effluent discharge. The following sections will describe these potential impacts in detail.

4.3.1.1 Soil Damage/ Erosion and Nutrients Loss Under Salvage Logging

Any disturbance on the natural forest could potentially affect the natural nutrient cycle. Since the tropical soils is generally nutrient poor and has thin top A horizon, the development would further jeopardize the nutrient status if the intended activities were carried out at a high intensity and in an uncontrolled manner. The possible ways by which nutrient could be loss is through: (i) timber harvesting; (ii) soil erosion; (iii) increased leaching; and (iv) forest fires (EPD, 2001). The loss of nutrients from disturbed parts of forest will have implications on the recovery of the eroded sites. Although little is known on the actual quantities, it would appear that the impact is substantial.

Use of heavy machinery during logging operations prior to planting often causes local soil compaction. In areas which have previously been cultivated there may be plough base panning compaction. Compaction may also occur during clearing, land preparation and planting. With increasing use being made of heavy machinery during clearing operations, compaction problems have multiplied. Soil compaction in the surface layer can increase runoff, thus increasing soil and water losses. In a number of areas this has caused both growth and yield of young palms to be significantly retarded. Problems are greatest on heavier clay soils, including the poorer-drained coastal soils, although the problem of compaction can also arise on coarser-textured soils. The resulting compaction retards development, delays maturity and is quite likely to lead to long-term yield reduction which is potentially of much greater value than the extra cost of manual labour for the clearing operation. When compaction does occur, frequently the first indication is the occurrence of small areas with poor surface drainage. There is concomitant retardation in palm growth and the appearance of induced symptoms of nitrogen deficiency. Other indications sometimes do not become visible until some time after planting, usually through apparently inexplicable poor development of palms over an irregular area.

In general, losses tend to occur more readily by leaching after logging. When the root-mat and surface litter are disturbed there is no longer the same filtering effect, which helps to capture nutrients washed down from the canopy or released from the litter on the forest floor. The sum result is increased drainage into the stream network and more leaching of soluble nutrients.

4.3.1.2 Soil Damage/ Erosion and Nutrient Loss under Plantation Cropping

Soil problems under oil palm or industrial tree plantation normally occur due to one of following reasons:

- Soil instability (erosion/land slides) due to cropping on too stoop slopes or fragile soils
- Soil instability during intensive transport during harvesting
- Soil damage by agrochemicals
- A simplified natural nutrient cycle through litter fall under monocultures compared with that of a mixed, natural forest.

In a well managed plantation, these effects are normally insignificant once the plantation is established and ground cover has been achieved. The individual causes for soil problems as mentioned above is dealt with in further detail in the sections below.

4.3.1.3 Erosion and Slope Stability

Erosion and slope stability is controlled by the following factors:

1. Geology and Geomorphology
2. Hydrology including rainfall

The details on the geological setting, geomorphological features, lithological units and soil descriptions are presented in **Annex A1.2.1** to **Annex A1.2.2**.

In general, Benta I is characterized by sharply undulating terrain, consisting of a series of steep ridges and valleys incised by three main drainage systems, viz. Sg. Brantian, Sg. Kalabakan, and Sg. Kuamut. Elevations range from less than 100 m above mean sea level (a.m.s.l) in the trough of the basins to over 1,300 meters a.m.s.l at the margins of the basins. Development on these undulating terrains would affect the slope stability and heighten the potential of soil erosion. The hazardous areas are illustrated in a slope classification map in **Figure 4.3.1**.

Benta IIC comprises the southern part of the Maliau Basin in the North, the southern part of the area is within the Silimpopon Basin and its southwestern boundary within the Luis Basin. The Basins are underlain with rocks of the Tanjung and Kapilit Formations; comprising mainly mudstone, siltstone, sandstone and coal seams. See **Figure 4.3.1**.

The strata are moderately to strongly folded into arcuate to sub-circular basin-like structures with dips ranging from 70° (at the fringes) to 14° towards the centre. Due to the difference in erodibility of the mudstone and sandstone, alternating steep ridge scarps of sandstone and gentler valley slopes of mudstone developed following the generally sub-circular shape of the basin.

The sandstone beds commonly contain close spaced joints with quartz or calcite in-fills of 0.5mm – 5mm thick. En-echelon normal faults are common, forming incline step-like ridge escarpments. Overhangs of sandstone are commonly developed when the undercutting of the softer underlying mudstone beds are eroded off. Owing to unfavourably orientated joints and fractures, the sandstone scarps tend to be unstable even in its natural environment. The risk of slope failures (e.g. rock falls and debris slides) will be hastened if these slopes are bared upon deforestation, since the weathering and hence erosion of unfavourable joints is accelerated. Needless to say complete removal of the vegetation during construction activities such as road building, slope cutting and terracing will increase the risk of slope instability.

On slope cuts, if the inclined sedimentary beds daylight the slope, the more resistant sandstone beds may move down-slope en bloc, parallel to the underlying plane of weakness (which is weaker mudstone and shale). Alternatively, mudstone and shale beds may move (slide or slump) down the slope especially if they are exposed on cut slopes.

The slump deposits form hummocky topography. These deposits contain a mud-silt matrix that have low shear strength and will fail even at shallow angles as evidenced in many road cuts along the the Lahad Datu – Tawau Highway. Swelling clay (found in the volcaniclastics of the Chert-Spillite Formation) compound the stability problems, particularly during the wet periods.

Steep hill ridges formed from ultramafic bodies are highly structured, and have higher risks of instability. The risks are even higher with the removal of vegetation since they are exposed to higher infiltration of rainwater. It is recommended that areas with steep gradients be left alone and monitored regularly for instabilities if there are activities at the bottom of these slopes.

Overall, the area is unlikely to suffer large instabilities, but unless detailed assessments of faulted areas are made, they cannot be ruled out.

4.3.1.3.1 Digital Analyses of the Slopes

The results of a digitised slope analysis for the purpose of impact assessment are shown in **Figures 4.3.1, 4.3.2 and 4.3.3**. The national 1:50,000 topographic maps, which were used as basis for this analysis does not sufficiently show smaller details, wherefore the analysis for this SEIA is indicative for management purposes, rather than a detailed operational tool.

4.3.1.4 Soil Loss

Soil erosion is the removal and subsequent loss of soil by the action of water, wind and gravity. Soil erosion is a process that occurs naturally but can be accelerated by man-made structures. The average natural geologic rate of soil erosion is approximately 0.44 tons per Ha per year. This is approximately equal to the average rate at which soil is being produced from parent rock and organic materials. The soil in managed forests erodes at an average rate of 1.1 tons per Ha per year. Lands being disturbed by construction activities experience soil erosion at even higher rates. Unprotected construction sites can experience annual soil loss rates of 330 to 440 tons per Ha.

The erosion potential for a given area is dependent on several factors or characteristics. These characteristics can be grouped as those pertaining to:

(1) Soil composition;

(2) Topography;

(3) Climate; and

(4) Land use & management, especially soil cover.

Soils with high percentages of silt or fine sand are more erodible than soils with higher clay content. When clay is added to a sandy soil, its erodiblity is reduced because of the binding effect of clay with sand particles. Organic content in a soil improves its soil structure and allows water to infiltrate more easily (improved permeability). The improved infiltration reduces the quantity and rate of runoff and therefore decreases the shear stress acting on the surface soil particles.

The topography of the area feeding runoff to a given location (watershed) has a major influence on erosion. The size and shape of a watershed partially controls the quantity and rate of runoff. Additionally, slope gradient and slope length contribute to the quantity and velocity of runoff. The orientation of the slope can also be a factor. For instance, a north-facing slope may have less well developed vegetative cover because it receives less solar radiation.

Climatological factors contributing to soil erosion include form of precipitation, intensity, duration, and frequency. When precipitation is frequent, erosion potential is high because infiltration capacity is reduced. High intensity, short duration storms have higher erosion potential than low intensity, long duration precipitation of equal rainfall volume, partly because of the high intensity storm's ability to generate rainfall rates greatly exceeding infiltration rates.

Vegetation cover is the most significant factor in controlling the erosion process. Vegetation of all kinds is nature's protective soil cover, shielding particles from the shear energy of raindrops.

In order to estimate the total amount of soil loss within the Project area due to OPP development, the Universal Soil-Loss Equation (USLE) is used in the soil loss modeling. Further details are presented in **Annex B1.2.1.1**.

Summarising the results obtained, it can be concluded that soil loss erosion rate for Benta I is generally low for existing condition (E), ranging from 0.22 t/ha/yr to 128.48 t/ha/yr with an average of 12.76 t/ha/yr. It is estimated that 999,005 tons of soil sediments would be eroded from this area every year. It should be noted here that average erosion rates over such a large area with diverse relief has little meaning. See **Figure B1.2.1** in **Annex B1.2.1**.

During the development phase, the rate of soil loss will increase drastically when compared with the existing environment, ranging from 243.97 t/ha/yr to 36,708 t/ha/yr. On the higher end, this is equivalent to about 2.3 m of soil, eroded from steep terrain. The annual soil loss including the uncultivated steep terrain is estimated at 245,989,748 tons. See **Figure B1.2.2** in **Annex B1.2.1**.

Using the factor P (a factor in the calculation determined by the level of conservation practice) of 0.5 for normal conservation practice, the rate of soil loss would theoretically be reduced to half. The soil loss rate would range from 117.49 t/ha/yr to

18,354 t/ha/yr, with an average of 1,960 t/ha/yr. Including soil loss in uncultivated terrain the amount would be 122,845,742 tons. Under cultivated, crop managed conditions, the total soil loss is 767,927 tons. See **Figure B1.2.3** in **Annex B1.2.1**.

For Benta IIC, the results showed that the soil loss erosion rate is generally low for the existing conditions, varying from 0.15 t/ha/yr to 77.90 t/ha/yr with an average of 8.15 t/ha/yr. It is estimated that 239,729 tons of soil and sediments would be eroded from this project area every year. See **Figure B1.2.1** in **Annex B1.2.1**.

During construction and operation phase, if it is assumed that the area is left bare for one whole year and no conservation was undertaken (worst condition), then the soil loss rate will increase drastically, ranging from 42.63 t/ha/yr to 31,164 t/ha/yr, giving an average rate of 2,680 t/ha/yr. It is expected that 42,550,879 tons of soil will be eroded from this area per year under cleared conditions. See **Figure B1.2.2** in **Annex B1.2.1**.

Using a factor P of 0.5 for normal conservation practise, the rate of soil loss would theoretically be reduced to approximately half, i.e. 21,332,061 tons. Under ideal conditions, when the estate is established and cover crops occupy the planted areas, the soil erosion rate is expected to revert to its existing conditions or better (C factor is 0.005). An estimate of the soil loss is 197,050 tons/year. See **Figure B1.2.3** in **Annex B1.2.1**.

<u>Road Construction and Upgrading</u>

Road network have to be constructed or rehabilitated within the Project area. Roads built on slopes are a major cause of slope instability over a large range of geologic, topographic, vegetative and climatic conditions.

Road construction will decrease slope stability in at least five (5) ways:

- Embankment fill adds weight to slope;
- Slope is increased in both cut and fill surfaces;
- Support is removed at the base of the cutslope;
- Concentration and rerouting of stormwater from road surface; and
- Exposure of sub-surface water carrying strata.

The relative importance of any of these influences on slope failure depends on site conditions (differences in inherent stability) and construction techniques.

Changes to the terrain and hydrology through road construction or earthworks may cause erosion which creates conditions conducive to mass movement if exposed surfaces are not protected within a short period. Exposed rocks will be weathered at a faster rate and the weathered material is susceptible to movement especially when saturated with water.

Road construction usually involves cut-and-fill operation to site the road. Slope cutting changes the slope topography and releases residual horizontal stresses and causes expansion of the slope. Joints or weak zones may be exposed along which sliding may occur. Overcutting the toe or oversteepening of the slope gradient to create a platform can therefore induce instability. Placement of fill will also lead to increase in shear stresses acting on slopes and may lead to slope failure. The fill may fail if it is not properly designed and constructed to stringent requirements.

Drainage patterns of an existing terrain may be altered as a result of road construction. The change in groundwater flow patterns may cause changes detrimental to the stability of the newly constructed slopes of the existing *in-situ* slopes that were stable prior to construction. Blockage of, lack of, or too few culverts, can cause soil saturation from storm water runoff in specific areas of the fill slope, which brings about slope failure. Routing of runoff into slope depressions can bring about shallow, rapid failures.

Road cuts made into the dip slopes of the Tanjong and Kapilit Formation may result in bedrock slides. This is because the planes of structural weakness such as bedding or major joint planes dip towards the cut. This is aggravated by the fact that mudstone interbeds are structurally weak and the contact between the competent sandstone and mudstone beds act as a slide plane. Rock falls and topples are also expected to occur at cut slopes, especially on the scarp slope, because of the highly jointed nature of the strata.

Slides and slumps commonly developed in cut slopes of the slump deposits because of the low shear strength and presence of swelling clays in the mudstone matrix. These slides and slumps tend to develop during the rainy season.

Most of the above mentioned hazards are of local nature, *i.e.* they are more a problem for the daily management of the plantation than an actual negative environmental impact.

The problem only fully arises as a significant environmental impact when eroded material reaches streams and rivers that flow out of the plantation area.

<u>Land Clearing for Oil Palm & Tree Plantation Establishment</u>

The main impacts of the proposed Project will be the removal of vegetation, land clearing and planting of oil palm and industrial trees at a later stage. The damage increases with the interval of time between clearing and plantation establishment—the longer the delay, the more the erosion, sedimentation and siltation.

- Removal of vegetation, tree stumps, roots, etc. exposes soil surface to high rates of erosion;
- Removal of topsoil reduces site productivity;
- Compaction of soil through movement of excavators, bull dozers and tractors reduces planting site productivity;
- Site disturbance and erosion is significantly higher on steep slopes and where no proper terracing is practiced. Observation: Soil erosion of steep slope in neighbouring oil palm plantation caused by improper terracing and lack of cover crop (see **Plate 3-2**); and

- Clearing of steep areas can lead to loss of site productivity, increased sediment downstream, loss of aquatic life, stream channels blockage and flooding. Observation: The river becomes very muddy because of timber operations and planting of *Acacia mangium* on steep slopes of more than 20^{o} without terracing and planting of cover crops (see **Plate 4-1**).

4.3.2 Deterioration of Water Quality (see also Section 4.3.1.4)

Sediment eroded from the Project site due to the logging and land clearing operations may cause further deterioration of water quality in Sg. Kuamut, Sg. Kalabakan as well as Sg. Brantian and their tributaries. Currently, all these major rivers have relatively high level of total suspended solids (see **Annex B1.2.2**). Any additional discharge into these rivers will exacerbate the existing conditions and will eventually affect the already dwindling aquatic life within the site and indirectly downstream fishing activities, especially in the Cowie Bay.

Increased sedimentation

Deposition of eroded materials may contribute to a change in the hydraulics of larger rivers downstream of the proposed Project site that receive the eroded sediment from the proposed Project site. This may have an effect on the profile, flooding frequency and flooding intensity of these rivers. Furthermore, shifting and new sandbanks may affect the navigation in these rivers and subsequently increase maintenance cost to keep them navigable.

Loss of habitats for aquatic life (see **Section 4.4.3**)

Any disturbance to the riparian reserves would cause an increase in the suspended sediment load discharged into Sg. Kuamut, Sg. Kalabakan and Sg. Brantian. This in turn would affect the aquatic habitats in these rivers and may reduce the catch for villagers in Kalabakan and Brantian who use these rivers as their fishing grounds.

More serious for the aquatic life may be the loss of shade and the supply of food originating from the vegetation along the banks.

Usage of fertilizers/agrochemicals

Deterioration of water quality can also be associated with the routine application of agrochemicals during maintenance stage of oil palm plantation such as fertilizers, weedicides and pesticides. The quality of surface and ground water may be affected. The aquatic ecosystem, fauna, and humans who depend on the water directly will be most at risk. Malaysia is making efforts to protect the environment and its population and has banned or never registered the following pesticides: aldicarb, camphechlor, chlordane, heptachlor, chlordimeform, DBCP, DDT, aldrin, dieldrin, endrin, EDB, HCH/BHC-lindane, paraquat, parathion, methyl parathion, pentachlorphenol–PCP and 245-T.

The main nutrient elements applied in oil palm plantation will be nitrogen(N) phosphorus(P) and potassium(K). Under plantation practices they are applied in the form of straight fertilizers, mixtures or compounds. Slow release fertilisers are seldom used because of higher cost but empty bunch and palm oil mill effluent (POME) are often applied.

Excess Nitrogen is applied in the form of urea, ammonium or nitrate compounds. Both the urea and ammonium compounds are eventually converted to nitrate in well drained soil. Nitrate being water soluble can easily find its way into water sources.

Nitrate promotes undesirable growth of aquatic micro flora in water courses which affects the health of aquatic life. Consumption of high nitrate water can be fatal to infants as it may lead to 'Blue Baby Syndrome', a manifestation of nitrate toxicity.

Phosphorus in the form of phosphate has the same eutrophication effect in surface water as nitrate, causing excessive algae growth, and preventing sunlight from reaching aquatic life in deeper water.

Fertilizers applied correctly at the recommended rates and at the correct time will not pose any environment hazards as most of them are readily absorbed by the dense fibrous roots of oil palm. Any surplus would be taken up by the ground cover vegetation or are immobilised in the soil and later released slowly thereby posing no pollution problem. Only excessive and ill timed application will have undesirable impacts.

In oil palm plantation the level of pesticide usage is normally very low. Hence, impacts from these sources are usually not significant. However, herbicides are more widely used. Common herbicides used in oil palm plantations are paraquat dichloride, glyphosate, methyl metsulfuron and glyphosinate ammonium.

Paraquat dichloride salts are very soluble in water. Any stray chemical that falls into the ground is inactivated by inert clays and anionic surfactants such an organic matter. Paraquat is degraded by microbial action to CO_2 and other naturally occurring products. The intermediates produced are of low toxicity. The residue is also degraded by the photolytic and microbial degradation processes on plant leaves. 50% of paraquat would be degraded within 2 weeks. It is reported not to accumulate in the ecosystem even through prolonged use. As it is strongly adsorbed in clay and organic matter it is not easily leached to contaminate groundwater. It presents little risk to aquatic life.

Glyphosate isopropyl-ammonium salts are very soluble in water. They are strongly absorbed by the soil in which decomposition is mainly by microbial action at the rate of 50% loss in less than 60 days. Metsulfuron methyl salts are again soluble in water. When the chemical falls on foliage it is transmitted to the root system causing damage to the stem and root tissues. The residue degrades microbiologically.

Glyphosate-ammonium salts are also very water soluble. After application its residue is readily absorbed by soil components and is rapidly degraded to CO_2 and water by soil microorganisms. Its active ingredient does not accumulate in the food chain. Its relatively short half-life and high LD50 value make it a very environmentally safe herbicide. It is particularly safe for aquatic life and birds and non toxic to beneficial insects such as bees, weevils and earthworms.

It has been estimated that 75 – 95% of the spray usually lands on the foliage. Most of the rest land on the soil and gets deactivated. Unless sprayed under windy conditions very little will get into streams. Spraying of drains and waterweeds is not recommended, as it would be hazardous.

Effects of Oil Palm Mill Effluent

The oil palm mills generate many by-products and liquid wastes that may have a significant impact on the environment if they are not dealt with properly.

Wastewater is discharged from the palm oil extraction, by wet process, normally from the oil room. This effluent, is a combination of sludge and centrifugal waste which together with steriliser condensate and hydrocyclone washing and normally formed palm oil mill effluent or POME. Examples of average pollutant loads in wastewater discharged in four (4) oil mills in Malaysia are as shown in **Table 4.3.1**.

Table 4.3.1: Average pollution load in Wastewater discharged from four Oil Palm Mills in Malaysia.

Mills	Working Hours	FFB (tons)	Effluent flow (m^3/h)	Effluent/FFB (m^3/t FFB)	COD (Kg/t FFB)	BOD (Kg/ton FFB)
Apa	19.56	464.60	10.05	0.44	47.51	25.88
SPb	17.60	437.53	21.53	0.94	62.54	27.59
Upc	24.00	220.00	10.79	1.18	47.81	26.62
UPOc	15.58	414.67	22.37	0.90	51.93	26.24
Mean	19.26	384.20	16.19	0.87	52.54	26.58
Std deviation	3.03	96.43	6.67	0.27	6.08	0.64

Source*: A.H-Kittikun., et al. Department of Industrial Biotechnology, Faculty of Agro-Industry Prince of Songkla University, Hat Yai, Thailand.*

Untreated and uncontrolled loading of this wastewater into the riverine system may affect the aquatic lives and downstream settlers who may depend on the river as their source of water supply.

4.3.3 Hydrology

Large-scale agricultural development has in recent years, been extended to the undulating inland areas of Sabah. The method used in land treatment and the change in land use have great impacts on river basins which often show changes in short and long term runoff volumes. Land use and treatment measures will reduce the volume of direct runoff by either increasing the infiltration rates or surface storage compared to bare soils. In the lack of local data, the hydrology study aims to assess the effects of land use changes on the basin river flows such as direct runoff (surface runoff) and base flow based on methodology and experience established elsewhere.

4.3.3.1 Impact on Annual Runoff

Increases in water yield are expected following forest cover removal and change of land use. **Table 4.3.2** is a summary of water yield change in the Humid Tropics. In general, conversion of tropical rainforest to other land use in Australia, Tanzania and Taiwan resulted in increases in water yield, ranging from 264 mm to 2,187 mm per year or 7 to 58%. The study at Sg. Tekam, Pahang provides an excellent example on the impact of forest conversion to commercial crops (DID, 1986 & 1989). Increase in water yield up to 470% or 822 mm/year were observed following a 100% clearing. A rather large water yield increase following deforestation is not unexpected in the three affected Kalabakan, Brantian and Kuamut catchments, especially the first two catchments, conceivably due to the tremendous reduction in the evapo transpiration loss from the forest vegetation.

Table 4.3.2: Forest Cover Transformation in the Humid Tropics and Changes in Water Yield

Location	Type of Transformation	Catch-ment Size	M.A.R.*	Eleva-tion	Changes in Water Yield (mm/yr)					Ref
		(ha)	(mm)	(a.m.s.l)	1st yr.	2nd yr.	3rd yr.	4th yr.	Ave.	
Babinda, Queensland	Lowland rainforest to grass (35%) & scrub (35%)	18.3	4035	10-200	+264 (7%)	+323[a] (13.4%)			+293	Gilmour, 1977
Lien-Hua-Chi, Taiwan	Clearcutting of mixed evergreen hill forest; regeneration	5.9	2100	725-785	+448 (58%)	+204[b] (13.4%)			+326	Hsia & Koh, 1983
Kimakia, Kenya	Montane rainforest/bamboo to Pinus plantation; agriculture intercropping (3 yrs) until canopy closed	36.4	2198	2440	+457	+229	+178		+328	Blackie, 1979a
Mbeya, Tanzania	Evergreen montane forest (1/3 grass & shrub) to agriculture land use (50% annual cropping & 50% grazing land)	20.2	1900	2428					+220	Blackie, 1979b
St. Emille, French Guyana	Primary lowland rainforest to plantation of Eucalyptus	1.0	3230	<100	+408 (25.9%)					Fritsch, 1983
Sg. Tekam (A), Malaysia	Secondary dipterocarp forest to cocoa plantation	37.7	1878	72.5	+110 (117%)	+706[c] (157%)	+353 (94%)	+263 (158%)	+358	DID, 1986; DID, 1989
Sg. Tekam (B), Malaysia	Secondary dipterocarp forest to oil palm (60%) and cocoa (40%) plantation	96.9	1878	68.5	+145 (85%)	+155 (142%)	+137 (97%)	+822[c] (470%)	+314	DID, 1986; DID, 1989
Berembun (1), Malaysia	Selective logging (40%) of primary dipterocarp forest	13.3	2126	221	+165[a] (70%)	+142 (55%)	+175[a] (72%)	+155 (67%)	+160	Abdul Rahim, 1990
Berembun (3), Malaysia	Selective logging (33%) of primary dipterocarp forest	30.6	2126	236	+87[a] (37%)	+70 (28%)	+106[a] (44%)	+94 (41%)	+89	Abdul Rahim, 1990

Note: * Mean Annual Rainfall [a] Wet Year [b] Dry Year [c] 100% clearance

Sources: Abdul Rahim (1990) and Bruijnzeel (1986)

The study of Berembun catchment shows that the increase in water yield is 4mm for every percentage of forest removed and results of study by Oyebande on tropical forest shows that the increase in water yield is 5mm for every percentage of forest removed. Adjusting a 5mm increase for every percent of forest removed, the increase in water yield for the basins are:

River	Increase in Annual Water Yield (mm)
Sg. Kalabakan	120 (24% of the watershed cleared)
Sg. Brantian	475 (92% of the watershed cleared)
Sg. Kuamut at Project area	475 (92% of the watershed cleared)

4.3.3.2 Impact on Catchments Baseflow

Data on components of runoff such as base flow, direct runoff and total runoff are available from the Sg. Tekam experimental catchment (DID, 1986 & 1989). In order to estimate the increase in base flow from calibration period to transition period years with almost equal / total runoff in the calibration and transition period were chosen so that, the base flow of the two periods can be compared. The increase in baseflow for the years for catchment A and B ranged from 12% to 40%. An increase of 30% in baseflow is adopted for this study for project in bare soil conditions. The baseflow for Project area plated with oil palm or industrial trees is assumed to be the same as catchment in forested condition. Analysis of DID daily streamflow record shows that the average base-flow component of the flood hydrograph is 15 m^3/s for Sg. Kalabakan. This is equivalent to 0.013 m^3/km^2. This specific base-flow value has been used for design for the catchments in natural condition.

4.3.3.3 Impact on Flooding Downstream

Land use and treatment measures reduce the volume direct runoff during individual storm event by increasing infiltration rate or increasing surface storage. The principle of unit hydrograph states that with other factors constant the peak rate of flow varies directly with the volume of flow. This principle is the basis for proportionate reductions in peaks when volumes are reduced. Normally, a 50% reduction in runoff volume gives a 50% reduction in peak rate.

4.3.3.3.1 Direct Runoff Volume and Peak Discharge

In order to estimate direct runoff from storm rainfall, the U.S soil conservation service method (USDA, 1972) is used. The details, together with the computer programme used (RORB – runoff routing model) are presented in **Annex B1.2.3**.

The direct runoff of each catchment is then converted into flood peaks at the point of interest using RORB and subdivided into subareas for RORB modelling as shown in **Figure 4.3.4**. The results of the peak discharge for the catchments in the Project area are presented in **Table 4.3.3**. From the table, it can be seen that flood discharges of Sg. Kalabakan with Project area cleared and planted with oil palm and ITP are not significant (22% and 3% higher than catchment under natural conditions). The flood discharge of Sg. Brantian, Sg. Kuamut catchments K1, K3, K4 are significant for the case where the Project area is cleared (with bare soil) since they are more than 24% higher than the flood peaks estimated for catchments under natural conditions. For Project area planted with oil palm and ITP, the change in peak discharge is not significant for all the catchments. The flood hydrographs of Sg. Kalabakan and Sg. Brantian under various land use condition are shown in **Figure 4.3.5** and **Figure 4.3.6**.

Table 4.3.3: 20 Year Flood For The Catchments In The Project Area

Catchment Name	Catchment Area Km^2	Peak Discharge m^3/s			Critical Storm Duration Hrs		
		Natural Condition	Bare Soil For Project Area In Catchment	Oil Palm Trees For Project Area In Catchment	Natural Condition	Project Area Bare	Project Area With Oil Palm
Sg. Kalabakan at Gauging Station	1150	1535	1890	1580	Frequency Analysis	32	32
Sg. Kalabakan Near Kg. Kalabakan	1229	1580	1929	1634	36	32	36
Sg. Brantian Near Kg. Brantian	490	873	1335	907	16	12	12
Upper Kuamut Catchment K1	236	376	267	399	16	9	12
Upper Kuamut Catchments K2	122	313	372	317	3	3	3
Upper Kuamut Catchments K3	46	125	356	142	4	3	4
Upper Kuamut Catchments K4	34	106	295	121	4	1	4

Figure 4.3.5 : Sg. Kalabakan near Kg. Kalabakan 20 year flood hydrograph (Direct runoff)

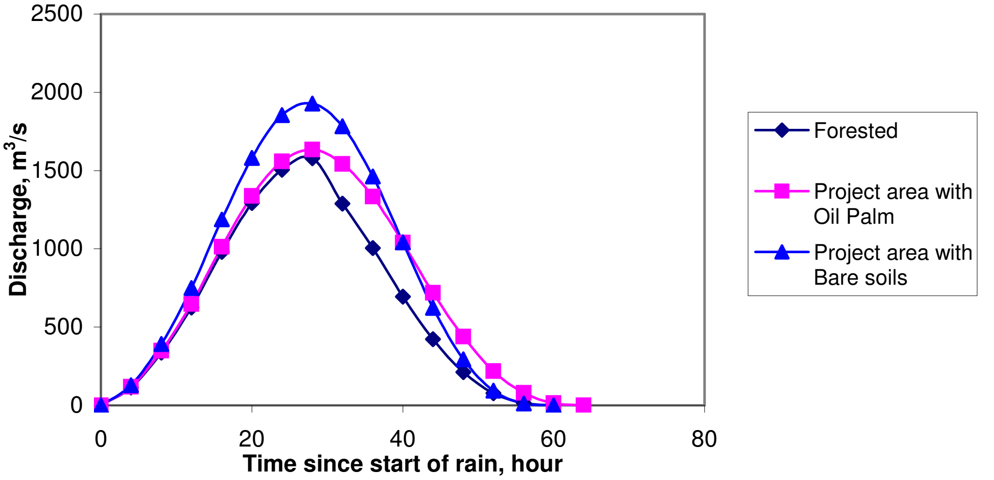
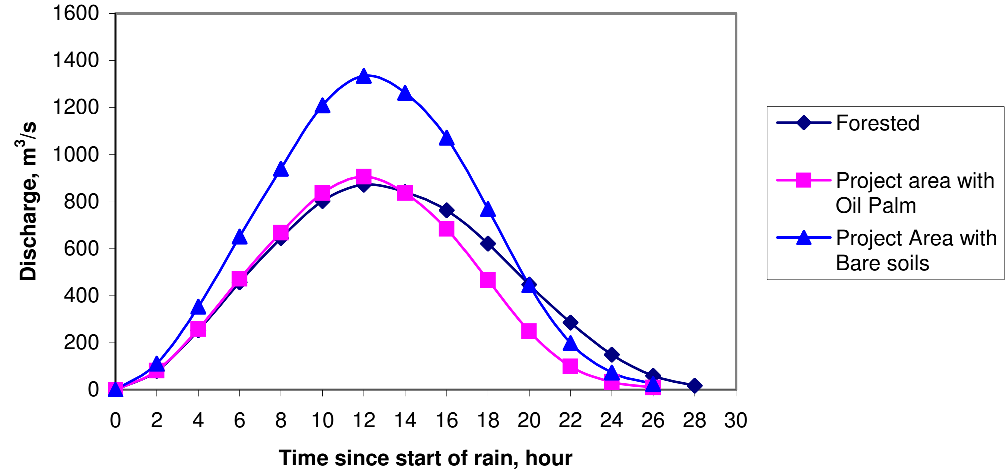


Figure 4.3.6 : Sg. Brantian near Kg. Brantian 20 year flood hydrograph (Direct runoff)



As the Project will be carried out in phases, the runoff volumes were also estimated for areas of the phases completely cleared, with palm oil trees planted and well established. The details on the results and significance of change in flood discharges are presented in **Annex B1.2.3.9**. From the data obtained, it can be seen that significant 1 in 20 year peak discharges are expected in Phases 2 and 4 at Sg. Kuamut catchment K1 (peak 29% and 32%, respectively higher than peak of catchment with natural condition); phase 1 at Sg. Kuamut catchment K3 (peak 184% higher than peak under natural condition); and phase 2 at Sg. Kuamut catchment K4 (peak 108% higher than peak of catchment under natural condition). This means for Sg. Kalabakan, Sg. Brantian and Kuamut K1, the significance of flood discharge increase has been greatly reduced due to the reduction of Project area cleared for phase development.

4.3.3.3.2 Flood Levels

Increase in peak discharge will affect the flood level along the river when heavy rain occurs. Rating curve of Sg. Kalabakan is available from DID and river cross-sections are available at the downstream reach of Sg. Kalabakan and Sg. Brantian (SEIA, 2002). The surveys cross-section ended at about 17 Km from the river mouth for Sg. Kalabakan and 7 Km for Sg. Brantian. The highest tide level is 2.03 m LSD for Sg. Kalabakan and 2.40 m LSD for Sg. Brantian.

Using the DID rating curve and the peak discharge obtained from the computer model, the 20 year flood levels of Sg. Kalabakan at the gauging station are 11.2, 12.1 and 11.3 m (chart datum) for a forested Project area in bare soil condition, and the Project area planted with oil palm. The increases for the flood levels are 0.9m and 0.1m for the respective change in land use for the Project area.

The HEC-2 water surface profile programme has been used to estimate the flood level using the peak discharge obtained from RORB and the recorded maximum tide level as boundaries conditions. The data obtained and the results are presented in **Annex B1.7**.

For Kalabakan, the flood level will increase 0.79m for project area changing from forested to bare soil condition. The increase in flood level for the case when land use is changed from forest to oil palm is 0.11 m. As for the Brantian catchment, maximum increase in flood level is 1.27 m for project area changing from forested to completely cleared and with bare soil condition, and 0.11 m when the land use is changed to oil palm. There is a higher increase in flood level for Sg. Brantian because the Project area in the Brantian catchment occupied almost the whole catchment.

The increase in peak discharge for Sg Kalabakan and Sg Brantian are 22% and 53% respectively for bare soil condition, compared to natural condition, which is significant. This is shown also from the flood level obtained from modelling. However, the increase in peak discharge and flood level when the project area is planted with oil palm is not significant. The increase in flood peak discharge is only 3% and 4%, respectively for Kalabakan and Brantian.

When phased development is practiced, the maximum differences in water level have been reduced as compared to cases where the Project area is completely cleared available for Sg. Kuamut. For Sg. Kalabakan, the maximum flood level ranges from 0.08 to 0.15 m whereas for Sg. Brantian, it ranges from 0.13 to 0.58 m. See further details in **Annex B1.2.3.9**. These values are not considered significant compared to total clearing as described above.

4.3.3.4 Impacts on Sediment Yield

Rate of erosion is normally termed as sediment yield. Forest canopy, undergrowth and litter layer provide an ultimate protection to soil against erosion. The removal of protective cover due to logging and conversion to forest plantation may cause accelerated erosion and increase sediment yield. Sediment transport in the river may be broadly categorised as either the transport of cohesive, or of non-cohesive material. Cohesive materials comprise clay, silt and small quantities of organic material. Non-cohesive material comprises the coarser materials – sands and gravels. These materials are transported by two different processes. The fine material is carried in suspension which is termed the wash load of the river. The transport of the coarser sediment present at the river bed is termed the bed material load.

Studies by Zulkifli et. al. (1991) show that the baseflow sediment concentrations under undisturbed and partially altered forested catchments were usually less than 10 mg/l but a ten to hundred times increase in concentration can be expected from storm.

The Total Suspended Solids (TSS) data collected during 23rd to 26th November 2005 (Refer **Section B1.2.2**, **Figure B1.2.4 and Plate B1.1** in **Annex B**) are presented in **Tables 4.3.4** to **4.3.6** below:

Table 4.3.4: Total Suspended Solids in the Sg. Kalabakan System (from downstream to upstream)

Sample	River	TSS (mg/l)	General Land Use
W11	Sg. Kalabakan	171.7*	Log yard, town area
W10	Sg. Kalabakan	67.5*	Logging
W9	Sg. Kalabakan	71.9*	Logging
W8	Sg. Anjeranjermut	17.5*	Logging
W7	Sg. Anjeranjermut	5.6	Logging
W14	Sg. Mawing	49.4*	Plantation
W12	Sg. Mukandut	27.5*	Kampong water intake point
W13	Sg. Tiagau	37.0*	Logging

Note: '*' – TSS > 10mg/l

Table 4.3.5: Total Suspended Solids in the Sg. Brantian System (from downstream to upstream)

Sample	River	TSS (mg/l)	General Landuse
W15	Sg. Brantian	130*	Plantation
W5	Sg. Brantian	42.4*	Logging
W6	Sg. Bang	358*	Logging
W4	Ulu Sg. Brantian	56.3*	Logging
W3	Sg. Geminchau	25.0*	Cleared

Note: '*' – TSS > 10mg/l

Table 4.3.6: Total Suspended Solids in the Sg. Kuamut System (from downstream to upstream)

Sample	River	TSS (mg/l)	General Landuse
W2	Sg. Imbak, Tributary of Sg. Kuamut	280.4*	Logging
W1	Sg. Kuamut	41.5*	Forest, logging

Note: '*' – TSS > 10mg/l

The above results indicate that all three river systems have relatively high TSS concentrations especially Sg. Imbak (tributary of Sg. Kuamut) exceeded 280 mg/l suggesting fairly intense disturbance activity going on within its catchment. The TSS concentrations at the upper catchments are lesser, partly due to cumulative effect of TSS, partly suggesting lesser logging activity. The coarser particle-size sediment would settle in the upper stretches of the river channel where flow velocity is faster.

The very fine suspended sediments would be carried all the way downstream and settle near the river mouth estuary where the flow velocities reduce to about 0.2 to 0.8 m/s, and the particles flocculates through the electrochemical processes in the saline water environment. The annual sediment yield for total clearing and clearing in phases for the oil palm development has been estimated and presented in the earlier section, i.e. **Section 4.3.1.4** above.

4.4 Terrestrial and Aquatic Fauna Ecology

4.4.1 Terrestrial Fauna Ecology

The Project site is within the Tawau Wildlife District as proposed by the Tawau Wildlife Department. It is bordered to the west and northeast by two of the world's renowned conservation area namely Danum Valley and Maliau Basin respectively.

Danum Valley and Maliau Basin conservation areas are of international significance. They have been reported to support an array of fascinating flora and fauna of national and international significance. Both areas are home range to Sabah's very important wildlife namely the Sumatran rhino, clouded leopards, sun bears, tembadau, orangutan, proboscis monkeys, the Asian elephants, hornbills and Argus pheasants. Majority of the wildlife is under full protection of Schedule I, Part I of the Wildlife Conservation Enactment 1997 and are also found in the Yayasan Sabah's concession area.

Another pristine area to the north of the Project site has recently been proposed as a conservation area. This is the Imbak Canyon Conservation Area. In fact, recognising its high biodiversity value, Yayasan Sabah voluntarily designated this area as a conservation area in 2003 (Source: Imbak Canyon Conservation Area by the Research & Development Division of Yayasan Sabah). See location in **Figure 4.4.1**. The area is about 30,000 hectare of virgin forest. One of the interesting findings is the presence of the rare and critically endangered Sumatran rhinos and proboscis monkeys.

4.4.1.1 Wildlife of Importance

The key species of local, national and international significance are the Sumatran rhino (*Dicerorhinus sumatrensis harrissoni*), orangutan (*Pongo pygmaeus*), proboscis monkey (*Nasalis larvatus*), tembadau or banteng (*Bos banteng*), clouded leopard (*Neofelis nebulosa*), sun bear (*Helarctos malayanus*), Borneon gibbon (*Hylobates muelleri*), elephant (*Elephas maximus*), Argus pheasant and hornbills. These species are protected under the Wildlife Conservation Enactment 1997. The Sumatran rhino, Orangutan, Proboscis Monkeys, Tembadau and Sun Bear are given full protection under Schedule I, Part I of the Wildlife Conservation Enactment 1997. Several inventory surveys have been undertaken in YS concession area, particularly in the Project site. As shown in **Table 4.4.1** (see also list in **Annex A1.3.1**), the area is found to be rich in terms of bird diversity. See also **Annex B1.3.1** for further details on the fauna assessment conducted in this SEIA.

Table 4.4.1: Summary of fauna inventory (Source: SEIA 2002)

Area surveyed	No. species Mammal	No. species Amphibian	No. species Reptile	No. species Birds
Gunung Rara Forest Reserve	61	8	4	193
Brantian	22		1	69
Kalabakan	39			255
Imbak	16		1	37
Kalabakan/Sapulut	49			165
Kuamut	13			102
Luasong	16			

Source: SEIA 2002

4.4.1.1.1 Orangutans (Pongo pygmaeus)

According to a survey conducted by the Sabah Wildlife Department in 2002, 1,000 orangutans are estimated to occupy the proposed project site of the Sino-Malaysia JV Forest Plantation. In order to mitigate the impact of forest disturbance due to logging and forest clearance to the orangutan population in the Project site, an area of 13,930 ha located at the northeastern part was excluded from the proposed ITP and reverted to NFM as a refuge area for the displaced orangutan. This specially reserved area is outside the proposed oil palm plantation (OPP) and ITP development. Although not many orangutans were sighted during ground surveys in the Project area, special attention must be accorded to a species with a very significant importance to conservation in Sabah. Orangutan nests were spotted in BW5/98 during the November 2004 surveys. Only a limited number of orangutan nests were observed during the surveys was due to the difficulty in detecting the nests and also due to low density of nests. According to the Sabah Wildlife Department's orangutan survey report, the density of orangutan in the projected site is generally low compared to other orangutan ranges in Sabah. However, the total number of orangutan is significant when the size of the Project area is considered.

4.4.1.1.2 Sumatran rhino (Dicerorhinus sumatrensis harrissoni)

Sumatran rhino have been reported in Danum Valley and Maliau Basin conservation areas. In May 2004, fresh hoof prints were found in the proposed Imbak Canyon conservation area. A female was killed south of the SUAS Project area (FMU 25) in March 2001 (New Sabah Times, 17 April 2001). Follow-up surveys conducted thereafter the killing found evidence of another animal still roaming in the same area. There is a possibility that this individual rhino has moved to other areas. Therefore, it is hoped that the wildlife corridor linking Maliau Basin and the SUAS area can provide the passage. However, there has been no report of Sumatran rhino found in the Project area either from this survey or other surveys conducted by the Sabah Wildlife Department.

4.4.1.1.3 Asian Elephants (Elephas maximus)

It is reported that the Asian elephant is an introduced species. Research based on genetic fingerprinting is underway to determine this hypothesis. At the moment, there are probably 1,100 to 1,500 elephants in Sabah and about 350 to 500 individuals are found in the Tawau District (Malim, et. al., 1998). They are mainly confined to the lowland forest in the east coast, and a small number at the Sabah/Kalimantan border. Within the Kalabakan and Gunung Rara Forest Reserves, there are about 20 elephants (Anon, 1999).

Being large, they depend on vast amount of feeds. Elephants are known to have established a 'feeding schedule' within their home range, returning to the same area after a few months. Davies & Payne (1982) have indicated that a viable population of elephant requires at least 6,000 square km of forest. Elephants are also dependent on minerals from saltlicks and mud volcano.

With the rapid development in Tawau region especially Kalabakan region, elephant-human conflicts have emerged where oil palm plantations have taken raided by the elephants and even grocery stores were not spared (Jomitin, 1995)

From the survey conducted, about a dozen elephant were observed foraging along the Kuamut river (see **Plate 4-2**), north of the proposed Project site on 23rd November 2004. Dung was found in Ulu Napagan VJR, BW2/99 and the road from Luasong Forestry Center to Kuamut. See **Plate 4-3**. There are about 350-500 individuals in the Tawau District (Malim et. el., 1998). Since elephant herds occupy large areas and sometimes have overlapping territorial ranges among herds, it is difficult to estimate how many animals occupy an area. However, based on the size of their range in relation to the size of the Project area, it can be estimated that the Project area can support about 100 elephants. Elephant herds from the surrounding area may enter the area from time to time. Elephant will pose the highest threat to oil palm plantation. Damage caused by elephant raids on the palms can be extensive and costly. Therefore, effective measures to protect oil palm from elephant raids must be put in place. As required under section 39 of the Wildlife Conservation Enactment 1997, the owner of the land has the responsibility to protect their crops from entry or damage by protected animal.

4.4.1.1.4 Tembadau (Bos banteng)

The Tembadau (Banteng) or wild cattle is a new inclusion into Schedule I, Part I of the WCE 1997. During the survey in 2001, tembadau hoof prints were observed in the Brantian area. Our recent survey indicated that the species have disappeared from their former range. There is a possibility that they have moved into nearby forest areas, which are outside the Project area, due to habitat disturbance.

4.4.1.1.5 Proboscis Monkey (Nasalis larvatus)

This primate is another endangered species of Borneo that have attracted the attention of national and international researchers. The species has been discovered along the lower part and estuary of the Sg. Brantian (Chemsain Konsultant Sdn Bhd, 2002) and in Maliau Basin Conservation Area (Anon, 1988).

They are also found on the upper part of the river such as the Brantian, Kuamut and Imbak. During the survey in November 2004, no proboscis monkeys were observed along the stretch of Sg. Brantian. Since inland areas do not normally contain significant number of proboscis monkeys, they are considered not significantly affected by the Project.

4.4.1.2 Impact of Oil Palm and Forest Plantation on Wildlife

The establishment of oil palm and forest plantation involves clear felling, staking, terracing and planting. The impact on wildlife is critical, major and permanent. There is no hope of re-colonizing except for some species which benefit from the young palm or fruiting palm trees in which case their invasions are regarded as damaging. These species include elephant, wild pigs, porcupine and squirrel but may include important species such as the orangutan. Some endangered wildlife species need to be rescued and relocated. Others will migrate to adjacent forestlands while others will perish. Generally, matured oil palm plantation will contain poor faunal diversity and lower density.

When forests are cleared wild animals and birds lose the element of shelter, breeding and nesting grounds, food source and camouflage. Disruption of habitat can ruin such a delicately balance systems. Certain animal species may be physically or psychologically constrained from migrating to other patches of forest if their territory is decimated. When one species is lost then others may be affected, as most of them are inter-dependent of species (Gralwohl & Greenberg, 1991).

Tropical forest plants and animals have economic importance in medicinal, agricultural and industrial production. As an unknown number of potentially useful or valuable species become extinct, the economic loss could be tremendous (Gralwohl & Greenberg, 1991). One such example is the Tembadau or wild cattle, which may have good genes that can be exploited by the bovine industry.

For the area to be developed for oil palm, a study by Duff, Hall & Marsh (1984) showed that very few animals would return to colonize the area after the establishment of the plantation. Animals such as wild pigs, civets, leopard cats, black spitting cobra, monitor lizards, rats, squirrels, owls, swallows, egrets, spotted neck doves, bulbuls, sparrows to name a few, are quite common sighting in oil palm plantations. Their presence is directly related to food sources found in the plantations.

One species that will continue to intrude into the proposed Project site, in particular the proposed oil palm area, is the elephant. Keeping them in the forest area may require electric fences. Managing elephant raids will be a challenging task for the Project Proponent.

4.4.1.3 Local Perspective

The conversion of large area of land primarily into oil palm plantation will have a profound effect on wildlife. Ground surveys in November 2004 already showed very low presence of wildlife within the Project site. The only species of significance found in the project site is the orangutan, at BW5/98. When this coupe is cleared for oil palm the orangutan has to quickly move to the Brantian-Tatulit VJR. Few nests were also spotted in this VJR.

Previous logging, clearing and planting activities have pushed animal population to dwindle in terms of diversity and number. This may be due to migration to nearby forest areas to seek refuge or simply perished due to starvation for being unable to adapt to the habitat disturbance. This will lead to the low density and diversity of wildlife in the Project site. It appears that every coupe has a camp with many workers. The presence of hunting dogs in these camps provides a clue that hunting is rampant. Tembadau or wild cattle that inhabited the Brantian area in 2001 has now disappeared. However, they continue to be observed at Ulu Napagon VJR.

All sensitive areas must be protected. They provide a temporary refuge for wildlife during the clearing exercise. They could also become a permanent habitat for many smaller animals and birds. Illegal hunting activity must be curtailed within the project site especially during the salvaging and clearing stages.

The elephants were observed mainly outside the Project site. They were seen along the Kuamut river. See **Plate 4-2**. Dung was found along the road from Luasong Forestry Center to Ulu Napagon VJR, in Ulu Napagon VJR and in BW2/99. Elephant-human conflict is expected when the area is converted into oil palm plantation. It is one species that will continue to intrude into the proposed Project site even after the establishment of the oil palm plantation.

Along forest boundaries, orangutans, wild pigs and porcupines are also likely to damage the palms. It is a challenging task for the oil palm plantation to control these protected animals. And during its productive years, rats and squirrels are the most common ‘pest’.

4.4.1.4 Regional Perspective

Of concern is the fate of orangutans, fully protected and listed as endangered species by IUCN. The Wildlife Department Sabah has estimated about 1,000 individuals are concentrated especially on the northern part of Benta Wawasan I. Fortunately the said area of high orangutan concentration, which was excluded for ITP in SEIA 2002 is outside the proposed oil palm plantation of Benta Wawasan I.

The elephant of Borneo, which is fondly called the pygmy elephants, is a protected species. However, there is provision to kill them when human life and crops are threatened. The conflict between elephants and oil palm plantation is real, and it requires a proper management system in dealing with it.

As per SEIA 2002, the areas south of Maliau Basin to the Sabah/Kalimantan border and the area between Maliau Basin and Danum Valley will be very critical for wildlife. Aerial survey on 28th November 2004 has shown that the proposed wildlife corridor is still intact. This corridor must now be extended to cover the proposed Imbak Canyon conservation area to the northwest. See **Figure 4.4.1**. Surveys have shown very low presence and diversity of wildlife within the proposed Project site. Thus, the last stronghold for wildlife in YS concession is within the major wildlife corridor linking Maliau Basin to Imbak Canyon to Danum Valley.

4.4.2 Aquatic Ecology

Clearing of trees and vegetation for the proposed Project will increase significantly the silt load in the streams and eventually into the rivers and sea. Soil will be washed into streams during rainy periods. In small quantities the organisms are able to cope and gradually adapt. In large and rapid deposition the organism will be smothered and will die off. If this continues eventually the whole stream would be completely changed from a rocky sandy substrate to a muddy silty substrate which is inhabitable by the existing group of organisms. The impact may create a new habitat eventually allowing the recruitment of a different composition of fishes or if no recruitment is possible the river will remain bare.

With the loss of the riparian along the banks and the inundation of sediments into the streams and rivers whole populations of aquatic organisms is loss either to be replaced by a new composition of organisms or in some cases to be totally devoid of any large organisms.

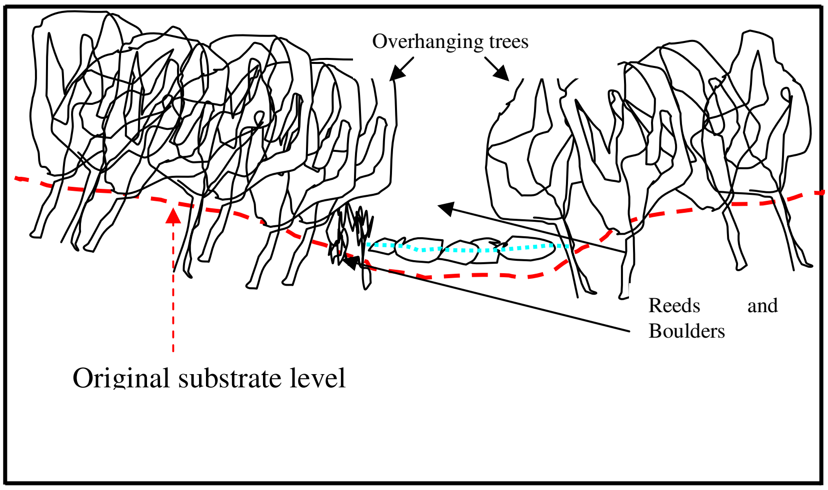
A number of changes occur with this inundation that changes the environment and causes a succession of composition of organisms. Some of these changes and effects are discussed below:

a) Habitat changes caused by erosion, loss of riparian reserve and bank erosion

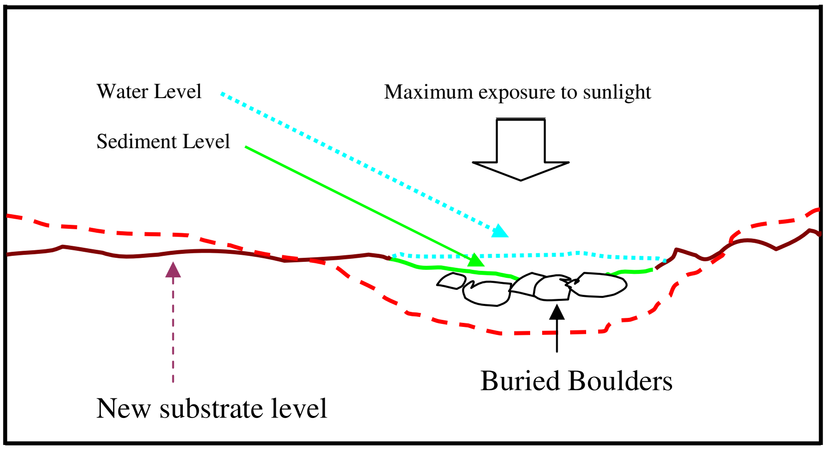
With land development for both urban and rural requirements as well as industrial and agricultural development, the water ways are affected. **Figure 4.4.2** shows the ways in which this affects happens causing massive impacts on the aquatic environment.

Figure 4.4.2: Habitat changes caused by land clearing and loss of riparian reserve

a) Undisturbed landscape



b) Disturbed Landscape



Impacts caused by the change in the physical and chemical factors due to erosion and riparian reserve loss are:

1. The overhanging trees shade the streams from direct sunlight, thus together with the rapid flow of water flowing through the narrow stream controls the growth of algae. However once the shade is removed and the substrate in the stream is exposed to the maximum exposure of the sun coupled with increase nutrients in the water and the slower water flow algal blooms occur especially with the filamentous algae.

2. With these algal blooms, the algae will collapse and settle to the substrate, this could with low water flow lead to Eutrophication and a change in the water quality for the worst. Oxygen levels will drop due to Eutrophication and other organisms will die off slowly.

3. The erosion of the river banks and the settlement of sediments as the river widens also contributes to the above effects. This also covers all the boulders in the stream effectively taking away valuable shelter, breeding and feeding habitats of many aquatic organisms.

4. The loss of the bank vegetation apart from promoting erosion also contribute to the loss of feed and shelter habitats offer by them in the undisturbed state.

5. Under these conditions very few species of fish can thrive. Many will die off, some may manage to migrate up or down stream to find for suitable habitat but in the case of these catchments the succession has been poor and in many cases the local population had been succeeded by exotic introduced species such as Tilapia species.

6. Such conditions also built up behind weirs and embankments.

7. The increase in nutrient in the water is caused by the increase nutrient run off from the eroded soil. This nutrient can either be locked up in the sediments or released slowly into the water or it could be in the water itself. This increase in nutrient promotes algal growth.

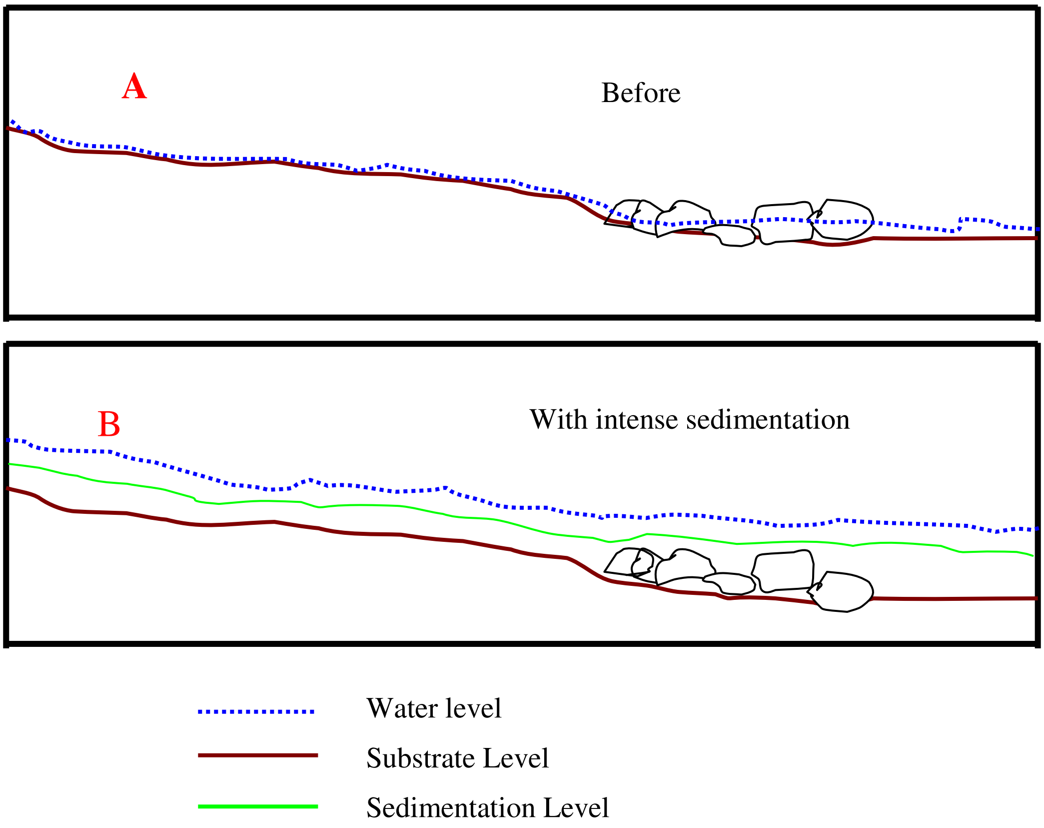
8. The loss of riparian along the river banks also is a major loss of habitat as these vegetation apart from having a function to stabilize the banks from erosion also serve as a shelter for a host of terrestrial animals that forage along the river banks such as shrews, mice, monitor lizards, tortoises and others.

9. In cases where reeds use to growth at the side of the banks with their stalks in the water, these offered shelter, food, breeding habitats for whole population of macro invertebrates, which attracts a whole array of feeders.

b) Changes in the river bed due to sedimentation

Due to the influx of sediments in the form of sand, silt and mud the structure of the river bed is changed. **Figure 4.4.3** depict such a change where **A** was the situation before sedimentation occurred and **B** shows a situation where sedimentation changes the level, structure and form of the river bed. These changes affect the habitat and diversity of the river. Together with **Figure 4.4.4 C** and **Figure 4.4.4 D** a detail discussion on a micro niche of the above situation is given below to explain the impacts of these changes.

Figure 4.4.3: Longitudinal section of a river bed



Figures 4.4.3 A and **4.4.4 C** show the condition of the stream before uncontrolled sedimentation set in. Favorable conditions are found where that are conducive habitats for fishes and other aquatic organisms to thrive. These include:

a. Ponding effects along the stream offer space for the fish to thrive.

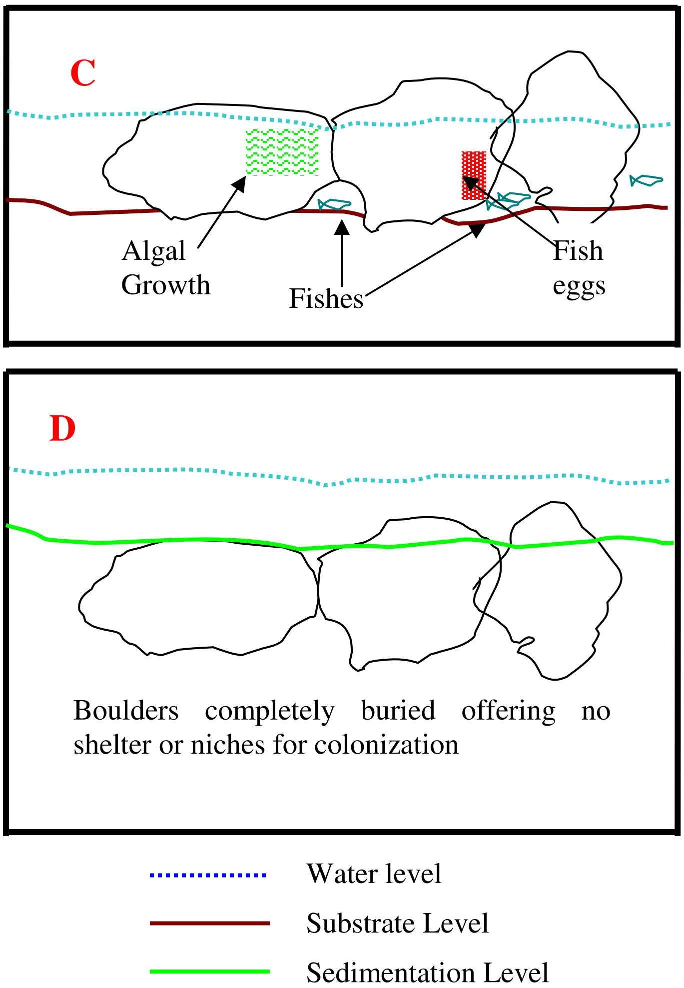
b. Shelter, protection and hiding places under the boulders for fish.

c. Surfaces of boulders supports colonies of algae whose growth is controlled by the limited sunlight and rushing water, these algae is fed on by many invertebrates.

d. Fishes and other aquatic organisms attached their eggs to the lee side and under side of boulders.

Once sedimentation sets in as shown in **Figures 4.4.3 B** and **4.4.4 D**, all the above conditions are lost and the stream bed is fully exposed to maximum sunlight exposure. Food chains are broken and organisms that depend on one another for survival die off one by one. Such barren stream conditions are evident throughout the catchment.

Figure 4.4.4: Habitat changes and loss due to sedimentation



The loss of a population of fishes would also mean a loss of an important genetic pool for those species. These may not be significant if we look at one stream at a time but the overall impact from all the stream combine could mean the loss of an entire species genetic makeup which has evolved over thousands of years.

As the silt is washed further down river the devastation continues. Deposition along bends and meanders along the rivers can lead to habitat changes, localize flooding and even altering the alignment of the river. The increased silt load in the water will also cause many species of fish to perish due to smothering of gill and loss of food sources. See **Plate 4-4**.

When the silt laden river water reaches the wider reaches of the estuary and river delta the silt begins to settle to the bottom. The major impact here will be on the mangrove swamps initially the impact will not be visible but the cycle of destruction can be slow and irreversible. To begin with, the mangrove swamps benthic zone is known to be an important breeding and nursery ground for a large number of importance species of fishes, prawns, crabs and a whole host of other marine organisms. The sudden and unceasing influx of silt into the area will carpet the benthic zone effectively destroying the delicate benthic ecosystem and all its inhabitants.

Prolonged settling of silt could eventually even smother the mangrove trees as it covers the aerial roots. The mangrove vegetation would die-back slowly and eventually all that is left is an unproductive mud flat.

During the rainy seasons and flooding the silt would be washed out to sea. The finer suspended silt could be carried a long way out to sea. Nearer the coast the silt would settle on the sea bottom, depending on the volume of settlement whole habitats could be changed or replaced by new less productive ones. Out at sea the fine silt could cause problems in coral reefs and other delicate marine ecosystems.

The silt load in the water also changes the light regime in the water column which is the effect of light penetration through the column. This causes reduced and eventually a complete loss of the vegetative growth which requires light for photosynthesis. After a prolonged lost of light the substrate and even the water column will be devoid of any vegetative community.

Another effect that runs concurrently with increase silting is the increase in nutrients in the water by way of nitrates, nitrites, phosphates and many other chemical. Some of these nutrients may cause temporary blooms in algae while other may be harmful and kill off other organisms.

Trees overhanging and covering a stream or river is important in that it create a unique habitat of its own. Removal of trees along the river will change this habitat in mainly two ways, i.e. removing the food source for carnivores and omnivores by way of insects and worms that live in the trees which the fishes depend on for food as they drop into the water and exposing the river completely to light causing a new habitat to be formed favoring the herbivores with algal growth.

In many instances smaller trees overhanging the streams and rivers are felled directly into the water or branches and stumps are washed into the streams during downpours. These are washed downstream where they will eventually be snared and accumulated in a bottle neck area causing water to divert leading to localize flooding and eventually changing the course of the river. Such accumulation of debris have been known to be the main cause for bridges collapsing as it accumulates under the bridge and the force of the water pushes against it causing the structure to give way.

The impact on the fish population will also be affected by the increase of human population with this development. Workers will fish the rivers and could wipe out whole communities especially if illegal means are used such as by poisoning, fish bombing and others. The rate of recruitment at present would not be able to sustain the population of fishes as the catches increases. The details on the methodology and findings for the aquatic survey are presented in **Annex B1.3.2**.

4.4.3 Human-Animal Conflict

Human-animal conflict is common in agro-related activity. When human opens up forestlands, wildlife residence will be displaced. Feed resources are depleted and can be lost totally. Animals venture into plantations to eat whatever is edible. Oil palms, in particular, become substitute feed for some animals. Human-animal conflict begins.

Four species i.e. elephants, orangutans, wild pigs and porcupines are the common ‘pest’. The elephant is the major threat.

The issue here is not that the wildlife poses a threat to the plantation. The environmental issue is two-fold:

1. By clearing a large tract of forest, wildlife is pushed out and may subsequently become a nuisance for others.

2. If the wildlife seeks to forage from or otherwise threaten the plantation crops, the plantation management becomes a threat to the wildlife.

The sections below seek to explain how this conflict especially point two above comes about and the background for why plantation management at times seek to further limit the movement or distribution of wildlife.

4.4.3.1 Elephant

Major losses in oil palm plantations have been attributed to raids by wild elephants. A herd of 20 elephants can consume and uproot some 500 palms in a newly planted area in a night. In one series of new developments in Malaysia, it was estimated that elephants destroyed 1.4 million palms over a four-to six-year period. The young palms are trampled or uprooted and their centre shoots torn out. Most damage is caused in plantings up to six years old. Where damage is not severe, the palms will recover, although development will have been retarded. The elephant is a protected animal under Schedule II, Part II of the Wildlife Conservation Enactment 1997. In extreme case, the authority allows the killing of elephants when human lives are endangered and/or crops damaged.

4.4.3.2 Orangutans

Orangutans eat very young oil palm shoots. Unlike elephant, not all palms will die when attacked by an orangutan. Adult orangutans are more destructive as they have the power to rip off the fronds to gain access to the soft juicy part of the palms. Oil palms as old as two years are still vulnerable to adult orangutans. Larger palms have thorns that keep orangutans away from them.

Orangutans are protected under the law and killing Orangutans carry a mandatory jail sentence of between 6 months to 5 years upon conviction.

4.4.3.3 Wild Pigs

The bearded pigs are common ungulate in Sabah. They are prolific and ubiquitous. With a gestation period of less than 4 months and an average of 8 piglets per litter, this species will be the last to extinct. The female reaches reproductive age at 6 months.

Wild pigs consume newly planted palms. However, they are fond of loose fruits, which are economically valuable due to the higher oil level. The extent of damage caused by wild pigs is very variable but has been severe on numerous occasions and has often been responsible for the most serious losses in recent developments. This has been particularly so in Indonesia and Malaysia. In the latter, it was estimated that pigs destroyed 902,000 young palms over a period of five to six years in a series of new palm developments. In Kalimantan, pigs destroyed 10,000 ha of a 12,000-ha estate over the course of two years, while losses of thousands of hectares elsewhere in Indonesia have not been uncommon. The wild pigs, *Sus scrofa*, and the bearded pig, *Sus barbatus*, attach palms of all ages. In a nursery, grubbing in the soil can bring about serious dislodgment of large numbers of seedlings in one night, and young field palms are uprooted. Mature fruit is eaten, either as loose fruit lying on the ground or by the pig standing on its hind legs to reach up into the crown to chew a fruit bunch. An unusual result of mature fruit damage is that harvesters have occasionally refused to handle such fruit because of religious beliefs relating to pigs.

Wild pigs are protected under the WCE 1997. However, they are considered game animals and can be hunted under licensed from the SWD. For sport, the hunting fee is RM5.00 per animal while for commercial purposes the fee is RM50.00 per pig.

4.4.3.4 Porcupines

Porcupine attack newly planted oil palm by nibbling through for the soft central core. Porcupine is protected under Schedule II of the WCE 1997. A permit can be obtained from SWD to hunt or kill them.

4.5 Flora Ecology

4.5.1 General

The proposed Project area was originally virgin forest. However, after the Second World War, a British-based company North Borneo Timber Bhd (NBT) started logging activity in the East Coast of Sabah in Sandakan and Tawau areas. In the late 1950's the NBT was set up in Tawau and started logging activity at the south-eastern part of Tawau. Gradually they progressed and extended their logging activity into the northern and western parts of Tawau. Although the said forest concession was gazetted for Yayasan Sabah in 1970, logging activity did not cease then. In 1999, it was estimated that only less than 10% of the primary forest left on the steep slopes.

The logging history of the Project area as shown in **Figure 4.5.1** showed that the area has been subjected to many rounds of logging.

4.5.2 Impacts

The impact of the proposed Project could be evaluated according to the existing condition and vegetation. See further details on the methodology and findings in **Annex B1.3.4**. Although a large portion of the area had been cleared or undergoing intensive reentry or salvage logging there are still pristine habitats that could be of importance to the local flora. The loss of ecological habitats, which may harbour a diversity of flora, will be the most prominent. Clearing of tree cover will destroy the microenvironment essential for the many shade loving species of the forest floor. The steep ridges with very thin layer of soil together with the sandstone parent material provide the substratum for many endemic herbs and shrubs. These habitats will be exposed to the extremes of condition, which will cause the irreversible loss of these plants. It has been noted by Holttum (1988) that of the 510 fern species recorded in Peninsular Malaysia, only 25 are found at the edge of forest with 210 species are confined to forest floor and 165 species are epiphytic on standing trees, 15 species are climbing ferns and 40 species are found on rocks in forest as well as stream banks. This indicates that large proportion of the fern flora is dependent on the presence of the forest habitat for continuous existence. Of equal importance are the riparian belts along the numerous rivers and streams within the Project area. Changes to these habitats will be permanent although localized within the Project site. These belts contain also uniquely adapted flora that could be damaged without adequately imposed protection. Sites with these sensitive habitats are in **BW 1/00, BW2/01, BW 3/00, BW3/01, BW4/00 (A), BW4/00(BII), BW4/01, BW 9/00, BW9/01 and BW9/03**.

With the removal of natural forest species for the establishment of a mono agricultural crop depletion of these species would follow. This loss of species will be localized and not be of significance in a regional level but is an irreversible and permanent impact. Many of the tree species are found in other lowland forests of the state but this impact could be more severe on shrubs and herbs where high degree of endemism is recorded. Kiew (1996) recorded high endemism in herbs with many of them confined to a particular hill owing to their poor dispersal system. The same report shows that of the 885 species of plants recorded in Fraser's Hill, 1.7 % are extinct, 5.4% are critically endangered, 13.8% are endangered and 7.7% are vulnerable.

It must be noted that the many commercial tree species especially those of the Dipterocarpaceae which are well represented in this area will be harvested. Trees of these species have developed genetic traits over the years to be competitive in this specific area. These genetic gains will be lost permanently with the project. These specific genetic variations are more crucial for plants with pharmaceutical properties where specific traits are often developed specific to sites. Fashuddin Ahmad & Hasmah Raji (1990) have documented many of the common medicinal plants of the lowland forest used by the Murut community in Sabah. A number of forest plants have been included in a listing of the ethnobotanical application of Sabah medicinal plants presented in Mohd. Yaakub Hj. Johari, Maryati Mohamed & Mary Sintoh (1988). A tree of the *Goniothalamus dolichocarpus* found near the Brantian VJR is known to contain goniothalamin, a biologically active stryldihydropyrone (Laily Din et. al., 1990). This same plant is reported to be an effective insecticide used by Iban to repel insects (Pearce et. al., 1987). Lee & Aban Gibot (1985) documented 3.4% of the known plant species in Sabah are edible with a large proportion of these are wild fruit tree species which had been recorded in the inventory done for the SEIA of 2001 (**Table B1.19 in Annex B1.3.3**). Bompard (1995), Lamb (1987) and Wong & Lamb (1990) have also recorded the important fruit tree species in the state. It must be noted that the loss of fruit trees will result in a depletion of food sources for the many arboreal animals within the forest. The reduction of ground vegetation will similarly affect the herbivore population on the forest floor.

Minimal impact on biological diversity will be in coupes that are completely cleared of the original vegetation. The five coupes covering an area of 9,202 ha cleared for industrial tree plantation have no tree vegetation except for some regenerating secondary species thus the impact is minimal in these sites. Increase surface erosion with construction of planting lines will be a temporary impact.

There are another 15,450 ha that have been established with *Acacia mangium*, with the earlier planted trees forming closed canopies that have prevented regeneration of any primary forest species. There will again be minimal impact on the biological diversity of the area but removal of these trees for replanting with oil palm will expose the sites to surface erosion especially if these areas are cleared together.

The largest component of the project site consisting of 43,503 ha is currently undergoing salvage logging for plantation establishment. In this harvesting process all trees at and above 25 cm diameter are removed. During this process high density of roads is constructed for transporting the logs and damages to residual vegetation is extensive. Owing to the opening of the canopy ground vegetation has suffered damages owing to the change in environmental conditions. The impact will be most severe on the residual vegetation, with the shade tolerant species gradually dying off allowing an invasion of more aggressive secondary species. This impact is of greatest concern as there are good pristine forests within these coupes, which had not been harvested previously owing to their steep terrain. Examples are found on the ridges of BW1/00, BW4/00 and BW9/00. Post felling data obtained from Innoprise Corporation show that the sites with the best volume of timber of over 60 m^3 per ha in BW1/00 (**Figure 4.5.2**), BW4/00(A) and BW4/00(B) (**Figure 4.5.3**) are all confined to the ridges within the coupes. These ridges are usually also habitats for very localized populations of shrubs and herbs. In addition these provide corridors for movement of animals and genetic transfer among vegetation. Similar very localization of herbs and shrubs has been reported in Brunei (Earl of Cranbrook & Edwards, 1994).

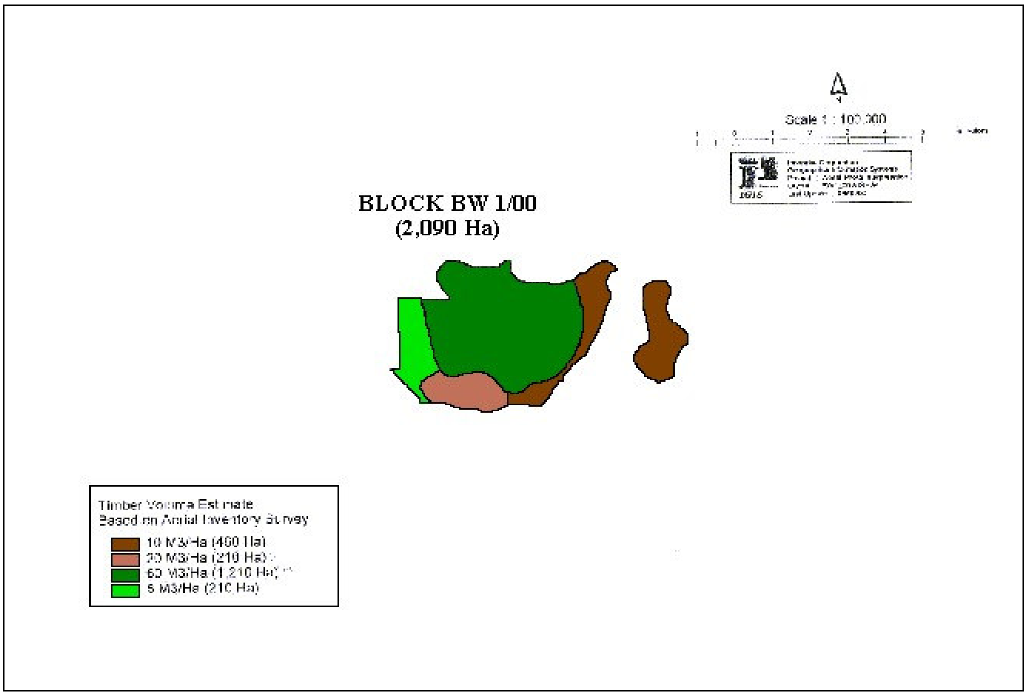


Figure 4.5.2: Volume of Timber in Coupe BW 1/00

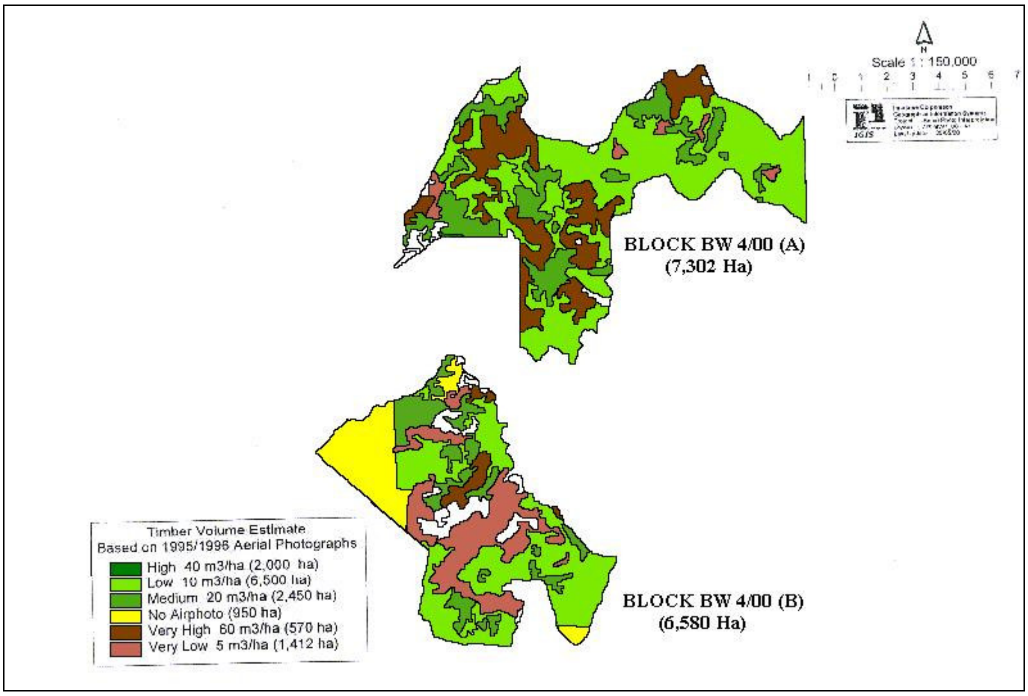


Figure 4.5.3: Volume of Timber in Coupe BW 4/00(A) and BW 4/00 (B)

In the harvesting process steep slopes and river buffer belts have been identified in the harvesting plans. The level of conformity to these requirements varies in different coupes. In Coupe BW1/00 felling of trees was observed in sites that were marked as steep slopes (**Plate 4-4**) resulting in severe impact on these slopes (**Plate 4-5**). River buffers were observed to be clearly marked in BW3/01 (**Plate 4-6**).

Another 19,492 ha are now undergoing re-entry logging where trees of diameter at and over 50cm are harvested. These areas will be undergoing salvage logging once these commercially more valuable timbers have been extracted with the exception of sites identified for exclusion from the plantation. It was also observed that some of the coupes identified for this activity with gentle terrain do not have high volume of timber trees owing maybe to the previous logging intensity. Examples are BW11/01 and BW11/02 (**Plate 4-7**). The impact on **floristic** diversity will be **less drastic** in these coupes. **Coupes BW1/00, BW9/00 and BW9/03, in contrast, have an abundance** of large trees along the ridges (**Plate 4-8**) thus loss of vegetation diversity will be of significant impact.

The salvage logging process that is prescribed will remove almost all the trees within the forest, reducing the amount of residual biomass. It was estimated in the 2002 SEIA, 185 ton/ha would be left in the process. This reduction will reduce the need to dispose large volume of biomass commonly associated with plantation clearing. Strict enforcement of zero burning will have to be imposed. Evidence of open burning of wood was observed in **BW5/99** (**Plate 4-9**).

4.6 Socio Economics

Socio economics assessment will address the local issues such as employment and business opportunities, hunting or poaching, vector borne disease, waste management, health and safety, dust and noise pollution, loss of ecotourism opportunity, impact on land use, cultural and historical impacts and economic aspect of the project cost and benefit.

4.6.1 Employment Opportunities

The proposed OPP and ITP would generate demand for workers during the site preparation, construction and operational period. These would have a positive impact by generating direct employment and spin-off service employment opportunities within the region. The number of direct employment (based on the calculated net plantable area for OPP and ITP presented in **Table 4.6.5**) generated is summarised below:

Land Usage	Area (hectare)	Estimated No. of Employment	Assumption
Oil Palm Plantation (OPP)	75,754	9,469	125 workers for every 1,000 of plantation
Industrial Tree Plantation (ITP)	12,976	649	50 workers for every 1,000 ha of ITP
Total	**88,730**	**10,118**	

Such potential use of the local labour force would be considered a beneficial impact therefore no mitigating measure is required.

4.6.2 Foreign Workforce

Although the employment opportunity created would appear to be beneficial, however, the Project is anticipated to face labour shortages especially during operational stage due to the small population and manpower pool of the area. Locals are generally not keen to be employed as plantation labourers because of the heavy labour involve relatively low wages in comparison to other sectors (construction and timber) and long working hours. Although the Project may help reduce out-migration of the existing population, it is also expected to lure labour from outside the area, especially from neighbouring countries (Indonesia and the Philippines).

The size and type of in-migration can cause a number of social impacts. For example, construction labour forces tend to be young, single men with few local connections. Generally, they are transient, moving from one site to another. The main demand of such individuals is likely to be for adequate accommodation, sewage treatment, medical and recreation provision.

Over the years, immigrant workers have been associated with a series of social ailments – increase in crime rates, proliferation of the drug-trade and use, involvement in false identity card syndicates, increase incidence of sexually transmitted diseases, squatter problems, etc. All of which creates an atmosphere of fear and distrust with the local communities. On the other hand, the migration of large numbers of foreign workers into areas traditionally inhabited by native people of Sabah (e.g. Malay, Kadazan-Dusun, Murut, etc.), may led to social conflict.

Illegal hiring of these workers will further add to the State's illegal immigrants' problem. Proper control by the State Government on foreign workers is required to help minimise this problem.

4.6.3 Infrastructure, Facilities, Amenities

The presence of this large number of workers into the Project area will require proper housing, infrastructure and amenities. As in normal practice, this will be provided by the Project Proponent or its sub-contractors. As the increase in the workforce will take place gradually according to the phases and stages of development, impact on local infrastructure, which is almost none-existence within the Project site, is not expected to be significant.

4.6.4 Business in the Project Area and Region

The proposed development is envisaged to boost the Kalabakan and Tawau business and economy that is heavily dependent on timber and oil palm. The direct potential business opportunities arise from this proposed Project are:

- Infrastructure development – quarries to supply gravel for road and building; cement factory to supply cement for buildings and housing, equipment to supply the heavy machineries and equipment as well as servicing.
- Contractors and subcontractors – covering site clearing, planting, maintenance, harvesting and transportation where work is undertaken on a contract basis.
- Commercial business – nursery to supply seedlings; agricultural company to supply fertilizers and other agro-chemicals products and machineries; banking sectors to finance loan; hotels to provide temporary accommodation; transportation companies to supply transportation services (products or people); machinery and equipment repair and servicing; food supply and other consumable materials supply.
- Apart from the potential business opportunities, Kalabakan town will benefit from the spin off effect through generation of services provider businesses like the food sectors, transportation, tyres, petrol/fuel, repairs and services, auto electrical services, wholesale trade, etc.

To the Local Authority/State/Country, the indirect benefits that accrue from the Project are:

- Assisting the State in achieving its developmental objectives.
- Help the State Government to speed up their development and economic diversification program.
- Injecting funds into the State and national economy through agriculture activities.

- Direct and indirect taxes from households and expanded business (e.g. transport of goods and services).
- Injecting funds into State and national economy through levy charges from foreign workers.

This is considered as beneficial impact, therefore no mitigating measure is recommended.

4.6.5 Water Resources Degradation and Siltation

The most likely settlements to be affected in terms of water resources degradation are Kalabakan and Kpg. Brantian. These settlements are located within the lower catchments of Sg. Kalabakan and Sg. Brantian respectively. For years, forest clearing, road construction, indiscriminate disposal of factory wastes (especially in Kalabakan) and higher densities of households (factory workers' quarters at Kalabakan) along the river, development of plantations (tree plantation and oil palm plantation) has caused problems such as frequent outbreaks of skin disease and diarrhoea. Water samples collected from these rivers showed high level of Total Suspended Solids and faecal coliform count, especially near human settlements (see **Annex B1.2.2-Laboratory analysis result for water quality**).

Both catchments (lower) area have been developed for oil palm plantation and tree plantation developments (see **Figure 3.8.3 – Land Use map**). The development of this project will further pollute these rivers, as it will affect the upper catchments of these rivers. Of concern is high level of sediment load due to earthworks in the earlier stage of the development and agro-chemicals pollution during operation stage.

Both Luasong Forestry Centre and Kpg. Fajar Harapan Luasong would not be affected by the project as ICSB has set aside about 1,000 ha of water catchment area within the Luasong Forestry Project area.

4.6.6 Impact on Community Use of Forest Resources

The proposed Project sites are located within the Yayasan Sabah Forest Management Area, one of the largest forest Licence Area in the State. These sites are located at a distance from the nearest permanent settlement and not frequented by the public except for hunters and loggers. Furthermore, both Kalabakan and Kpg. Brantian are surrounded by land already developed into oil palm plantations or tree plantation.

Hunting of wildlife in general is allowed under a valid license issued by the Sabah Wildlife Department. However, the licence permits certain animal to be hunted or collected except for those under Schedule 1 Part 1, which is prohibited. The licence holders, on the other hand, is not entitled to enter any alienated land, forest reserve, park, reserved land or State land where entry is restricted without the consent of the owner or the appropriate authority (Section 28 (9) of the WCE 1997). Despite the conditions of the licence, illegal hunting or poaching is still noted within the Yayasan Sabah Management Area. Hunting by the contractors or workers in the adjacent forest in the future will be another problem for the wildlife conservation.

4.6.7 Cultural and Historical Sites

With a sizable project like this, the possibility that it may have some historical sites within its boundary is probable. However, based on available literature, surveys and interviews with the locals and the Museum Department the area seems to be void of any significant historical site. The nearest site where there is a historical significant is in Kalabakan where a memorial site is erected to commemorate the warriors during the confrontation in the 60's.

There is a burial ground outside adjacent to Kg. Fajar Harapan Luasong and another one was noted along Sg. Kalabakan near to Kalabakan town. Both cemeteries are still in-used.

4.6.8 Waste Management

The main environmental problems associated with waste generations from this Project are air pollution due to open burning of biomass (see **Section 4.7**) and health hazard as a result of indiscriminate disposal of domestic wastes and sewage.

Domestic wastewater or sewage is the spent water originating from all aspects of human water usage. Sewage comprises 99.9% water and the remaining 0.1% comprises contaminants which are potentially harmful to waterways, causing adverse impacts to fish and other aquatic life and consequently to human utilisation. These contaminants include oxygen demanding substances [Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD); pathogenic micro-organisms; and nutrients (e.g. Nitrogen and Phosphorus)], that may result in the growth of algae and weed. All these may lead to a reduction in dissolved oxygen levels, deterioration in the water quality, possibly cause eutrophication and emit odour, creating an unpleasant environment.

The magnitude of the impact will depend on the actual population and the strategies put in place to avoid pollution of this nature. In order to quantify the environmental impact caused by untreated sewage, the projected population is estimated using the recommended population equivalent factors as stipulated in the Guidelines for Developers published by the Ministry of Housing and Local Government (Sewerage Services Department). A crude estimate of the projected population based on population equivalent (PE) can be calculated and is presented in **Table 4.6.4**. The calculation for the BOD estimation is in **Annex B1.5.2**.

Table 4.6.1 Estimation of BOD Loading for Untreated and Treated Sewage on Sg. Kalabakan, Sg. Brantian and Sg. Kuamut

PE	Effluent Characteristics	Quantity, mg/l	Estimated BOD Loading, kg/day	Instantaneous Increase of BOD level (mg/l)
Oil Palm Plantation				
9,469	Untreated sewage BOD	225	498.82	2.72×10^{-9}
9,469	Treated to Standard B – BOD	50	109.52	6.04×10^{-10}
9,469	Treated to Standard A – BOD	20	43.81	2.41×10^{-10}

PE	Effluent Characteristics	Quantity, mg/l	Estimated BOD Loading, kg/day	Instantaneous Increase of BOD level (mg/l)
Industrial Tree Plantation				
649	Untreated sewage BOD	225	33.15	1.83×10^{-10}
649	Treated to Standard B – BOD	50	7.37	4.06×10^{-11}
649	Treated to Standard A – BOD	20	2.95	1.62×10^{-11}

Assumptions:-

- Approximately 125 PE (Population Estimate) for OPP; 50 PE (Population Estimate) for ITP and 20 PE (Population Estimate) for NFE per 1,000 ha of plantation.
- Per capita discharge of wastewater of 227 l/day.
- Average flow for Sg. Kalabakan, Sg. Brantian and Sg. Kuamut is 2.1×10^{9}, 7.8×10^{8}, and 8.7×10^{8} cumecs respectively.
- Complete mixing of the stream for instantaneous increase of BOD load.

Based on the above estimation, any untreated sewage would increase the BOD loading even though it is not significant. However, the cumulative impact may be of some concerns. For this development, septic tanks may be used and the effluent, discharged to the river system. The discharge would meet the acceptable Standard B of Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979 under the Environmental Quality Act (**Annex B1.7**).

4.6.8 Safety

Accidents are likely to occur during forest harvesting activities where machines and cutting tools are widely used. Improper handling and carelessness will expose workers to accidents and may result in serious injury or even fatalities.

4.6.9 Dust and Noise Generation

During land clearing and planting, fugitive dust is the main pollutant expected. Dust is generated from activities such as grading, road construction and vehicle movement and from exposed surfaces.

Impacts due to fugitive dust during land clearing and planting phase are expected to be short-term and minor as the site is located in a remote area, well away from residential areas. Fugitive dust is generally emitted at or near to ground level and are heavier, hence would be expected to settle within a short distance from its sources (US EPA, 1995). Under normal wind condition, areas more than 200 metres away will not be significantly affected. There is no true settlement within the Project site, except existing logging base camps. Outside the Project site, however, the houses in Kg. Fajar Harapan Luasong and some of the Luasong Forestry Centre are built less than 50m from the main road. Dust particles resulted from vehicular movement along the road could be an irritant for the residents living next to the road. This occurrence on the other hand, is only temporary and will cease after some time when the dust settles down.

During operational stage, air emission from the oil palm mills are from the boilers and incinerators, and are mainly gases with particulates such as tar and soot droplets of

20-100 microns and a dust load of about 3,000 to 4,000 mg/NM. Incomplete combustion of the boiler and incinerator produces dark smoke resulting from burning a mixture of solid waste fuels such as shell, fiber and sometimes empty bunches.

4.6.10 Industrial, Urban and Commercial Development

The proposed development is envisaged to boost the Tawau economy that is heavily dependent on timber and oil palm (refer to **Section 4.12.2** for economic benefit). The direct potential business opportunities arise from this proposed ITP are:

- Infrastructure development – quarries to supply gravel for road and building construction; cement factory to supply cement for buildings and housing, equipment to supply all the heavy machineries and equipment.
- Land clearing and planting - Contractors and subcontractors to carry out planting, maintenance, harvesting and hauling where work is undertaken on a contractual basis.
- Commercial business - nursery to supply seedlings; agricultural company to supply fertilizers and other agro-chemicals products and machineries; banking sectors to finance loan or credit.

Apart from the potential business opportunities, Kalabakan town will benefit from the spin-offs effects through generation of service provider businesses like the food sectors, transportation, petrol/fuel, auto repairs and services, electrical services, wholesale trade, etc.

4.6.11 Loss of Ecotourism Opportunities

Although the Project site is not located right next to the two (2) known conservation areas in Sabah, i.e. the Danum Valley (43,800 ha) and the Maliau Basin (58,840 ha), it must be recognised that there is a direct visual impact. This is particularly true as one of the access roads to Maliau Basin Conservation Area has to traverse Benta IIC, the potential tourist will see the same boring oil palm trees for miles. In the existing environment, this is already being felt when one travels from Tawau towards the Project area, one has to endure the unchanging view of oil palm plantations. This is a common occurrence in many parts of Sabah where large scale oil palm plantations are located very near or close to the conservation areas such as the Tabin Wildlife Reserve (120,000 ha), Kulamba Forest reserve (30,000 ha), Lower Kinabatangan Wildlfie Sanctuary (26,000 ha) and Danum Valley Conservation Area (43,800 ha). Tourist has to travel through sea of oil palms outside Sandakan, Tawau and Lahad Datu to reach these conservation areas.

The proposed oil palm and tree plantation area is classified under commercial forest (production forest) and there is no promotion on ecotourism within the area.

4.6.12 Changes to Landscape / Land use Changes

The development of this Oil Palm and Industrial Tree Plantations Project will change the landscape within the YS Management area as well as Sabah as a whole.

Based on the SEIA team's assessment, which involved exclusion of large areas for nature conservation and environmental protection of steep, high risk, sensitive areas, the net plantable area for oil palm and tree plantations development has been calculated to be approximately 75,750 ha and 13,000 ha. See **Table 4.6.5** for the details of the net plantable area for the oil palm and tree plantation development.

Table 4.6.5 Calculation of Net Plantable Area in Oil Palm and Tree Plantation Project Area

No.	Description	SEIA Recommen-dations	Area in Hectares
1.	Total Project Area (ha)		109,600
2.	Sensitive area (incl. high risk area within the natural links)	9,522	
3.	Steep area (> 25 degree)	6,343	
4.	Road/ River Buffer in Benta IIC: Kalabakan-Sapulut (1000m x2 for aesthetic function)	1,577	
5.	Road Buffer in Benta I (100m x2)	532	
6.	INIKEA Project Buffer (1000 m)	1,448	
7.	Buffer zone around VJR and other protection areas (100m)	233	
8.	River Buffer		
	Sg. Brantian (250m x 2)	688	
	Sg. Kalabakan (100m x 2)	878	
	Sg. Tiagau (200 m x2)	214	
9.	**Net Plantable Area**		
	OPP (Benta I)		58,983
	OPP (Benta IIC)		16,771
	SUB-TOTAL		75,754
	ITP (Benta I)		10,073
	ITP (Benta IIC)		2,903
	SUB-TOTAL		12,976

**Note: Items 2 to 8 are computed separately and does not take into consideration of areas where it overlaps. However, the net plantable areas for OPP and ITP are derived from deduction of all the areas to be excised from development.*

4.6.12.1 Impacts to the Other Land Use Within and Surrounding the Project Area

The proposed OPP and ITP Project lies within Yayasan Sabah's Forest Management Area - 99-year forest concession, which at almost 1 million ha, is one of the largest forest Licence Area in the State. The majority of the Licence area (80%) is classified as Commercial Forest Reserve (production forest) and most of this area has been logged. The remaining 20% consists of unlogged conservation Areas (existing & proposed) (+/- 10%); and inaccessible, non-productive and un-workable areas (swamps, rocky areas, etc) (+/- 10%). With this proposed project, approximately 11% of the production forest will be taken out as OPP and thus reduce the total available area under natural forest (before exclusion of sensitive areas).

Apart from the reduction in the natural forest, the ICSB (mother company of Benta Wawasan Sdn Bhd) operates a few projects near to the boundary of the proposed Project area. There are the Luasong Forestry Centre (LFC), the renowned international collaboration projects i.e., INIKEA rehabilitation project (Rehabilitation of Tropical Rain Forest for IKEA, Sow-a-seed), Swedish University Agricultural Sciences (SUAS) project, RBJ/NEP Reduced Impact Logging (RIL) project and Virgin Jungle Reserves (VJR) (refer **Annex A1.4.3** for these projects background).

The Brantian-Tatulit VJR within the Project site in particular, will be affected by the proposed development once the area is cleared for oil palm plantation. The creation of islands will reduce the opportunity for genetic exchange among populations as well as weaken the success of reproductive capacity as many species have low number of individuals within a site. This could lead to inbreeding within populations. Owing to the greater accessibility of these isolated areas of natural forest stands illegal felling will be more prevalent and difficult to control. With the clearing of vegetation and establishment of oil palm plantation there is a danger of a change in the micro climatic factors at the fringes which will encourage invasion of more aggressive plant species, thus the sustainability of these islands may not be secured.

Small isolated islands of this highly complex forest type have been noted to disintegrate slowly but surely elsewhere, not only due to loss of genetic exchange but also to the loss of pollinators, predators for pests, change of the meso climate, hydrological changes, loss of interrelation with species not represented in the area, and much more.

4.6.12.2 Regional Land Use Changes

On the regional scale, land use in Sabah is predominantly forestry and agriculture based as shown in **Table 4.6.6.**

Table 4.6.6 Land Use in Sabah

Landuse	Area in Hectares (%)
State Land (agriculture, belukar, etc.)	3.2 million ha (43%)
Forest Reserves (permanent forest)	3.8 million ha (51%)
Other Land (towns, infrastructure, private land)	0.4 million ha (5%)
Total Land Area	7.4 million ha (100%)

Source: Publications of the Sabah Forestry Department, Sandakan.

As oil palm is the main development, this section will discuss the effect of this crop to the regional land use changes. Compared to other states in Malaysia, Sabah ranks top in total area planted with this crop by 30 percent. As of year 2004, this area was estimated to be approximately 1.17 million hectares. See **Table 4.6.7** below.

Table 4.6.7: DISTRIBUTION OF OIL PALM PLANTED AREA BY STATES: 2004 (HECTARES)

State	S/Holders (Licensed)	FELDA	FELCRA	RISDA	State Schemes/ Govt. Agencies	Private Estates	Total
Johor	151,694	117,988	24,450	7,517	43,590	321,129	666,368
Kedah	13,626	0	1,130	1,756	0	55,809	72,321
Kelantan	1,814	36,052	5,307	767	8,397	35,307	87,644
Malacca	5,413	1,181	2,475	2,005	0	38,512	49,586
N. Sembilan	10,897	29,707	7,036	11,131	2,883	79,491	141,145
Pahang	23,218	240,667	30,641	17,847	59,692	206,783	578,848
Penang	6,868	0	501	53	0	6,446	13,868
Perak	22,580	18,668	32,154	18,790	13,010	197,736	302,938
Perlis	35	0	0	0	0	0	35
Selangor	31,981	591	4,491	241	2,314	87,770	127,388
Terengganu	5,423	40,244	20,361	20,671	19,094	55,672	161,465
P. Malaysia	**273,549**	**485,098**	**128,546**	**80,778**	**148,980**	**1,084,655**	**2,201,606**
Sabah	77,673	118,980	15,221	0	95,722	857,816	1,165,412
Sarawak	15,264	7,681	16,547	0	77,657	391,160	508,309
Sabah/Sarawak	**92,937**	**126,661**	**31,768**	**0**	**173,379**	**1,248,976**	**1,673,721**
MALAYSIA	**366,486**	**611,759**	**160,314**	**80,778**	**322,359**	**2,333,631**	**3,875,327**

Source:MPOB

A quick review of the history of growth for this crop development in Sabah from 1975 to 2004 (see **Table 4.6.8**) indicates that it has been rather steady after which at least 20,000 to 50,000 hectares of the area is converted to oil palm plantation annually.

Table 4.6.8: OIL PALM PLANTED AREA:1975-2004 (HECTARES)

Year	P.Malaysia	Sabah	Sarawak	Total
1975	568,561	59,139	14,091	641,791
1976	629,558	69,708	15,334	714,600
1977	691,706	73,303	16,805	781,814
1978	755,525	78,212	19,242	852,979
1979	830,536	86,683	21,644	938,863
1980	906,590	93,967	22,749	1,023,306
1981	983,148	100,611	24,104	1,107,863
1982	1,048,015	110,717	24,065	1,182,797
1983	1,099,694	128,248	25,098	1,253,040
1984	1,143,522	160,507	26,237	1,330,266
1985	1,292,399	161,500	28,500	1,482,399
1986	1,410,923	162,645	25,743	1,599,311
1987	1,460,502	182,612	29,761	1,672,875
1988	1,556,540	213,124	36,259	1,805,923
1989	1,644,309	252,954	49,296	1,946,559

Year	P.Malaysia	Sabah	Sarawak	Total
1990	1,698,498	276,171	54,795	2,029,464
1991	1,744,615	289,054	60,359	2,094,028
1992	1,775,633	344,885	77,142	2,197,660
1993	1,831,776	387,122	87,027	2,305,925
1994	1,857,626	452,485	101,888	2,411,999
1995	1,903,171	518,133	118,783	2,540,087
1996	1,926,378	626,008	139,900	2,692,286
1997	1,959,377	758,587	175,125	2,893,089
1998	1,987,190	842,496	248,430	3,078,116
1999	2,051,595	941,322	320,476	3,313,393
2000	2,045,500	1,000,777	330,387	3,376,664
2001	2,096,856	1,027,328	374,828	3,499,012
2002	2,187,010	1,068,973	414,260	3,670,243
2003	2,202,166	1,135,100	464,774	3,802,040
2004	2,201,606	1,165,412	508,309	3,875,327

Source : Department of Statistics, Malaysia : 1975 to 1984
: MPOB : 1985 - 2004

Oil palm plantation in Sabah is mainly concentrated in Tawau and Sandakan districts (see **Table 4.6.9**). From the table, it can be seen that about 95 percent of the area planted with oil palm plantation in Sabah is concentrated in these two (2) areas. In Tawau district alone, it is approximately 40 percent of the area.

Table 4.6.9: Industrial Plantation Areas (in hectares) in Various Districts of Sabah: 2003

District / Type of Plantation	Tawau	Sandakan	Kudat	West Coast	Interior	Total
Rubber	647	3,466	9,222	22,666	27,888	**63,889**
Coconut	8,641	1,106	9,275	649	1,165	**20,836**
Oil Palm	435,711	591,687	12,568	4,312	32,497	**1,076,775**
Cocoa	22,467	1,064	121	368	1,268	**25,288**
Paddy	-	1,948	11,294	15,120	12,855	**41,217**
Coffee	1,319	43	39	307	2,282	**3,990**
Sugar Cane	5	-	5	32	134	**176**
Tea	-	-	-	334	2	**336**
Tobacco	-	-	-	50	835	**885**

Source: Sabah Agriculture Department (2003)

As of Year 2001, in the area nearby the Project site, Sabah Softwoods Bhd already operates approximately 15,000 ha of agriculture plantation area. See **Table 4.6.10**. With the addition of plantations of the oil palm project, the area of oil palm plantation in Sabah will increase approximately 7 percent (%) to about 1.25 million ha.

Table 4.6.10: Sabah Softwoods Berhad (SSB) Plantations

SSB Plantations (Approximate area in hectares)	
Forest Plantation	36,000 ha
Agriculture Plantation	15,000 ha
Planted Area	51,000 ha
Unplanted Area	9,000 ha
Total SSB	60,000 ha

Source: Sabah Softwoods Berhad (2001)

When combined with other extensive oil palm plantations in the area or Sabah as a whole, the result will be a landscape dominated by mono-culture tree crop plantations. The impacts of this large area of intensively managed, mono-culture tree crop plantations have not been fully assessed. However, locally significant negative environmental impacts are expected, due to loss of biodiversity and natural habitat, as well as increased soil erosion, sedimentation, and risk of outbreaks of pests, disease, and fire (see **Section 4.8** and **Section 4.9**).

4.7 Biomass and Waste

The development of the oil palm and industrial tree plantation will generate various types of biomass and waste, which must be properly managed and disposed off. Although the Project area will be handed over for plantation development only after salvage logging, a large quantity of forest biomass - stumps, tops, branches, bark, etc. is expected to remain widely distributed over the site. Based on investigation, the biomass that will be generated at this stage (based on 185 tonne/ha) is estimated to be about 14.8 million tonne. See **Table 4.7.1**.

Table 4.7.1: Estimated Quantity of Biomass Generated for the OPP Development

Year	Area to be developed (ha)	Biomass After Salvaging (tonne)	Biomass After Harvesting (tonne)	Biomass After 30-Year Cycle (tonne)
2005	2,500	462,500	27,500	250,000
2006	9,000	1,665,000	99,000	900,000
2007	16,300	3,015,500	179,300	1,630,000
2008	21,800	4,033,000	239,800	2,180,000
2009	21,900	4,051,500	240,900	2,190,000
2010	8,500	1,572,500	93,500	850,000
TOTAL	**80,000**	**14,800,000**	**880,000**	**8,000,000**

During oil palm growing in plantations, the major co-product is oil palm fronds from pruning. Based on studies carried out by Mohamad Husin *et al.* (1986)[4a], the annual dry

[4a] Compiled by Jaccrhni & Martens, 1992 in 'Biomass Production in the Oil Palm Industry'.

weight of fronds is estimated to be approximately 11 tonne per hectare. The total annual dry weight of fronds[4b] is hence calculated to be approximately 880,000 tonnes for the whole development. See **Table 4.7.1**.

At the end of the 30-year cycle, the oil palm is expected to have reached its economic lifespan. Since this Project is intending to rehabilitate the area into forest, a fair amount of biomass in the form of trunks will be generated. Based on studies carried out by Mohamad Husin et al (1986), the annual dry weight of trunk is estimated to be 100 tonne per hectares. Hence, the total dry weight of trunk generated from the whole development is estimated to be approximately 8 million tonne.

As for the industrial tree plantation, it will be carried out at a much later stage. Assuming that it will be developed over a period of five (5) years and based on a net plantable area of 13,000 ha (see **Table 4.6.5**), the biomass is estimated to be approximately 481,000 tonne/yr (based on 185 tonne/ha). The total amount of biomass is then estimated to be approximately 2.4 million tonne.

During oil palm processing, there are many co-products that are generated e.g. empty fruit bunches (EFB), fibre, shell and effluent (POME). The most common one is the empty fruit bunch. The empty bunch is a solid waste product of the oil palm milling process and has a high moisture content of approximately 55-65% and a high silica content, from 25% of the total palm fruit bunch (Noel Wambeck, 1999). The treated empty bunches are mechanically crushed (de-watered and de-oiled) in the process but are rich in major nutrients and contained reasonable amounts of trace elements. They have a value when returned to the field to be applied as mulch for the enrichment of soil. However, it was noted that over application of the effluent must be avoided as it may result in anaerobic conditions in the soil by formation of an impervious coat of organic matter on the soil surface (Noel Wambeck, 1999).

Assuming the mean average yield per hectare to be 20.08 tonnes FFB/ha/year, Chan *et al.* (1981)[4c] estimated the wet and dry weights of the four types of co-products after milling of FFB from 1 hectare of mature palms to be as shown in **Table 4.7.2**.

Table 4.7.2: Availability of fresh and dry weight of EFB, shell, fibre and effluent in tonnes per hectare per year after milling from one hectare of mature palms

	1 hectare of mature palms	
	Fresh weight (t/ha/year)	**Dry weight (t/ha/year)**
FFB	20.08	10.60
EFB at 22% of FFB	4.42	1.55
Fibre 13.5% of FFB	2.71	1.63
Shell 5.5% of FFB	1.10	1.10
i) Steriliser condensate 12% FFB	2.41	0.12
ii) Clarification sludge 50% of FFB	10.04	0.50
iii) Hydrocyclone washing 5% FFB	1.00	0.05
Total POME	13.45	0.67

4b Based on 140 palms per hectares.
4c Compiled by Jaccrhni & Martens, 1992 in 'Biomass Production in the Oil Palm Industry'.

4.8 Pests and Diseases Management

The common types of insects that could cause considerable damage to the oil palm trees include rhinoceros beetles, nettle caterpillars, bag worms and cockchafers. Other mammalian pests have been mentioned in **Chapter 3** of this SEIA, which include elephants, wild boar, Orang Utans, squirrels, rats and monkeys. There are also various common diseases that attack oil palm trees and these include seedling anthracnose, leaf blight, leaf spot, blast, leaf rot, basal stem rot and root rot and vascular wilt.

Attack of these pests and diseases on the proposed plantation are not environmental impacts *per se* but the large area of new plantation may attract these pests and diseases and thereby become a factor for their further distribution to already established plantations.

4.8.1 Rhinoceros Beetles

The adult beetles bore into the crowns to feed on the tender tissue at the growing points resulting in the decaying of the bud and thus retarding growth.

The damage to the growing point of a young palm is shown in **Plate 4-10**.

4.8.2 Nettle Caterpillars

The second group of pests were nettle caterpillars. They feed on young leaflets of the frond leaving only the midrib. See Plate 4-11 for nettle caterpillars collected from an infested palm stand. The damage in mature palms is also shown in **Plate 4-12**.

4.8.3 Bag Worms

The third group of pests were bagworms. Young caterpillars scrape the epidermis. Mature caterpillars make holes on the leaf as they feed on them. See **Plate 4-13** for damage to frond pinnae caused by bagworms.

4.8.4 Cockchafers

The adult cockchafers feed on the leaves especially on young palms. Serious infestation may result in complete defoliation.

4.8.5 Mammalian Pests

The mammalian pests include the squirrels, rats and monkey. They are pests of fruits mainly. Squirrel gnaws a hole on the fruit and eats the pericap. Rats and monkey cause similar damage. See **Plate 4-14** for damage on a maturing bunch caused by rats.

4.8.6 Seedling Anthracnose

The first type of disease that commonly attack oil palm trees is the seedling anthracnose. It is associated with associated with three different fungi:

a) *Botryodiplodia anthracnose*
Small clear spots on the leaves at first. Necrosis advances from the spot leaving brown dead tissue in the centre of the lesion and yellow halo on the edge. Spores are black.

b) *Glomerella anthracnose*
Small watery soaked spots restricted in between the veins that extend lengthwise into streaks are seen. Lesion also has brown black-centre with yellow halo. Spores are black.

c) *Melanconium anthracnose*
Symptoms are similar to that of the Botryopodia infection.

4.8.7 Leaf Blight

The second type of disease is leaf blight. Young seedlings are very susceptible to leaf blight. Disease appears as small round translucent yellow spots on new leaflets, turn brown with sunken centres and yellow halos but remain small (7-8 mm). Serious infection causes stunting.

4.8.8 Leaf Blight

The third type of disease is leaf spot. See photo on the left. Early sign of attack is the appearance of small bright yellow spots with halos. Brown sunken centre develops later on. Coalescence gives uniform yellowing followed by blackening and death from tip inwards.

4.8.9 Blast

This is a disease whereby ainly seedlings under high temperature and water-stress conditions are affected. Loss of glossiness of foliage rapidly with general yellowing together with die-back of leaves and spear-rot. Roots are rotten except the cortical tissues. Pulling up the seedling will strip off the decayed tissue inside leaving an empty tube.

4.8.10 Leaf Rot

Irregular pale-green patches with violet-brown zonations at the base of spear giving shot-holes on the unfolded leaflet later on. Tearing and splitting of dead tissue and purple-brown margins are typical features.

4.8.11 Basal Stem Rot and Root Rot

First sign in the spear accumulation (which is the presence of an abnormal number of unexpanded spear leaves) and paler appearance of fronds together with some drooping of older fronds. Dry rot of trunk at the base will result in toppling and death of the palm.

Mushroom-like fructifications of the fungus Ganoderma develop at the base of the stem or on infected roots. The typical bracket shaped of sporophores of *Ganoderma* with a shiny upper is shown in **Plate 4-15**.

4.8.12 Vascular Wilt

Wilting, drying up and snapping of fronds but remain attached in mild cases. In an acute case, die-back of crown occurs rapidly except for the new fronds that survive for a while. New fronds are shorter. Necrosis of vascular bundles occur at the stem apex. See **Plate 4-16**.

4.9 Forest Fire

Most of the forest fires in Sabah are human-caused as a result of increase pressure to convert forested lands into agricultural lands or for other utilizations. The forest fires in the 80's and 90's have destroyed thousands of hectares of forest in Sandakan and Tawau Districts. Much of the extensive secondary forests consisting of pioneer species in the Project area, originated from these, and earlier, fires.

The impacts of fires are significant. Fire-induced loss of soil-cover and negatively affect the hydrological regimes and soil properties, lead to severe erosion and loss of productive topsoil. Economic costs are the loss of valuable timber and non-timber resources, natural regeneration and planted forests. Besides local impact, forest fire also exerts regional and global environments impacts. Large-scale forest fires reduce air quality and affect the human health, loss of lives, property and other economic activities.

For this Project, forest fire can be considered one of the most serious threats to the plantations. The potential risk to the natural forest also cannot be ignored. More often than not, forest fires are related to climatic factors and management of fire risk than whether the forest is natural or planted.

Rainfall in the Project area is relatively abundant (2,119 mm/year) and is more or less evenly distributed throughout the year, although there is more precipitation between May to November and a dryer period from December to April (see **Annex A1.2.4**). However, fires mostly occur in the years of abnormal, dry weather, especially during el Niño droughts.

The Project area is not subjected to high population pressure as are plantations in other parts of South East Asia. The closest settlements to the Project area are Luasong Forestry Centre and Kg. Fajar Harapan Luasong and a number of temporary logging camps but these are all related to the forestry activities themselves and therefore not competing or being provoked to actions of vandalism. There are only a few communities located south of the Project area, e.g. Kg. Kalabakan and Brumas camp. Most residents of these settlements are involved in forestry activities and are aware of the need to protect forests against fire in order maintain their livelihood.

Forest fires in the Project area have been infrequent and relatively minor in extent. The incidence of forest fires is mainly associated with the "El Niño" climatic phenomenon. During these periods, the normal monsoon rains fail to materialize and near-drought conditions prevail. In 1983, when forest fires affected a large part of Borneo, only a relatively small area of Yayasan Sabah's Management Area was affected. Additional small, isolated forest fires occurred in or near the project area during the El Nino droughts of the early and late 1990s. Most of these fires occurred in heavily logged forest, which is drier and contains more easily combustible, dead wood than primary forests or forest plantations. For example: Sabah Softwoods Berhad (SSB) forest plantations, which lie along the southeastern boundary of the Project area, have experienced few forest fires. They have an efficient fire risk management programme. SSB will be one of the contractors establishing and maintaining plantations in the Project area. They propose to follow fire prevention policies which they have developed from experience on their 60,000 ha forest/agricultural plantation over the past 27 years.

Based on the climatic and social conditions in the Project area and past experience with similar project adjacent to the proposed OPP project, the Project area is not a high forest fire risk area. It is anticipated that forest fire impacts can be kept to a minimum, provided the recommended mitigating measures are adopted (Refer to **Chapter 5**).

4.10 Green House Effects

4.10.1 General

This section discusses the amount of greenhouse gas emitted into or removed from the atmosphere resulting from the proposed conversion of forest to oil palm and industrial tree plantation (land use change) project. The methodology for this estimation is based on the latest published Revised 1996 Inter-Governmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories and follows the latest IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry guidelines **(IPCC, 2000)** (see **Annex B** – **Section B1.6**).

The priority calculations of emissions from land use change and forestry focus upon three activities, which are sources or sinks of carbon dioxide. It must be pointed out that there are inherent uncertainties or errors associated with these calculations. Future work will develop guidance for estimating and expressing these errors. On a global scale the most important land use changes and management practices that result in CO_2 emissions and uptake are 1) Changes in forest and other woody biomass stocks, 2) forest and grassland conversion, and 3) Abandonment of managed lands.

The immediate release of non-CO_2 trace gases from the burning associated with forest/grassland conversion is not calculated here because there will be no burning of forest waste in this Project.

As the objective of the Project is to establish an oil palm and industrial tree plantation from logged over forest, the computation of the net release or removal of greenhouse gases will be based on these activities, namely, “Changes in Forest and Other Woody Biomass Stocks” and “Land-Use Change and Forestry”. These deal with the emissions or removal of carbon (carbon dioxide) due to changes in forest and other woody biomass stocks and land-use change affected by human activity.

4.10.2 Results of the Analysis

Based on the data and information available, the first year (2005) of Project activity involves 2,500 hectares of the 109,600 hectares of forest being cleared and planted with oil palm. With a biomass dry matter of 185 tons/hectare, this means that 2,500 x 185 = 462,500 tons of biomass dry matter is removed and converted to carbon dioxide and released over a period of 10 years or 46,250 tons biomass dry matter per year or 84,792 tons of CO_2 per year as the disposal method proposed for wood waste is natural decay with no open burning. On the other hand, the replanting of palm oil on the 2,500 hectares of cleared land will result in an uptake of 2,500 x 6 = 15,000 tons of biomass dry matter by the growth of the oil palm and an uptake of 107,100 x 9 = 963,900 tons of biomass dry matter by forest regeneration of the remaining un-cleared land, resulting in a total uptake of 15,000 + 963,900 = 978,900 tons of biomass dry matter or 1,794,650 tons of CO_2.

However, as this 2,500 hectares is cultivated with oil palm, this means that it is subjected to land use change and management practice which can result in the loss or gain of carbon in the soil. The amount loss or gain is computed based on the factors such as carbon content of 60 tons carbon per hectare, tillage factor, input factor and base factor of 1.0, 1.0 and 0.6 respectively and area of the land. The amount is 2,500 x [60 – (60 x 1.0 x 1.0 x 0.6)] = 60,000 tons of carbon or 60,000 x 44/12 = 220,000 tons of CO_2 loss from the soil.

Summing the release of CO_2 from the clearing of the forest, uptake of CO_2 from the growth of oil palm and forest regeneration and loss of CO_2 from the soil due to cultivation, the net CO_2 inventory is 84,792 - 1,794,650 + 220,000 = - 1,489,858 tons of CO_2. This means that in the first year of development, 1,489,858 tons of CO_2 is removed or sequestered from the atmosphere.

The same method of accounting for the carbon dioxide inventory was conducted for the second year (2006) and subsequent year of development according to the forest area being cleared and planted with oil palm until the 80,000 hectares are planted with oil palm and the remaining area undisturbed as forested land. A spread sheet was used for the computations.

Tabulated below in **Table 4.10.1** is the amount of carbon dioxide released into or removed from the atmosphere over a period of 20 years.

Table 4.10.1: Amount of carbon dioxide released into or removed from the atmosphere for a period of 20 years.

YEAR	Forest Area (hectares)	Oil Palm Area (hectares)	CO2 Emission Inventory (tons)
2004	109,600	0	0
2005	107,100	2,500	-1,489,858
2006	98,100	11,500	-563,108
2007	81,800	27,800	721,783
2008	60,000	49,600	2,065,067
2009	38,100	71,500	2,937,092
2010	29,600	80,000	2,092,933
2011	29,600	80,000	1,344,933
2012	29,600	80,000	1,344,933
2013	29,600	80,000	1,344,933
2014	29,600	80,000	1,344,933
2015	29,600	80,000	1,260,142
2016	29,600	80,000	954,892
2017	29,600	80,000	781,917
2018	29,600	80,000	42,533
2019	29,600	80,000	-700,242
2020	29,600	80,000	-988,533
2021	29,600	80,000	-988,533
2022	29,600	80,000	-988,533
2023	29,600	80,000	-988,533
2024	29,600	80,000	-988,533
2025	29,600	80,000	-988,533
		TOTAL	**7,551,683**

Positive values indicate release of carbon dioxide into the atmosphere while negative values mean carbon dioxide is removed or sequestered from the atmosphere.

The tabulated results are plotted and shown in **Figure 4.10.1**.

After a period of time, approximately 20 years, an equilibrium state will be reached when the amount removed is balanced by the amount released. However, the net change in carbon stock is a positive 7,551,683 tons carbon dioxide. This means that the replanting of 80,000 hectares of forest with oil palms will result in the release of approximately 7,551,683 tons of carbon dioxide into the atmosphere.

To compare and assess the relative amount and impact of carbon dioxide (CO_2) emitted into the atmosphere by this oil palm plantation project, the amount of CO_2 emitted from a medium size open cycle power plant of 400 MW capacity were computed.

Based on emission factors of large uncontrolled gas turbines using natural gas as primary fuel and distillate oil (diesel) as secondary fuel (US EPA, 1995), the amount of carbon dioxide emitted is computed as shown below:-

Emission factor of CO_2: 546 g/kW-hr (natural gas)
799 g/kW-hr (distillate oil)

Using natural gas as fuel;

Emission rate of CO2: 546 g/kW-hr x 400,000 kW
= 2.184 x 10^8 g/hr
= 218.4 tons/hr
= 1.91 million tons per year.

Using distillate as fuel;

Emission rate of CO2: 799 g/kW-hr x 400,000 kW
= 3.196 x 10^8 g/hr
= 319.6 tons/hr
= 2.80 million tons per year.

As the conversion of 80,000 hectares of secondary forest to oil palm plantation releases about 7.5 million tons of CO_2 and a medium size open cycle natural gas fired power plant releases 1.91 million tons of CO_2 per year, it takes only 7.5 / 1.91 = 3.93 years of the power plant to produce the same amount of CO_2 from the whole life span of the oil palm plantation.

If the power plant is fired by distillate oil (diesel), the time taken by the power plant to produce the same amount of CO_2 is about 7.5 / 2.8 = 2.67 years.

Therefore in relation to power generation and fuel combustion in general, the amount of CO_2 emitted by the conversion from secondary forest to oil palm plantation is relatively conservative.

On a per hectare basis, the amount of CO_2 released due to the conversion is 7,500,000 / 80,000 = 93.75 tons is reasonable and most of the release is the result of emission from the soil due to tillage.

4.11 Project Abandonment

The proposed Project could be abandoned at any time due to financial, social, political problems or the occurrence of natural disasters or wars within or outside of the country.

4.11.1 Abandonment at the Investigation and Planning Stage

Impacts of abandonment at this stage are negligible to the environment but could have an impact on the Project Proponent in terms of investment opportunity and economic loss—time and money have already been spent on the proposed development – payment of forest licence fees, employment of consultants for feasibility studies, Environmental Impact Assessment, etc. and staff time spent on investigative surveys, planning, inventory, mapping, boundary marking, etc.

4.11.2 Abandonment at the Site Clearing and Preparation Stage

Abandonment at these stages would be significant on the biological environment due to unnecessary loss of habitat, flora and fauna. Likewise, the Project Proponent would incur heavy losses, as significant investment would have already gone into the Project. Impacts at these stages are the loss of topsoil, forest cover and *in-situ* biodiversity; build up of vegetative debris associated with re-logging and land clearing; risk of wild fires and invasion of pioneer species; sedimentation and siltation; as well as loss of employment and business opportunities. In addition, recently rebuilt roads could also provide access to a wave of illegal hunters and loggers into the area. If foreign workers were not repatriated properly, potential conflicts and disputes between local and foreign workers may be possible. All these would have negative impacts to the environment. The mitigation measures for such possibility are presented in **Chapter 5**.

4.11.3 Abandonment at the Operation Stage

If the Project were abandoned during the operation stage, the whole area would be left with monoculture species thriving in the area. The impacts would be the loss of biodiversity and genetic resources as well as a different ecosystem without many of its former environmental functions. Clearing and felling will only take place when an alternative development plan is identified for the site.

4.12 Economic Impacts

The two key drivers to plantation segment's earnings are production volume and CPO prices. The production estimate is based on average annual yield per ha for oil palm throughout the life cycle of the palms. An overview of the Malaysian Palm Oil Industry 2004, yield, prices and cost estimates are outlined in **Annex B1.9**.

Benefits

The direct benefit of the project is the revenue from sale of Fresh Fruit Bunches (FFB) as the mills have not been considered in the initial analysis. The reason for this is that the environmental impact does not include the impact of the palm oil mill. Thus benefits and costs refer to the same scenario. In general economic analyses of adding an oil mill to an OPP will show clear economic feasibility. It has therefore not been considered necessary to include this analysis in the report, which focuses on the environmental economics of clearing forest for OPP.

In addition there are short term benefits in terms of revenue from timber when the forest is cleared as well as potential long term development benefits to the region and the State of Sabah.

4.12.1 Short-term Economic Benefits from Clearing natural Forest for Plantations

When a plantation is established the initial clearing of mixed tropical hardwoods yields on average 20 m^3 to 30 m^3 of commercial logs suitable for sawn timber and plywood. There is also an estimated 50 m^3 of pulpwood, which would be suitable for manufacturing mixed tropical hardwood wood pulp. However, there is no pulp mill in the area at present and therefore the value of this wood is not being realized.

4.12.2 Long-term Economic Benefits to Tawau Region and State of Sabah

The proposed project will bring a much-needed economic stimulus to the Tawau region, as well as to the State of Sabah. However, the majority of the direct benefits have already been included in the economic analysis.

4.12.3 Total Benefit Stream

The total annual benefits of the project are provided in the **Annex B1.9**.

4.12.4 Environmental Costs of Converting Natural Forests to Oil Palm Plantation

As discussed earlier in this SEIA, forest conversion includes increased environmental impacts, associated with the loss of the natural forest eco-system. These costs relate mainly to the clear-felling and monoculture with use of fertiliser and pesticides, which characterize Oil Palm Plantation (OPP), compared to the long-term (60-years), highly selective (only a few commercial trees are cut) periodic harvesting cycles, characteristic of Natural Forest Management (NFM). The impacts associated with converting natural forests to Oil Palm Plantations are already addressed in the earlier sections of this chapter. Briefly, they are summarized below to assess the external environmental economic impact of the forest conversion. These external costs of conversion will reduce the economic results of the conversion to OPP provided above. The issues which have been considered are:

- Loss of soil and site fertility. Soil erosion and leaching associated with clearing of natural forest, will have to be offset by using fertilizers in the OPP. Recycling and re-use of waste materials from palm oil mills as fertiliser will minimise the demand for inorganic fertilisers, while maintaining soil fertility. Zero burning for land clearing and replanting which is mandatory in Malaysia, will also minimise the loss of soil fertility.

- Loss of watershed protection function. OPP involves increased exposure of the soil to rain and run-off, resulting in increased erosion and sedimentation in river systems, loss of aquatic life, clogging of river channels, impeded navigation and periodic flooding. Water storage capacity of sites converted to OPP is reduced. This can lead to water shortages during dry periods. Measures practised include planting of leguminous crops as a cover to mitigate and minimise soil erosion. Terraced plantings are practised as a soil and water conservation measure.

- Loss of flora and valuable non-timber products – rattan, medicinal plants, edible plants, etc. These irreversible impacts/losses will reduce the economic benefits of the OPP.

- Habitat loss negatively impacts fauna, including pollinators, seed disseminators and results in loss of a valuable source of food for indigenous people. Integrated pest management will minimise the use of toxic pesticides through the promotion of beneficial plants, natural enemies and bio-controls.

- Loss of accumulated biomass (carbon storage) due to clearing of mixed tropical hardwood (MTH) forest for establishment of OPP.

- Loss of Existence Values of bio-diverse tropical ecosystem. Tropical forest eco-systems have "existence" values to researchers, tourists, indigenous peoples, etc. all of whom are inspired to visit these eco-systems for research, recreation, spiritual renewal, etc. Conversion to monoculture oil palm plantation results in a loss of these values.

In estimating environmental impact cost, the value of each category of impact may be estimated for the net operable plantation area of 80,000 ha. The following assumptions have been made:

- Based on the previous studies of forest conversion in Sabah adjusted for changes in carbon dioxide emission for ITP compared to OPP, the total estimated environmental cost associated with converting the equivalent of 80,000 ha of natural forest to OPP, range from a low of RM 214.67 million to a high of RM 501.33 million. The median value—RM 357.99 million is equivalent to RM 4,475 per ha of natural forest converted to OPP.

- Plantation revenue loss has been estimated at 0.75 percent of the annual revenue from the OPP throughout the project cycle

- Reduced watershed protection, loss of soil etc. is estimated at RM 150/ha/year during the initial ten years of the Project.

- Loss of biodiversity is estimated at RM 40/ha/year throughout the Project cycle

- The existence and option value of the natural forest has been estimated at RM 350/ha. The loss has been allocated to year 1 of the Project.

The detailed breakdown calculation based on converting 80,000 ha from natural forest to OPP is shown in **Table 4.12.1** below. The values represent the total costs throughout the Project period without adjusting for present value. The values for low and high estimate have - except for carbon dioxide emission - been arrived at by subtracting or adding 20 percent to the base-estimate provided above.

Table 4.12.1: Approximate Estimates of Environmental Costs of Proposed Conversion of 80,000 ha of Natural Forest to Oil Palm Plantations (RM Million/Year)

No.	Description	Low Estimate	Base Estimate	High Estimate
1	Increased Carbon Dioxide emission	143.47	215.29	287.05
2	Plantation Losses (Fire, Pest, Disease, 0.5-1 percent of annual revenue)	77.04	96.30	115.56
3	Reduced Watershed Protection (3a-3c) (RM 150/ha/year for 10 years)	67.55	84.44	101.33
3a	Soil erosion/fertility			
3b	Soil erosion and sedimentation			
3c	Loss of aquatic habitat and resources			
4	Biodiversity Losses (4a-4d) (RM 40/ha/year)	65.70	82.12	98.54
4a	Rattan & other non-timber forest			

No.	Description	Low Estimate	Base Estimate	High Estimate
	products			
4b	Wildlife			
4c	Eco-tourism, etc.			
5	Existence and Options Value (RM 350/ha in year 1)	22.40	28.00	33.60
	Total Est. Environmental Costs	376.16	506.15	636.08
	Total Environmental Cost (RM per ha)	4,702	6,327	7,951

The highest environmental cost is associated with two items—carbon storage losses (42.5 %) and reduced water shed protection (19.0 %) followed by equal share of about 16.5 % for biodiversity loss and revenue loss from fire, pests and diseases. The carbon dioxide emission is discussed in more detail in **Section 4.12.5** below.

The above computations provide an indication of the environmental cost of the oil palm plantation Project. These costs have been used together with the costs and benefits in the economic analysis above to prepare the environmental economic analysis in **Section 4.12.5** below.

In the environmental economic analysis the figures above have been distributed throughout the Project cycle of 30 years according to when the various impacts are likely to occur. Some environmental costs are immediate, i.e. in Year 1 (existence and options values) while some values occur continuously throughout the project period (eco-tourism, non-timber forest products). These costs actually continue to occur beyond the Project cycle, but after 30 years these values have little impact in the present value analysis).

The estimates presented here are only indicative of the magnitude of the economic costs associated with forest conversion. These costs are difficult to quantify and therefore estimates vary greatly, depending on the assumptions made. The value of products and services lost, or reduced, by forest conversion are based on subjective estimates, which lack of precision.

This is particularly true of items #3 to #5. In order to quantify the value of lost or diminished benefits for these items, comparative figures from other studies related to environmental benefits (non-timber forest products, eco-tourism etc) have been reviewed. Estimates in the literature vary widely and the analysis was further complicated by the limited availability of "hard" empirical data on environmental costs. Many of the items lost or reduced by forest conversion are non-market items and therefore the analysis relies heavily on research and studies that have attempted to "derive" (rather than "measure") their values. The data used in the SEIA estimates originate from environmental literature based on studies conducted in tropical forests in S.E. Asia, Africa and South America. In reviewing these literatures, the estimates presented in this SEIA are within the range of recent research estimates (Ref: SEIA 2002).

It should be noted that it is not the intention to give the impression of certainty with regard to the estimates presented in this section. The range of complexities surrounding tropical forests is still not well understood, neither biologically, nor economically. Given such uncertainties, economic assessments are necessarily subjective. Therefore the results of the economic analysis presented in this SEIA should not be seen as highly precise, but rather as indicative of the orders of magnitude of the various environmental costs and benefits, in order to highlight the contributing factors.

4.12.5 Economic Implication of Carbon Dioxide Emission

The impact of Natural Forest Conversion on the Carbon Dioxide emission is presented in an earlier section of the report. The annual emission for the Project period is provided and the total estimated carbon dioxide emission to the atmosphere is 7.551 million tonne.

As a general guide to the economic implication of this oil palm plantation Project with regard to carbon dioxide emission, cost computations were made based on the following findings:

i). Report prepared for the Asian Development Bank by the Risoe National Laboratory of Denmark was referred to (K. Halsnaes, 1999). The report concluded that greenhouse gas emission reductions in the energy sector in the order of magnitude of 10 to 15 percent of future baseline emissions can be achieved at a cost of below US$ 25 per ton of carbon dioxide.

ii). Based on carbon offset trading markets, the expected prices can range anywhere between US$8 and US$40 per ton of carbon dioxide sequestered (Carolyn J. H., 2000).

iii). The potential carbon trading market for forestry-related investment estimated that it will cost approximately $20 per ton of sequestered carbon or US$5.45 per ton of sequestered carbon dioxide. This is only a very rough estimate as at the present time, no one really knows the exact amount it takes to sequester a ton of carbon dioxide (Roper J., 2001).

iv). Recent model simulations and actual trading practises which indicate that the likely long-term value of carbon trading credits is in the range of USD 5-10 per ton CO_2 Equivalent.

The following values have been used in the analysis:

Scenario	Value of CO_2 Equivalent (RM ton)	Total Value of CO_2 Emission (RM Million)
High	38.00	286.94
Base	28.50	215.20
Low	19.00	143.47

At the present moment, Malaysia although a signatory to the Kyoto Protocol which proposes to set legally binding commitments for emission reductions of greenhouse gases (mainly carbon dioxide) is exempted as she belongs to the group of Non-Annex 1 countries (developing countries). Therefore, the release of carbon from the conversion of forest to oil palm plantation in this project does not incur any "real" environmental cost until Malaysia is subjected to the Kyoto Protocol requirements.

4.12.6 Base-case Environmental Economic Calculation

The base-case environmental economic calculation is presented in the Annex using the "best estimate" values for the externalities identified for OPP development above. The resulting key economic indicators show that the Project is feasible as shown in **Table 4.12.2** below. A comparison with the economic analysis shows a drop in the economic indicators, particularly in the IRR which is reduced from 26.1 percent p.a. to 21.6 percent p.a. when the environmental costs are taken into consideration.

Scenario	Net Present Value (NPV) RM (Million)	Internal Rate of Return (IRR) Percent p.a.
Economic analysis	4,468	26.1
Environmental economic analysis	4,076	21.6

Comparative analyses of Natural Forest Management and Industrial Tree Plantation have shown that both alternatives provide lower economic indicators than found for oil palm plantations (Chemsain Konsultant Sdn Bhd, 2002).

4.12.7 Sensitivity Analysis

In order to test the robustness of the viability - measured in terms of NPV and IRR - the base case has been subjected to a range of variations in the underlying assumptions as follows:

- Environmental Costs plus/minus 20%.

- Worst case scenario combining worst case scenario for the economic analysis with the high estimate for the environmental costs.

The result of the two scenarios is shown in the following:

A change in cost and revenue estimates by 20 percent in either direction will have the following effect on the NPV and IRR:

Scenario	NPV (i=4%) (RM Million) (base-case)	NPV (i=6%) (RM Million)	NPV (i=10%) (RM Million)	IRR (Percent p.a.)
Base case	4,076	2,760	1,256	21.6
Environmental cost low estimate	4,180	2,852	1,330	22.7
Environmental costs high estimate	3,972	2,667	1,183	20.5
Worst case economic analysis plus High environmental cost estimate	2,293	1,411	435	13.9

The results show that even under the worst case scenario, the establishment of the Oil Palm Plantation is highly economically feasible when only the direct benefits (revenues) and costs are considered. Only in the worst case scenario does the project achieve economic indicator values which are on the borderline of being viable with an IIR of 13.9 percent. As expected the net present value is sensitive to increases in the discount rate.

4.12.8 Cost Benefit Analysis

This section covers the economic analysis of the Project to determine the circumstances under which the project is economically viable from a national economic point of view. It includes both direct and indirect costs and benefits. No financial analyses have been carried out to assess the financial viability of the project to the Project Proponent. However, the structure of direct and indirect costs indicates that if the Project is economically feasible it will also be financially viable. The cost and benefit streams in this section are based on the estimates developed in **Annex B1.9**. Only economic costs and benefits from Oil Palm Plantation development have been included in this analysis in order to assess the economic viability of the plantation on its own.

4.12.8.1 Basic Assumptions

The economic analysis requires a number of assumptions to be made to reduce the complexity of the analysis. These assumptions may at a later stage be subject to further analysis and assessment.

The analysis has been carried out for a base case scenario with the following assumptions:

- Ownership model: Private ownership in the form of a private company.
- Period of analysis: The period of analysis is assumed to be 30 years following the year of initial investment. Any addition to the length of period will have negligible effect on the viability calculation.
- Project costs: A detailed description of the various components of capital expenditure as well as operating and maintenance costs is provided in the previous sections.
- Scrap value: It is assumed that there is no scrap value at the end of the Project period and the Project area will be rehabilitated back to forest.
- Revenue from produce: The calculation is based on the assumption that the palm oil is sold in the open market at prevailing market prices.
- Prices: The analysis has been carried out with constant prices at the present price level assuming that all prices of inputs and outputs will change at the same rate during the planning period.
- Discount rate: The base-case discount rate has been assumed to be 4 percent p.a. based on the present general long-term marked interest rate of 6 percent and an estimated inflation rate of 2 percent p.a.

4.12.8.2 Key Economic Indicators

Two key economic indicators have been calculated: the Net Present Value and the Internal Rate of Return.

Net present Value (NPV): NPV is calculated by adding the initial investment (representing a negative cash flow) to the present value of the anticipated future cash flows. The interest rate will be referred to in this discussion of NPV and IRR as the rate of return on investment. The value of NPV indicates the results of the investment:

If NPV were positive, the financial value of the investor's assets would be increased: the investment is financially attractive. If NPV were negative, the financial value of the investor's assets would be decreased: the investment is not financially attractive.

Internal Rate of Return (IRR) is the rate of return at which the discounted future cash flows equal the initial cash outlay: IRR is the discount rate at which NPV is zero. The value of IRR relative to the present value discount rate also indicates the result of the investment:

If IRR is greater than the desired rate of return, the investment is financially attractive. If the IRR is less than the desired rate of return, the investment is not financially attractive.

It should be noted that the First Year Rate of Return, which is normally used to determine the optimum year of investment, is constant throughout the period of analysis as the facility is expected to run at virtually full capacity from the beginning. This indicates that the facility, when financially viable, should be opened as soon as possible.

4.12.8.3 Base-case Economic Analysis

4.12.8.3.1 Base-case Economic Calculation

The economic calculation is presented in the Annex for the base case, i.e. assuming that the Project does not have any external effects. The resulting key economic indicators show that the Project is feasible as shown in the table below.

Net Present Value (NPV) RM (Million)	Internal Rate of Return (IRR) Percent p.a.
4,468	26.1

As mentioned in **Section 4.12.6**, the economic indicators for both Natural Forest Management and Industrial Tree Plantation are lower than those found for oil palm plantations.

4.12.8.3.2 Sensitivity Analysis

In order to test the robustness of the viability - measured in terms of NPV and IRR - the base case has been subjected to a range of variations in the underlying assumptions as follows:

- Capital Costs plus/minus-20 %
- Revenue from product sales plus minus 20 %

- Worst case scenario combining both the above

Each of the above scenarios is discussed in the following:

A change in cost and revenue estimates by 20 percent in either direction will have the following effect on the NPV and IRR:

Scenario	**NPV (i=4%) (RM Million) (base-case)**	**NPV (i=6%) (RM Million)**	**NPV (i=10%) (RM Million)**	**IRR (Percent p.a.)**
Base case	4,468	3,105	1,525	26.1
Cost increase by 20 %	4,075	2,787	1,304	22.5
Cost decrease by 20 %	4,861	3,422	1,748	30.7
Revenue increase by 20 %	5,755	4,043	2,053	29.9
Revenue decrease by 20 %	3,182	2,166	999	21.7
Worst case (Cost plus 20 % and revenue minus 20 %)	2,789	1,849	777	18.3

Table

Figure