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24. CUMULATIVE AND ASSOCIATED IMPACTS

24.1 Definitions and Objectives

The following definition from Appendix 26, Social Impact Assessment has been adopted for the purposes of this discussion:

> The ***cumulative*** effects of an activity/intervention may be either: (a) **additive**—incremental accumulation; or (b) **synergistic**—produced by the interaction or combination of effects in the past, present, and reasonably foreseeable future.

The cumulative impacts discussed in this chapter mainly take the form of other developments *in the project area* that might add to the sum total of environmental and social impacts in the project area, that is, those which are 'additive'[1].

The cumulative impacts in the project area that are catalysed by the PNG LNG Project (that is, which are 'synergistic') are limited, for reasons set out below, to small-scale logging by villagers and population growth. The potential of project roads to enable or facilitate industrial-scale logging is inherently low, because they are generally not conveniently located, and those that are close to the boundary of a logging concession would add only a few of the many hundreds of kilometres required to log a large forest management area (FMA) (see 'Improved Access' in Section 18.7.4.1, Direct Impacts on Habitats, Flora and Fauna During Construction and Operations). In any event, long-standing and successful petroleum industry practice has been to exclude public access to oil and gas project roads and this will continue.

Associated impacts have been defined as those impacts arising *outside the project area* from the activities or initiatives of other parties, but which the PNG LNG Project might be in a position to facilitate, for example, gas consumption. These impacts are discussed in Section 24.5, Associated Impacts.

By its nature, most of this discussion is a broad characterisation of what other people may or may not do.

24.2 Cumulative Impacts Upstream: Oil and Gas

24.2.1 Existing Oil and Gas Developments

Existing oil and gas fields, facilities and infrastructure developments in the project area include:

- Hides, Kutubu, Gobe, South East Mananda and Moran fields.
- Kutubu Central Processing Facility, Gobe Production Facility and Agogo Production Facility.

[1] The upstream project area covers some 2,265,096 ha and the basis has been described in Appendix 1, Biodiversity Impact Assessment.

- Hides Gas to Electricity Plant.
- Moro Airfield and camp, other camps at Nogoli, Kopi, Agogo, Gobe and Hides Ridge and field camps.
- Kutubu crude oil export pipeline.
- Approximately 280 exploration, production and water and gas reinjection wells.
- In-field flowlines, pipelines and access ways (Gobe, Kutubu, Agogo, Moran and South East Mananda).

The PNG LNG Project environmental impacts, which will be in addition to those of existing oil and gas facilities, include air emissions, noise, treated wastewater, solid waste management and other discharges. Project-related impacts of this nature have been assessed in Chapter 18, Environmental Impacts and Mitigation Measures: Upstream Facilities and Onshore Pipelines, while waste will be managed as described in Chapter 25, Waste Management. These impacts are nominally incremental (at the regional scale) but take place in areas some distance from the comparable impacts of the existing facilities.

24.2.2 Future Developments

24.2.2.1 Onshore

The hydrocarbon resources closest to the PNG LNG Project gas fields include P'nyang (100 km west-northwest of Juha), Stanley (125 km west of Juha), Douglas (125 km west-southwest of Kutubu) and Elk (250 km east-southeast of Kutubu). These are all outside the area defined by Section 18.1, General Approach, for the discussion of indirect impacts. Nonetheless, the situation might arise where the gathering, processing and export infrastructure of the PNG LNG Project could, in theory, make the commercial development of a third-party gas accumulation more likely. In any event, the likelihood of these gas fields going into production increases as time passes, demand grows and existing fields peak and decline.[2]

24.2.2.2 Offshore

There are oil and gas resources and discovery prospects in the Gulf of Papua and the northern Coral Sea, including the Pasca and Pandora gas fields. The scope of possible future development is unknown.

24.2.2.3 Additional Gas

The operators of third-party gas accumulations may, at some future date, seek to enter arrangements to supply gas to the LNG Plant at Caution Bay. If such arrangements were feasible, commercially acceptable to the parties and considered by the PNG Government to be in the national interest, then they could have the effect of extending the productive life of the LNG Plant or of supporting an increase in production capacity, or both. The resulting cumulative impact

[2] The scope of such developments is hard to define, but assuming 50 ha for field facilities, a pipeline ROW of 30 m x 250 km and sundry other facilities might give a land requirement of between 125 and 175 ha for each field development.

would be 'synergistic' in nature, as the development in question would not be occurring as a stand-alone project, but would break new ground and face the same issues of habitat loss for wellpads and pipelines, and the same suite of access management and social development issues that arise for the greenfields components of the PNG LNG Project (see Chapter 18, Environmental Impacts and Mitigation Measures: Upstream Facilities and Onshore Pipelines, and Chapter 22, Project-wide Archaeological and Cultural Impacts and Mitigation Measures).

24.3 Cumulative Impacts Upstream: Project and Government Roads

Existing public roads within the upstream project area include the following:

- Moro to Poroma.
- Poroma to Mendi.
- Poroma to Idauwi.
- Highlands Highway connecting Tari to Mendi, Mount Hagen and Lae.
- Local roads connecting Tari to Nogoli and Komo.
- Moro to Homa.
- Kopi to the Samberigi turnoff.
- Local roads between Kikori and Kopi.

The Gobe Petroleum Development Project road from the Samberigi turnoff to the Gobe Airfield has only recently been gazetted as a public road but has long been used as such.

The PNG Government is currently completing the final sections of a road link between the highlands and the gulf coast at Kikori. This road will link Mendi and Mt Hagen to Kikori via Kisenapoi, Erave, Kagua, Samberigi and Gobe Airfield (see Figure 18.4).

The PNG LNG Project proposals for new and upgraded roads are given in Table 5.5 and Figure 5.5. Unlike the PNG Gas Project proposal, the PNG LNG Project is not required to (and does not intend to) complete pipeline construction access ways or ROWs as roads, or build new sections of road for other than project purposes. As pipeline construction access ways can adopt grades too steep for conventional vehicles, none of the new project roads will have the effect of completing a second link from the Southern Highlands Province to the Gulf Province coast. Furthermore, the project road from Hides to Juha will have a dead end and access will be controlled.

The implications of the PNG LNG Project for road access across the upstream project area are, for practical purposes, little different from the without-project case. That is:

- The PNG Government is expected to soon complete the eastern link through Erave and Samberigi (see Figure 5.5).
- The PNG Government may decide to build a second link to the west from Tari through Moro and Kantobo to Kikori and parts of this link could build on existing petroleum production roads. Upgrading of sections of project roads would further assist the linkage but there are sections that would still need to be built, notably through very difficult country between Homa and Idauwi.
- The completed eastern link weakens the case for a second, western link.

Therefore, the PNG LNG Project will:

- Improve the condition and safety of existing road links in the highlands part of the project area.
- Have little bearing on the eastern link between the Southern Highlands and Gulf provinces, most of which is some distance to the east of the project area.
- Have little effect on the outcome of a second link.

Moreover, the restricted-access PNG LNG Project roads will be maintained only to meet operational requirements. If these roads are not maintained post-production, then the pavement will become unserviceable and/or overgrown and impassable[3].

24.3.1 Forestry

24.3.1.1 Existing and Proposed Forest Management Areas

Section 10.5.1.2, Forestry, summarises the forest industry in the project area. There are extensive declared forest management areas (FMA) in both Gulf (728,000 ha) and Southern Highlands (250,000 ha) provinces and eight existing or proposed future forest management areas are generally within or overlap the project area (see Figure 18.4).

The large-scale logging all takes place in the southern parts of Gulf Province, where there is access to the sea. As these logs are taken, it seems likely that logging will move inland to the northern parts of Gulf Province and the southern and eastern parts of Southern Highlands and Western provinces respectively.

New PNG LNG Project roads will be closed to general use and unavailable for logging purposes (and would in any case be of little help for opening up new logging areas, see 'Improved Access' in Section 18.7.4.1 Direct Impacts on Habitats, Flora and Fauna During Construction and Operations). However, if logging interests continue to develop their own infrastructure, then there will be the cumulative (additive) impact of associated clearing. Section 10.5.1.2, Forestry, has described the existing and proposed forest management areas (logging concessions) and the extent of this additive impact has been estimated in Table 24.1.

24.3.1.2 Other Forest Resource Areas

Section 10.5.1.2, Forestry, has noted some timber potential in the Juha–Hides area and the factors affecting logging potential. If logs were to be exported from here, however, they would face a circuitous journey of some 400 km via the eastern link from Southern Highlands to Kikori that is currently nearing completion. A more likely export route would involve a new road west to a

[3] This has been the case with the access roads built to service the Kutubu Petroleum Development Project (see Plate 18.1) and with some of the less frequented public roads in rural Papua New Guinea, including the road from Poroma to Moro, which was built subsequent to, and as a condition of, the Kutubu Petroleum Development Project, but became unusable due to lack of maintenance.

barging point sufficiently far down the Strickland River to be navigable, then by barge several hundred kilometres down river to a port for export. An example of a log yard on a river is shown in Plate 24.1. There are large areas of FMA proposed to the west of Juha and so export logging from the Juha–Hides area (where there are no FMAs proposed) seems unlikely within the life of the PNG LNG Project. Estimates of areas cleared have therefore not been included in Table 24.1 (see Section 24.2.1, Existing Developments).

24.3.1.3 Small-scale Logging

The small-scale logging that routinely accompanies construction works in rural Papua New Guinea (see Section 10.5.1.2, Forestry) will be a synergistic cumulative impact of the PNG LNG Project (Plate 24.2).

The evidence of the oil and gas development to date is that small-scale logging is localised to areas close to customers, which in practice has meant around Moro. Logged-over areas are typically used for food gardens and or expansion of settlements as the terrain allows, resulting in permanent loss of forest.

The project will develop a use of renewable resources plan to oversee sourcing and usage of timber for the project. This plan will be developed considering the recommendations cited in Appendix 7, Forestry Impact Assessment.

24.3.2 Food Agriculture

Commercial, large-scale agricultural potential in the project area is very limited (see Appendix 26, Social Impact Assessment). Agricultural pursuits in most of the area are severely constrained by poor soils, flooding and steep terrain. Existing small-scale gardens and settlements are located in the better-quality soils on gentler terrain, mainly to the northeast and east of Hides, and on the more gentle volcanic terrain around Komo.

Over much of the project area, agriculture contributes less to subsistence production than does sago harvesting, fishing, hunting and gathering.

Crops with potential for expansion and export are sago around Kikori and coffee at Hides, Kutubu, Samberigi and surrounds. Rice may also have some potential in alluvial areas and oil palm in logged-over lowland forest. However, various attempts to commercialise agriculture on a large-scale basis in the project area have failed.

There have also been programs to diversify the product base of subsistence farming; and a range of new crops and livestock have been introduced, including African yams, Chinese cabbage, nutmeg, wongbok, salabeer, capsicum, pak choi, new varieties of taro and muscovy ducks

Plates

distributed from the Moro Agriculture Resource Centre. Crocodile skins have been successfully exported, and there is local interest in vanilla, with small plots being established around Gobe, Kikori and Kutubu.

If the road linking Kikori to the highlands currently under construction were to be completed, it could in theory encourage the development of commercial agriculture in the project area.

However, Appendix 26, Social Impact Assessment, notes that the experience of the existing oil projects has been that far from providing impetus to this sector, the opposite will be the case, as landowners with cash turn out to be less, not more, likely to invest in small-scale cash cropping or animal husbandry.

24.3.3 Biofuels

The pattern has developed in the forests of South East Asia of selective logging of high-value timbers, followed by broadacre forest conversion to biofuel crops, in particular oil palm. The drivers for this type of development (mandated use of biofuels and subsidies) have come under criticism for their cost, food and energy market distortions and environmental and social impacts. Nonetheless, they may have a bearing on post-logging land use in the project area, for example by taking advantage of the network of logging roads for clearing, replanting, harvesting and plantation management. There are at present no known plans for such developments in the project area, but if the drivers continue, then the experience elsewhere in the world suggests that biofuel will become the focus of development proposals in the project area lowlands in due course.

24.3.4 Fisheries

Up to 70 t of fish are taken from Lake Kutubu annually with an estimated value of K400,000. It is reported that the fish catch is in decline and the recent discovery of European carp may cause further declines. The saline and brackish swamps in the Kikori River delta are among the largest in the South Pacific, and fish, crabs and shellfish have traditionally been an important source of food for the inhabitants of the area. In addition, more than 60% of the households surveyed in the Kikori area reported cash income from fish during the past year.

Previously, there was a small local export fishery in Kikori that had operated for over thirty years, based on supply of ice to local fishermen and domestic sale of frozen fillets of high-value species such as barramundi and threadfin salmon. However, after many years of operation and supply of income to local fish suppliers, there are currently no commercial nearshore fisheries or fish farms in Gulf Province. This is not through any decline of the fish resource; more the result of logistical difficulties of maintaining reliable supply to freezers and market, and motivation of suppliers once cash is paid or if returns are not immediately realised, as described for other agricultural ventures (see Section 24.3.2, Food Agriculture). A number of deltas of South East Asia have been converted into prawn or other fish farms, but no such projects have been proposed to date for the Kikori–Turama delta complex. The roads to the highlands would provide some limited domestic sales opportunities but such ventures would probably require export markets and well-planned facilities and labour to be viable.

The driver for aquaculture worldwide is the inability of wild fish stocks to meet supply. If this trend continues, then the deltas of the project area will presumably attract development proposals as

similar deltas have elsewhere in the world. However, the project is unlikely to catalyse this level of development in the immediate future, if ever.

24.3.5 Tourism

WWF and others have promoted small-scale, eco-tourist schemes, such as guiding and lodges. The main hindrances to tourism development in the area are inadequate access and concerns about law and order. There is also competition for Papua New Guinea's small, inbound tourist market from the country's many other attractions. The project area does not appear to have any compelling competitive advantage and substantial investment in this sector seems unlikely for the foreseeable future.

24.3.6 Mining

There are no mines in the project area. The Porgera mine, for which electricity is generated at Hides Gas to Electricity Plant, is approximately 76 km from the proposed Hides Gas Conditioning Plant. Papua New Guinea is highly, but not uniformly, prospective for gold and base metals, and historically productive areas are under active exploration at present. However, the Kikori River basin is relatively less prospective, and there are currently no mineral exploration licences in the region. Exploration, let alone a new mine, seems unlikely in the foreseeable future with or without the presence of the existing or new oil and gas infrastructure.

24.3.7 Population Growth and Mobility

Table 2.2 in Supporting Study 10 of Enesar (2005) records a population growth in the upstream project area from 11,200 (rounded) to 24,000 between 1990 and 2000**,** as follows:

- The Southern Highlands Province ('highlands'):
  - A near doubling of the population around Gobe, Kutubu (Moro) and to a lesser extent Moran (to 10,900) in response to crude oil developments.
  - A two-and-a-half fold growth at Hides (Nogoli) (to 9,800), due in part to the natural gas developments in the area but due mainly to malaria control programs in the Tagari River valley implemented by the petroleum development operator.

  Now that oil development and malaria control programs are in place, their impact on future population growth will not be as significant.
- Table 2.2 in Supporting Study 10 of Enesar (2005) records a much lower growth rate in the Gulf Province 'lowlands' of 25% (to 3,300).

The rapid growth rates of the period 1990–2000 would have been a consequence of the arrival of the oil and gas industry at Hides and Kutubu and the industry's successful efforts to control malaria in the Tagari River valley.

24.3.7.1 Future Population Growth, Movement, Settlement and Activities

The scenario for future population growth, movement, settlement and activities in the project impact area is based on the following:

- The employment at the facilities of the PNG LNG Project, especially the 300 jobs at the Hides Gas Conditioning Plant, are expected to replicate the growth drivers of earlier phases of petroleum development between 1990 and 2000. If so, then a substantial percentage increase in population will occur in the highlands part of the project area and most particularly in the Nogoli–Komo–Hides Gas Conditioning Plant area, possibly in the order of 10,000 more people if the pattern of the recent past recurs.
- Some distance to the east, the expected opening to general traffic of the eastern road link from Southern Highlands Province to Kikori will create business opportunities, such as:
  - Small trade store businesses along the route.
  - Opportunities to sell fish, agricultural products, and timber and to service vehicles.
  - Public motor vehicle (PMV) freight and passenger operations.
  - Banking services.
  - Reactivation of cash cropping, such as coffee or vegetables, for export via Kikori (a much shorter (less than 300 km) route to a port than the Highlands Highway to Lae, which is more than 600 km from Tari).
- The ability to settle, establish subsistence gardens and conduct business with travellers will be constrained by:
  - Inhospitable and unproductive terrain and soils.
  - Malaria.
  - No legitimate claim to land and the resistance of current landowners to newcomers squatting.
- Permanent settlement will most likely focus on the existing centres of Nogoli–Komo–Hides Gas Conditioning Plant, Moro, Kopi and Kikori. The eastern road link currently nearing completion will probably see a small settlement spring up at the Samberigi turnoff from the existing Kopi–Gobe Airfield road. Some newcomers may marry into the area, rent land for a period or seek work from the very small number of local employers (most of whom will be more likely to give employment preference to local people).
- The prospects of settlement will become more attractive as time passes, as the centres named above grow and as the number of *wantoks* (relatives) rises. However, these are secondary encouragements. The primary drivers – the prospect of acquiring money – will remain a constraint: first, because there will be little new employment available once the project is in operation; and second, because the quantum of money flowing to project area landowners, although a material sum, has not been in the past – and should likewise not be in the future – sufficient to support an ever-growing population.
- Most travellers on the new road will be motivated by curiosity.
- Travellers are predicted to be almost entirely Highlanders visiting Gulf Province. Travel in the other direction will be discouraged by an inhospitable reception from the local clans.

These factors suggest a potential population movement scenario as follows:

- There will not be a tide of migration from the highlands to Gulf Province.

- The high historic population growth rates between 1990 and 2000 in the 'highlands' parts of the project area will probably be repeated in the same general area and to a similar degree.
- Future population growth will probably concentrate on existing towns, but particularly in the Nogoli–Hides–Komo area.
- The environment outside the towns in the lowlands remains inhospitable, and so only sporadic settlement is expected along the new government road from Southern Highlands Province to Kikori approaching completion.[4]
- The population growth in the 'lowlands' between 1990 and 2000 was much less, despite the arrival of the crude oil export pipeline and associated rents to local people. The PNG LNG Project does not appear to bring anything new to suggest that this situation will change.

24.3.7.2 Refugee Movements or Migrations

Catastrophic social and environmental pressures, such as a major drought in the PNG highlands, could force refugees to seek food, safety, shelter and better conditions elsewhere. Such large refugee movements are likely to overwhelm traditional systems of defending land. In addition, desperate people could be forced to establish gardens in areas where terrain and poor soil would normally inhibit such activities. While unsustainable in even the medium term, gardens in marginal areas would be sufficient to provide some sustenance in the short term (two to three years). The project roads would facilitate refugee movements or migrations on foot.

24.3.7.3 Hunting of Fauna and Collection of Flora

The new government road from Southern Highlands Province to Kikori will enable hunters to use vehicles to travel further afield to poach wildlife from the property of other landowners and to transport their prey home or to markets.

24.3.8 Cumulative Impacts Upstream Summary

The cumulative land requirements of the activities discussed above are estimated in Table 24.1.

The potential cumulative impacts associated with the PNG LNG Project reflect the likelihood that the restrictions on public access to oil and gas project roads will continue to work, as they have since 1992. The cumulative impacts of the PNG LNG Project will mainly comprise population growth at the existing oil towns in the highlands part of the project area and small-scale logging. The likelihood of people settling along the project logistics routes, that are not public roads, is low.

These findings are grounded in what has actually happened since the oil and gas industry began operations in 1992. Notwithstanding, Esso will consider a review of the reduced emissions from deforestation and degradation (REDD) mechanism as a means of limiting potential indirect forest degradation and deforestation related to project development.

[4] This is the so-called 'eastern link', which is largely to the east of the PNG LNG Project upstream facilities area. It runs from Mendi via Kagua, Erave and Samberigi to Kopi and Kikori. The road is under construction but the final section between Samberigi and the existing Kopi–Gobe Airfield road northwest of Kaiam is not yet completed.

Table 24.1 presents estimations of existing and future forest clearing from all sources within the Kikori River basin. Clearing for agriculture has historically been the biggest source of forest habitat loss (approximately 97% of the area that has been cleared to date). Estimates of forest habitat loss from timber harvesting activities are based on the loss attributable to the building of access roads (see Plate 10.49 and Figure 18.4), with no subsequent, broadacre conversion of forest to other vegetation types (see footnote to next paragraph).

The estimates exclude small snig tracks and the degradation of forest habitat by selective logging. The Hekiko FMA might involve clearing for roads of the order of 2,000 ha to support timber extraction over perhaps 115,000 ha, in which the removal of the larger trees will create irregular gaps in the forest canopy. In any given area, these gaps might range from between 20% to 80% of the extent of an area, depending on the spacing of the merchantable trees[5].

As far as the people are concerned:

- Gas royalty wealth will be the main driver for population growth in the 'highlands'.
- The new government road from Southern Highlands and PNG LNG Project benefits will be the main drivers of population growth in the 'lowlands', almost all in Kopi and Kikori.

Settlement along the new government road will be sporadic, with localised impacts on the forest due to the establishment of new gardens and burning to clear vegetation. The zone of this impact might extend for a few kilometres on either side of the settlements along the road. Numbers of settlers and associated impact areas are difficult to estimate, but might involve in the order of 1,000 to 2,000 people along the new government road between Kisenapoi and Kikori and the clearing of perhaps 1,000 ha of forest.

Table 24.1 Existing and predicted additional forest clearance in the project area

Source of Forest Clearing	Data Source or Basis of Calculation	Approx. Forest Loss (ha)	
		Existing	Predicted Additions
Agriculture and settlements	FIM mapping (veg type ='O')[a]	127,900[b]	7,895[c]
Existing oil and gas project facilities[d]	Satellite imagery[e], GIS	1382	0
Public roads nearing completion (Erave to Kopi)[h]	GIS (approx. 100 km by 30 m)	300	0

[5] Selective logging does not clear fell but it is not straightforward to derive values for Table 24.1 (see Section 24.3.1.1, Existing and Proposed Forest Management Areas) from the clearing effect of the variable and unpredictable spacing characteristic of selective logging. (See also Plate 10.49.) Clearly the pre-logging integrity of the forest is degraded. Furthermore, Shearman et al. (2008) find that conversion to non-forest cover increases with time since logging began and cite a number of studies pointing to burning, further logging incursions, by new operators, local people with walkabout sawmills and shifting cultivators. These pressures will probably be less in the sparsely inhabited lowlands of Gulf Province than in the highlands. However, the question remains of the time required for logged forest to recover a structure and biodiversity approaching that of primary forest, with estimates ranging widely from less than 100 years to more than three centuries (Shearman et al., 2008).

Table 24.1 Existing and predicted additional forest clearance in the project area (cont'd)

Source of Forest Clearing	Data Source or Basis of Calculation	Approx. Forest Loss (ha)	
		Existing	Predicted Additions
Logging roads – Turama Block 1	Approx. 251 km by 30 m[e]	753	970[f]
Logging roads – Kikori Block 2	Approx. 246 km by 30 m[e]	738	1,680[f]
Logging roads – East Kikori	Approx. 224 km by 30 m[e]	687	0[f]
Logging roads – Nogoli	GIS PNGRIS	0	160[f]
Logging roads – Hekiko	GIS PNGRIS	0	2,000[f]
Logging roads – Kutubu-Poroma	GIS PNGRIS	0	130[f]
Logging roads – Pi Tukere	GIS PNGRIS	0	40[f]
Logging roads – Bosavi	GIS PNGRIS	0	460[f]
Small-scale logging	30 coupes @ 500m x 500m	No estimate	750
PNG LNG Project	This EIS (see Table 18.22)	0	1,768
Total (rounded)		**132,250**	**15,850**
Total oil and gas		*1,382*	*1,768*
Total project area is approximately 2,265,096 ha[g]			

[a] Applies only to existing forest loss estimates. [b] Most of this clearing has been in the Nogoli and Komo areas in Southern Highlands Province. [c] Only limited reliance can be placed on this estimate. It is derived from two sources (1) gardening where it has been assumed that up to 200 families might settle along the new government eastern road link joining Southern Highlands to Kikori, with clearing at a rate of 0.75 ha/household per 3 years (upper value adopted here) over the 30-year project life and (2) an expansion of cash cropping assumed to be 5% of existing clearing. [d] Oil and gas values summed for convenience; facilities digitised from satellite imagery; 130 wells @ 1ha/well; flowlines and pipelines (approx. 157 km by 30 m) and access roads (approx. 105 km by 30 m—Moro and Agogo to Kutubu Central Processing Facility, Moran, Gobe) from GIS. [e] Roading system digitised from satellite imagery TM/Pan using edge technique UTM Zone 54S WGS84 ETM 98/64 (acquired 7-Aug-01), ETM 98/65 (acquired 1-Dec-02), ETM 99/65 (acquired 24-Sep-91), ETM 99/64 (acquired 4-Jul-02). [f] Analysis of roads from satellite imagery indicates approximately 0.018 km of access roads per hectare in production forests. Remaining loggable areas within concessions inside the KICDP area were estimated from areas of volcanic alluvial or mixed sedimentary geology on low slopes from PNGRIS data. Areas calculated were as follows: Kikori Blk 2 – 93,850; Turama Blk 1 – 54,314; Hekiko – 114,819; Kutubu–Poroma – 7,582; Nogoli – 9,253; Pi Tukure – 2,116; Bosavi – 25,720. Estimated hectares cleared have been rounded. [g] The upstream project area comprises the former WWF Kikori Integrated Conservation and Development Project area (the Kikori River Basin) plus an envelope around the Juha Gasfield and pipelines (see Section 6.1, Definitions' and Figure 2 in Appendix 1, Biodiversity Impact Assessment). Goldman (pers. com., 2008).

24.4 Cumulative Impacts Downstream

24.4.1 Squatter Settlement

It is difficult to gauge the attraction to squatters of a high-security LNG facilities area compared to other sites nearer Port Moresby with open access to the city. However, some squatters will almost certainly settle in numbers and locations that are hard to predict. The impacts will be adverse, since almost by definition squatters will be jobless and in part at least predisposed to *raskol* activity. The effects will be felt by workers (as crime against people and property), by Esso (as a

threat to its workforce and the security of the plant), by road users (as a traffic hazard) and most of all by the legitimate landowners (as crime and loss of access to their own land and resources). These affected people and entities are project stakeholders of standing and media profile and so their representations to the Government will probably see the squatter settlements cleared, as occurred in 2008 in Tete (Port Moresby) and Moro.

24.4.2 Habitat and Biodiversity Impacts of Squatting

Clearing of squatters, however prompt, will be preceded by their settlement. Again, the extent is hard to predict, but some idea of the impacts on habitat and species can be inferred from the nature of the area that might be affected and of its current conservation status.

The habitats most likely to be settled in this way are savannah and grassland/woodland (see Figure 12.11) around the perimeter of the LNG Facilities site and savannah along the road from Port Moresby (see Figure 12.10). Both have been heavily disturbed by clearing, cutting and fire. Their occurrence in the region (see Table 20.12) is respectively some 17,400 ha and 11,000 ha respectively. The findings of Section 20.6, Aquatic Ecology, of a low overall direct threat to biodiversity values are based in part on the large proportion of similar habitat remaining in the region, in part on the fact that the affected areas of habitat have been so disturbed and predated as to be unlikely to host listed species that would be threatened directly by the project, and in part—indeed mainly—by the project's mitigation measures to control weeds, pathogens and feral fauna. The latter measures cannot apply to squatter settlements, and so similar inferences about their effects on local biodiversity depend in very large measure on whether the settlements are allowed to grow or, as seems on recent history to be the more likely, whether they are cleared. Either way, if proximity to the LNG Facilities site is the attraction to squatters, then the effect is by its nature localised and hence self-limiting in extent.

24.4.3 Cultural Heritage Impacts of Squatting

The cultural heritage assets of the LNG Facilities site and environs, unlike the biodiversity assets, are regionally as well as locally significant. Chapter 22, Project-Wide Cultural Heritage Impacts and Mitigation Measures explains how sites within the LNG Facilities site footprint will be managed. It also explains how the site layout for the LNG Facilities has been able to avoid the more important ancient village complexes of Konekaru and Aemakara to the north and south respectively (see Figure 16.1). However, visitors and squatters will disturb these and other specific locations, such as ancestral oral tradition sites, individual archaeological sites, and crashed aircraft and artillery batteries from WWII. The PNG LNG Project, will consider recommendations in Chapter 4 of the SIA (See Appendix 26, Social Impact Assessment) relating to suggestions to conserve Koita and Motu (landowner) interests in the general area of the site as part of broader community initiatives that will be managed under the national content plan (see Section 23.6.4.3, Other Benefits). Esso will consult with the PNG National Museum and the Natural Cultural Commission on this initiative.

24.4.4 Air Quality

The LNG Facilities site is approximately 20 km northwest of Port Moresby and 15 km north-northwest of the InterOil Refinery at Napa Napa. These are the only significant sources of anthropogenic pollutants that could affect the area.

The Kinhill Kramer (1997) modelling of air emissions from the InterOil Refinery indicates that the 99.9 percentile 1-hour average SO_2 concentrations are unlikely to exceed 2 ppb (5.7 µg/m^3) and annual average concentrations are unlikely to exceed 0.5 ppb (1.4 µg/m^3) at the LNG Facilities site area. The 99.9 percentile of 1-hour average concentrations for NO_2 are expected to be less than 2 ppb (4 µg/m^3) and annual average concentrations are expected to be well below 1 ppb (2 µg/m^3).

This distance from Port Moresby and from the InterOil Refinery make the industrial pollution of the LNG Facilities site unlikely and air quality modelling has confirmed that this is the case, with pollutants present either below detection or at extremely low concentrations and well within applicable criteria (see Section 20.8, Air Quality and Appendix, Air Quality Assessment).

24.5 Macro-economic Impacts

The size of the PNG LNG Project in the future economy of Papua New Guinea blurs the distinctions between the indirect impacts of the project and its cumulative effects, especially in the nation's capital, Port Moresby. While the LNG Facilities site will be the dominant industry with its own local indirect impacts, these will be dwarfed by the effects of project revenues flowing through the Port Moresby and indeed the national economy. Almost every sector of the economy will be involved: primary production (mainly of food and building materials); secondary activities, such as fabrication, food and beverages, construction and utilities; the tertiary sector of services in retail and wholesale sales, transportation and distribution, hotels, entertainment, restaurants, clerical services, media, tourism, insurance, banking, healthcare, and law; and the quaternary sector of government, culture, education, research and information technology.

The macro-economic effects in the economy have been summarised from ACIL Tasman, 2008) in Section 23.6 Future Economic Benefits.

In terms of impacts, it seems likely that the following pressures will be felt:

- A substantial boost to the economy of Port Moresby, where much of the direct project expenditure on goods, services and wages will be made, and from the revenues to the National Government of K67 billion over the life of the Project.
- The flow-on effects will be substantial and there will be rapid population growth as people from elsewhere in Papua New Guinea travel to Port Moresby to see the project for themselves and to take advantage of its opportunities, however, poorly understood and accessible these might be. Moreover, it seems likely that the existing 3% birth rate of the National Capital District, already higher than the national average of 2.7% (AusAID, 2008), will rise further.
- The demands of population growth: employment, engineering infrastructure and public health and education services.
- Increased marine traffic into the ports of Lae and Port Moresby, with corresponding demands on their respective hinterland infrastructure.
- Increased air travel and passengers through Port Moresby's Jackson's Airport.
- Additional demands on law and order and the criminal justice system.
- The general increase in consumption of goods and services and the associated costs to the environment of resource development and waste management.

ACIL Tasman (2008) has noted that the PNG LNG Project will double the gross domestic product of the country, which provides the national and provincial governments with the opportunity to

address these issues. The impacts will be significant (see Appendix 26, Social Impact Assessment).

These projections are based on a number of financial assumptions and, not least, the view that there will be an improvement in the equity, accountability and transparency of benefits allocation and distribution processes (see Appendix 26, Social Impact Assessment).

24.6 Associated Impacts

Associated impacts are those related to developments lying outside the project area that could be facilitated by the existence of the PNG LNG Project or parts of its infrastructure. These activities are the initiatives of other parties and would require their own environmental impact assessments under the applicable legislation before proceeding.[6]

The PNG LNG Project has been sized as an export LNG and condensate project. It will contribute to the critical mass and human capital of Papua New Guinea's oil and gas sector, but the ways in which it might directly facilitate other domestic projects are not readily apparent, at least not during its commercial life. If new energy-intensive industries projects, such as cement manufacture, gas-fired power generation or gas processing to produce petrochemicals, fertilisers, methanol or other products, were to be based on domestic gas, then new gas production infrastructure would probably have to be developed on fields other than those of the PNG LNG Project.

24.7 Project Impacts in Customer Countries

The PNG LNG Project's customers will need to receive, store and regasify the LNG and reticulate the natural gas to users. This will require either existing or new facilities, either of which will entail operational impacts of gas combustion.

The merits of these facilities will be assessed under the planning and environmental approval processes of the countries concerned.

[6] Such developments would also be expected to comply with all applicable national, provincial/state, and local legislation and other appropriate/applicable requirements (see Chapter 8, Legal, Administrative and Planning Framework).