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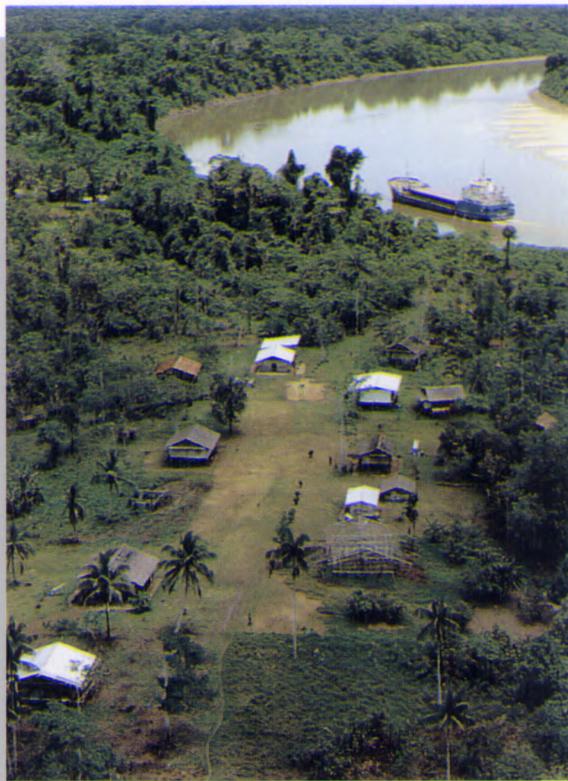
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# The Fly River Catchment Papua New Guinea

A Regional Environmental Assessment





The Fly River Catchment Papua New Guinea  
A Regional Environmental Assessment

This One



3ABT-YHN-YXPP

## **The Department of Environment and Conservation - Papua New Guinea**

The Department of Environment and Conservation has responsibility for overseeing policy relating to environment and conservation and for administering legislation pertaining to environmental planning and pollution control. Within its mandate the Department has responsibility for the conservation of species of flora and fauna, their habitat and other areas designated for wildlife management and national parks.

Its role in environmental protection includes the environmental assessment of development activities and monitoring the environmental effects of the operations of major projects, including the Ok Tedi and Porgera mines in the headwaters of the Fly River catchment.

The Department of Environment and Conservation is a government member of IUCN and currently one of its staff is a Regional Councillor of this world conservation union.

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# **The Fly River Catchment Papua New Guinea**

A Regional Environmental Assessment

The Department of Environment and Conservation  
Papua New Guinea

IUCN - The World Conservation Union  
1995

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The cover photograph shows a barge for carrying copper concentrate travelling up the Fly River past a local village and was taken by the Ok Tedi Mining Ltd

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# Abbreviations and Acronyms

<b>AIDAB</b>	<b>Australian International Development Assistance</b>
<b>APL</b>	<b>Acceptable Particulate Level</b>
<b>CESP</b>	<b>Commission of Environmental Strategies and Planning</b>
<b>CIE</b>	<b>Centre for International Economics</b>
<b>CNA</b>	<b>Conservation Needs Assessment</b>
<b>DEC</b>	<b>Department of Environment and Conservation</b>
<b>DF</b>	<b>Department of Forestry</b>
<b>DMP</b>	<b>Department of Mining and Petroleum</b>
<b>EMMP</b>	<b>Environmental Management and Monitoring Program for Porgera Gold Mine</b>
<b>EP</b>	<b>Porgera Gold Project Environmental Plan</b>
<b>IIED</b>	<b>International Institute for Environment and Development</b>
<b>IUCN</b>	<b>The World Conservation Union</b>
<b>K</b>	<b>Kina</b>
<b>NANGO</b>	<b>National Alliance of Non-Governmental Organisations</b>
<b>NFCAP</b>	<b>National Forestry and Conservation Action Programme</b>
<b>NGO</b>	<b>Non-Government Organisation</b>
<b>NH &amp; MRC</b>	<b>National Health and Medical Research Council (Australia)</b>
<b>NSO</b>	<b>National Statistics Office</b>
<b>NSR</b>	<b>Natural Systems Research Pty. Ltd</b>
<b>ORWB</b>	<b>Off River Water Body</b>
<b>OTDT</b>	<b>Ok Tedi Development Trust</b>
<b>OTML</b>	<b>Ok Tedi Mining Ltd</b>
<b>PJV</b>	<b>Porgera Joint Venture Ltd</b>
<b>PNG</b>	<b>Papua New Guinea</b>
<b>SSG</b>	<b>Special Support Grant</b>
<b>SPREP</b>	<b>South Pacific Regional Environment Programme</b>
<b>STD</b>	<b>Sexually transmitted disease</b>
<b>TRP</b>	<b>Timber Rights Purchase</b>
<b>UNDP</b>	<b>United Nations Development Programme</b>
<b>UNEP</b>	<b>United Nations Environment Programme</b>
<b>UPNG</b>	<b>University of Papua New Guinea</b>
<b>WMA</b>	<b>Wildlife Management Area</b>
<b>WWF</b>	<b>World Wide Fund For Nature</b>

# Preface

## **Regional Environmental Assessment**

The catchment of the Fly River is, after the Sepik, the largest water catchment in Papua New Guinea. The catchment embraces 76,000 square kilometres and it is navigable for over 800 kilometres. As a source of transport, water and food the river makes an essential contribution to the communities along the path of its complex waterways.

The mining activities of Porgera Joint Venture Ltd and, particularly, Ok Tedi Mining Ltd in the headwaters of this catchment have been the focus of significant national and international attention. This is due principally to the impacts the Ok Tedi mine has had and may have on the environment of the catchment.

In 1990 the General Assembly of IUCN, the World Conservation Union, of which the Department of Environment and Conservation is a government member, asked IUCN to render what assistance it could to Papua New Guinea in addressing the environmental consequences of mining activities. This call was repeated in a further recommendation adopted at the 1993 Buenos Aires General Assembly.

The mining activities in the catchment have been subjected to a number of reports and it was decided that rather than simply limit investigations to the consequences of mining, an appraisal of the long term implications of development activities within the whole catchment should be undertaken. This approach was designed to provide information that could lead Papua New Guinea to decide what responses may be needed to ensure the sustainability of development and the livelihoods of communities that depend on the natural resources of the catchment.

As a consequence, an IUCN team working with the Department of Environment and Conservation and other Papua New Guinea agencies has produced the current report. The report synthesises environmental, social, cultural and health implications of current developments and identifies issues of importance into the next century. A critical conclusion is that current and perceived development trends induce little optimism for a sustainable legacy in the Western Province early next century. Thus there is an urgent need to initiate appropriate strategic planning for regional development, well before the closure of the mines. The report recommends, as an initial step, the preparation of a Sustainable Livelihoods Strategy for the catchment. This is a recommendation the Department will actively pursue in collaboration with the different interests in the catchment and the communities themselves.

The Department of Environment and Conservation wishes to acknowledge the assistance of IUCN in the preparation of this report and of the German Ministry of Economic Cooperation and Development which financially assisted the IUCN mission and the publication of this report.

A handwritten signature in black ink, appearing to be 'Iamo Ila', written in a cursive style.

**Iamo Ila**

**Secretary,**

**Department of Environment and Conservation - Papua New Guinea**

# Summary

## Background to the Report

This report stems from Resolution 18.63 of the IUCN General Assembly in Perth, West Australia in 1990 which concerned Papua New Guinea's Fly River. The IUCN team was asked to prepare a regional assessment of the Fly River catchment, which would synthesise the environmental, sociocultural and health impacts of current developments, and identify development issues into the next century. Following from this Regional Environmental Assessment, the team was asked to prepare a proposal for preparation of a Sustainable Development Strategy for the Fly catchment.

## The Fly catchment

The Fly catchment, which includes both the Fly and Strickland Rivers, is over 76,000 km<sup>2</sup> and ranks among the world's largest rivers. The topographical variation within the catchment is extreme. The Fly and Strickland Rivers rise in mountainous land forms with elevations of up to 3,000 m. This topography rapidly gives way to foothills, before descending to the extensive plains of the middle and lower Fly. The Fly River is navigable as far as Kiunga, which, at an elevation of 40 m above sea level, is approximately 800 km from the delta.

The plains of the middle and lower Fly River support a mosaic of wetland and savannah habitats. These habitats are of international significance. The fauna and flora of the highland forests of the upper catchment are amongst the richest in Papua New Guinea.

## Settlement, administration and infrastructure

Ten distinct cultural groups inhabit the Fly catchment. Traditionally the Mountain Ok or Min people lived on the southern Highland Fringe. This is a distinctive mountainous terrain with extremely high rainfall, infertile soils and endemic malaria. Following the commencement of mining at Ok Tedi, virtually the entire Min peoples of the Star Mountains have relocated to the vicinity of the mine. This places considerable strain on traditional tenural and cultural relationships.

Unlike the upper Fly, the upper Strickland is a relatively well populated region within the central highlands. More than half the population of the Fly catchment, which totals some 151,000 people, are located there.

## The Fly River catchment

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Approximately 30,000 people live in the Fly River corridor which runs from the Ok Tedi mine site down to and including the delta. A further 12,000 people live in Tabubil, the mine's township.

Population growth in the Fly catchment as a whole is currently very high at 3.66% per annum. This is considerably higher than the national average of 2.03%. This can be attributed to a combination of a high fertility rate, decreased infant mortality and immigration.

The enormous distances, low population density and difficult terrain make the provision of an adequate road network inappropriate throughout much of the catchment. Long distance movement will continue to be either by air or boat and hence relatively expensive and limited. These factors combine to make the provision of Government services generally inefficient and expensive and to constrain the development of commercial enterprises.

## Primary resources

Economic development in the agricultural, forestry and fisheries sectors is at a very low level in the Fly catchment. With a few minor exceptions, these resources are essentially being used for subsistence, traditional lifestyle requirements and minor cash income needs.

Agriculture is considered to have a very limited development potential in this region. A possible exception of rubber at the smallholder level. There is more scope for the commercialisation of the fisheries but not necessarily a higher potential of success. In both sectors, the realities of economies of scale and distance to markets make commercial developments highly vulnerable. There is clear potential for the successful development of the timber industry.

Current knowledge of the biodiversity values in the Fly catchment is very limited, although a conservation needs assessment in 1991-92 identified large areas in the region as being very important for biodiversity conservation. The Department of Environment and Conservation (DEC) has no institutional presence in the Western Province. There are no established protected areas wholly within the Fly catchment.

## Mining

### The Ok Tedi mine

The Ok Tedi mine is a conventional, open-cut pit operation which brings substantial economic and social benefits to the area and to the nation as a whole. At present 160,000 tonnes of ore per day are mined of which approximately 50% is waste rock. This is stored so as to continuously erode into the river system. After the ore has been crushed and milled, the tailings are also released into the river system.

Although a tailings dam was originally intended, the geologically unstable nature of the area and the cost of building a reliable structure caused this idea to be abandoned. The absence of a tailing dam to contain the mine wastes is a highly controversial issue which has drawn worldwide criticism. The release of the tailings and waste ore to the river system is the cause of the most conspicuous environmental impacts. The immediate impacts on the Ok Tedi River are dramatic and undisputed. The significance, extent and permanency of sedimentation, and elevated copper levels downstream in the Fly River system is more uncertain.

**The Porgera gold mine**

Operations at the Porgera mine commenced in 1991. These include an open pit and an underground mine. The tailings are first treated in a neutralisation circuit and then disposed of in the river system.

The opening of the mine at Porgera has not resulted in social and infrastructure changes in the region of the magnitude of those at Ok Tedi.

**Social impact of the mining sector**

Two broad categories of social impact can be distinguished at both Ok Tedi and Porgera. These are the direct local level impacts on landowners and other affected residents and the much broader socio-economic impacts created by a massive revenue earner in a newly independent nation which is heavily dependent on the income from the mines.

The rapid and enclave nature of mining development in the Fly catchment has resulted in marked changes in traditional settlement patterns. These are accompanied by profound social changes brought about through the introduction of a cash economy, alcohol and an increasing reliance on imported food items and consumer goods.

The expected life of the mines will, essentially, span an entire generation. By the time of the expected closure of the mines, it is unlikely that the landowner and local communities will have retained a traditional inheritance which would provide a tolerable livelihood in the absence of an assured cash income. Social turmoil can be expected to arise in the absence of substitute economic activity or development centres.

**Sustainable development issues**

The Fly catchment has, by comparison with other remote areas in Papua New Guinea, experienced relatively rapid development and, arguably, progress. This has been brought about almost exclusively through the spin-offs of technologically intensive and commercially dominated enclave developments.

A series of forecasts of the likely conditions in the Western Province early in the next century have been prepared, through the generation of scenarios based on 'Business as usual', 'Expansionist' and 'Contracting' conditions. All of these scenarios are shown to be unsustainable which indicates considerable potential for social instability. This, together with three conjectural issues, underpin the urgent need for strategic planning for development in the Fly catchment. These issues are:

- the current mine-based enclave developments are likely to be transitory;
- the uncertainty about whether the river system will quickly return to normal;
- on the cessation of mining;
- the lack of tried and tested development alternatives.

## Conclusions and recommendations

Current and perceived development trends provide little optimism for a sustainable legacy in the Western Province early in the next century. There is clearly an urgent need to initiate appropriate strategic planning for regional development well before the closure of the mines.

- \* *A Sustainable Livelihoods Strategy for the Fly catchment should be prepared to help address current issues and to help communities manage a transition to a non-mining economy.*

Community participation is central to the success of development initiatives. Different social groups have variable and complex forms of land use and values. This makes distant planning of suitable development options highly uncertain and large scale development options highly vulnerable.

- \* *The Sustainable Livelihoods Strategy should incorporate the informed participation of local communities with the objective of promoting community stability and sustainable livelihoods within a framework of sustainable development.*
- \* *Local communities should be encouraged to develop their own livelihoods whilst protecting ecosystems and biodiversity upon which those livelihoods ultimately rely.*

Sustainable development initiatives in the Fly catchment will depend on the sustainable use of the varied natural resources of the catchment. Current knowledge and management of these resources is not sufficiently adequate to ensure that they can be exploited in a sustainable manner.

- \* *Conservation and environmental management activities within the Fly catchment need to be greatly enhanced to ensure the maintenance of a sustainable natural resource base and the conservation of the region's unique biodiversity.*

# 1

## Introduction

### Background to the regional environmental assessment

The regional environmental assessment is IUCN's initial response to Resolution 18.63 of the IUCN General Assembly in Perth, West Australia, 1990. The Resolution calls upon IUCN:

“...to respond favourably, within available resources, to any request from Papua New Guinea Government to assist Papua New Guinea through provision of:

- Training assistance to supplement the Government's capacity for management on the Fly River catchment, and by
- Technical and financial assistance for the expansion of current studies covering social, economic, health and cultural impacts in the Fly River catchment so that problems or potential problems can be identified and remedied”.

The PNG Department of Environment and Conservation has indicated the scope of the technical assistance it requires. IUCN has been asked to prepare a proposal for the preparation of a “Sustainable Development Strategy for the Fly/Strickland Catchment Area” which would be available to potential donors. This proposal, and any subsequent plan should focus on:

- existing and expected impacts of resource extraction industries;
- conservation of biodiversity;
- sustainable management of natural resources which are a basis for economic activity (forests, agricultural land);
- sustainable development options for other resources.

The overall goal is to enhance economic opportunities for local people and improve their quality of life.

### Objectives of the assessment

The assessment has three main objectives:

1. To synthesise information on the environmental, sociocultural and health impacts of developments in the Fly/Strickland catchment area.

2. To identify environmental, sociocultural and health problem areas (hot-spots) which may arise in the future (up to 2010) if expected development trends continue.
3. To assist in formulating a proposal, for presentation to donors, for the preparation of a Sustainable Development Strategy for the Fly/Strickland Catchment. This proposal is referred to as the “Sustainable Livelihoods Strategy” because this title captures the objectives being pursued by the work proposed. The objectives are to:
  - manage and, if possible, prevent or reduce the severity of the problems identified;
  - identify nature conservation needs within and outside existing protected areas and the appropriate management strategies;
  - identify sustainable development strategies for existing resource uses (e.g. forestry, agriculture);
  - identify additional sustainable development options; and
  - enhance the standard of living and quality of life of local people.

# 2

## The Fly River catchment - general description

### General features

The Fly River catchment is, after the Sepik River catchment, the largest water catchment in Papua New Guinea, covering approximately 76,000 km<sup>2</sup>. The three principal catchments are those of the upper Fly and the Strickland Rivers which comprise rugged, mountainous terrain and that of Lake Murray, which consists of many smaller rivers draining generally flat and rolling country (Figure 1).

There are major climatic and ecological differences between the upper, middle and lower reaches of the catchment. The most significant differences are related to rainfall patterns. The catchment headwaters have exceedingly high annual rainfall, with rainfall totals over 10,000 mm per annum and little seasonality. In contrast, in the middle and lower reaches of the Fly, rainfall is influenced by the prevailing monsoons and trade winds which produce distinct dry and wet seasons with lower rainfall totals of about 3,500 mm per annum.

Topographical differences within the catchment are extreme. The Fly and Strickland Rivers rise in 'ridge and ravine', mountainous land forms, with elevations up to 3,000 m. However, this topography rapidly gives way to foothills before descending to the extensive plains of the middle and lower Fly which comprise the Fly-Digoel Shelf (see Figure 2).

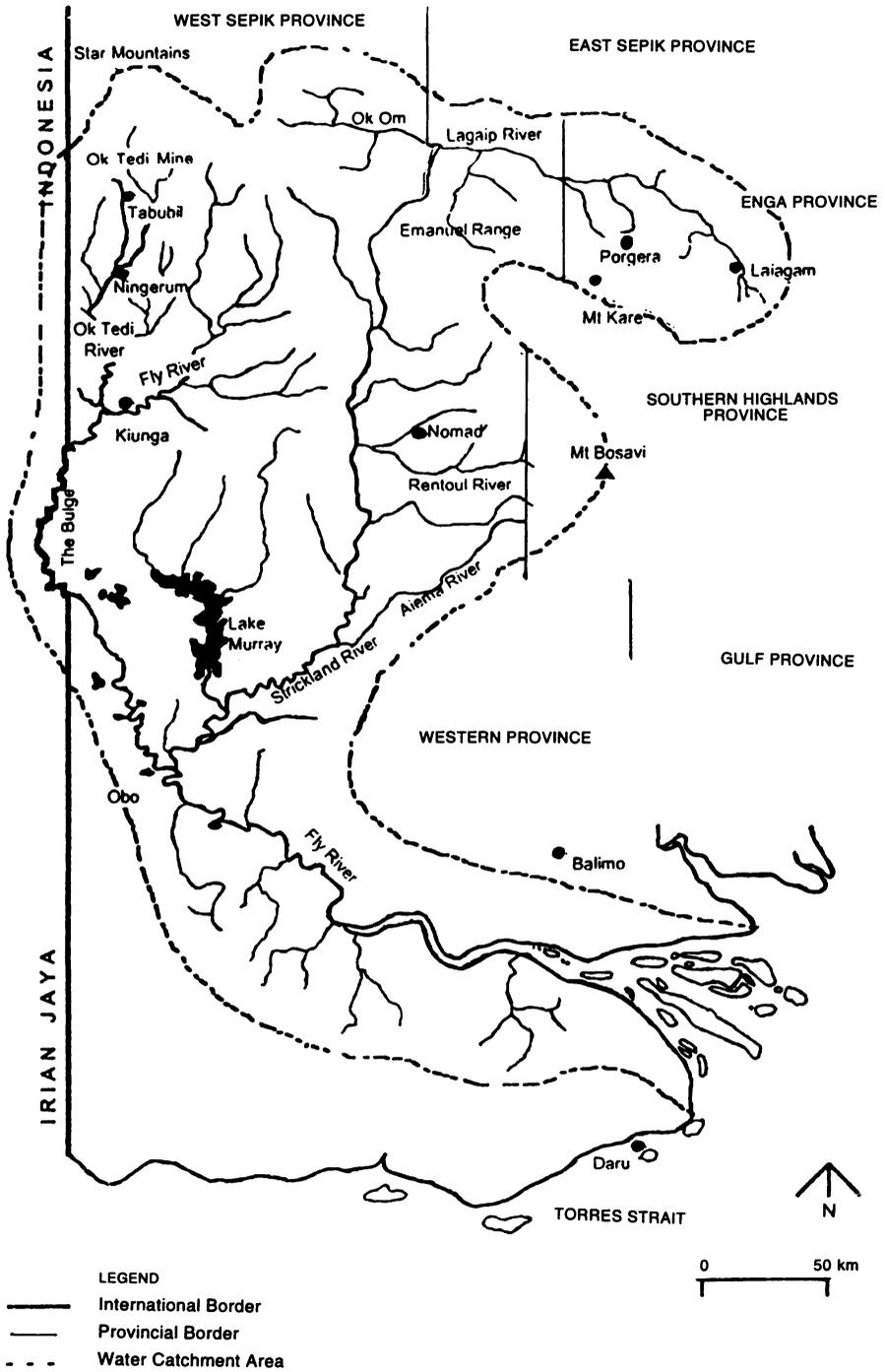
Table 1 provides general data on the catchment and its principal tributaries.

**Table 1** Selected information on the Fly River  
Source: OTML (1993); see Figure 8 for monitoring locations

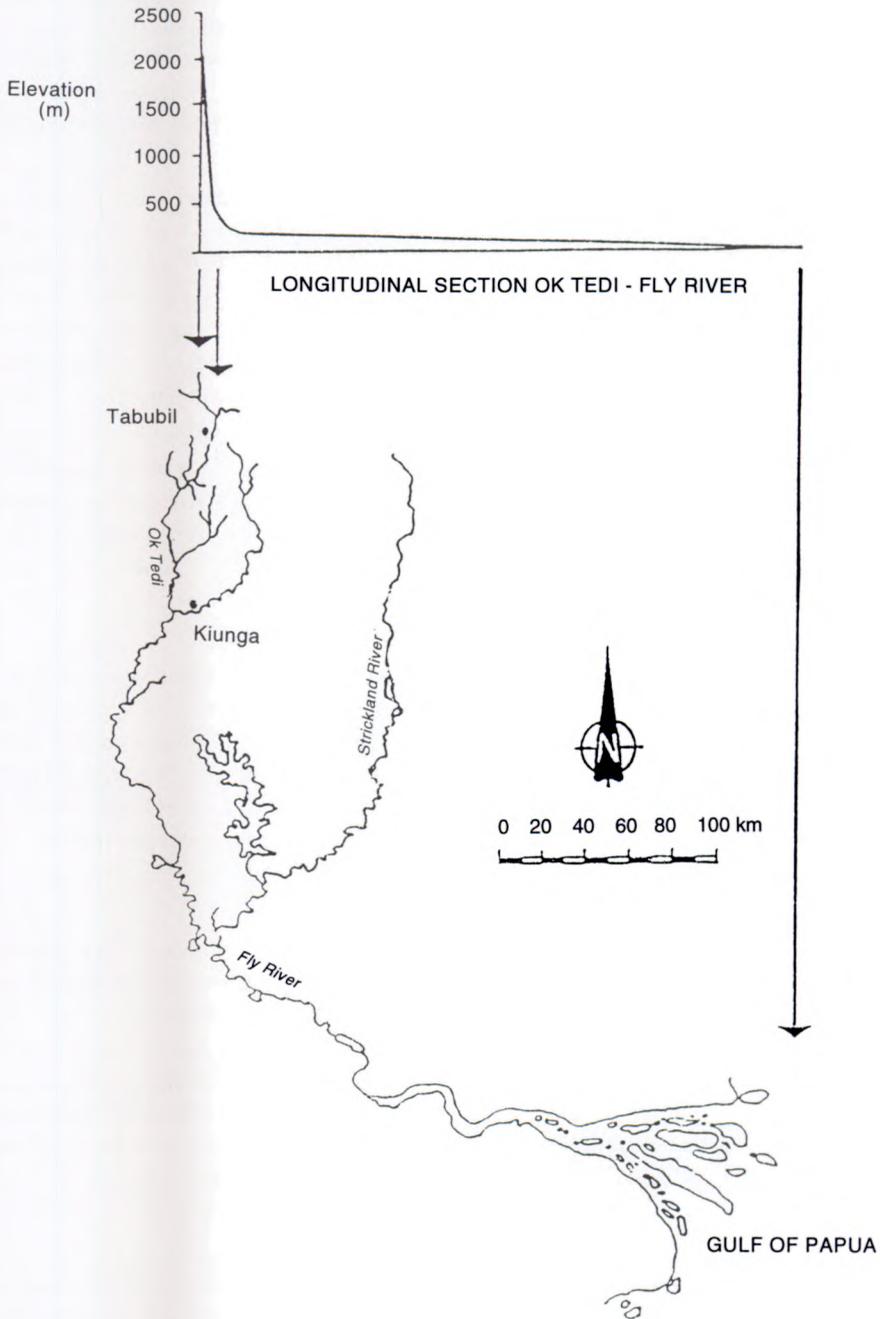
	Discharge cumecs	Drainage km <sup>2</sup>	Length km	Runoff mm	Natural sediment loading mt per annum
The entire Fly catchment	7,500	76,000	1,120	2,500	
Fly River at Obo	2,800				15
Strickland River	4,800				110
Fly River at Ogwa	7,400				115

mt millions of tonnes

# The Fly River catchment



**Figure 1** Location map



**Figure 2** Profile of the Ok Tedi and Fly Rivers  
Source: Pernetta & Osborne (1990)

## The Fly River catchment

---

**The Fly River** The Fly River rises in the karst ridge and ravine formations of an elevated limestone plateau comprising the Star Mountains and Hindenburg and Blucher Ranges. The river is approximately 1,120 km long, with the Ok Tedi mine at Mt Fubilan, approximately 1,000 km from the Fly delta. The river is navigable as far as Kiunga, which at an elevation of 40 m above sea level, is approximately 800 km from the delta.

The environs of Mt Fubilan in the Ok Tedi catchment are tropical and humid, with extremely high annual rainfall of over 8,000 mm. In this region, the river is fast flowing with a gravel bed and a high natural sediment load. The Ok Tedi River joins the Fly River at D'Albertis Junction. At this junction there is a transition from a fast flowing river in predominantly closed forest to a slow flowing river in open rainforest and swamp forest. This gradually merges with seasonally flooded savannah vegetation which characterises the middle Fly.

The middle and lower Fly is a meandering river with a relatively narrow active flood plain restricted to a range between 10-16 km wide. The off-river water bodies are numerous and important habitats. These include numerous oxbow lakes, back swamps, blocked valley lakes and extensive areas of alluvial forest and grassland.

**The Strickland River** The Strickland River rises as the Om and Lagaip Rivers which drain a large enclosed upland catchment in the Highlands of approximately 10,700 km<sup>2</sup>. Shortly below their confluence, the river enters a topographically confined section of river, termed the Strickland Gorge, before entering the extensive plains of the Fly-Digoel Shelf. An active floodplain on the Strickland develops further downstream than the Fly, long before Lake Murray is reached.

**Lake Murray** Lake Murray is the largest lake in Papua New Guinea, with a surface area of 647 km<sup>2</sup>. The lake lies in a shallow depression (maximum depth 7 m) north of the confluence of the Fly and Strickland Rivers. It is subject to marked seasonal fluctuations in water level. These result in major changes in habitat, vegetation, water chemistry and primary production. Lake Murray drains to the Strickland River by the Herbert River but, following the onset of the rainy season, periods of reverse flow occur from the Strickland into Lake Murray.

**The Fly River delta** The Fly River delta covers an area of approximately 7,100 km<sup>2</sup>, with an average water depth of less than 8 metres. Island formations and sediment distribution are symptomatic of a tidal current/river flow dominated system. The high discharge rate severely limits the degree of marine penetration and this results in the almost total absence of a true marine benthic community over much of the delta. The zone of

saline influence moves seasonally, and many of the pelagic animals move with it, depending on their salinity tolerance and habitat preferences. Mangrove vegetation is well developed and is dominant on most of the islands in the delta (Figure 3).

## Terrestrial habitats

Five different environmental zones can be distinguished in the upper Fly away from the wetlands and the immediate influence of the major rivers (Figure 4):

- up to 500 m: lowland forest
- 500-1,000 m: foothill rainforest
- 1,000-1,750 m: mid-mountain rainforest
- 1,750-2,200 m: moss forest
- 2,200-3,000 m: upper montane rainforest

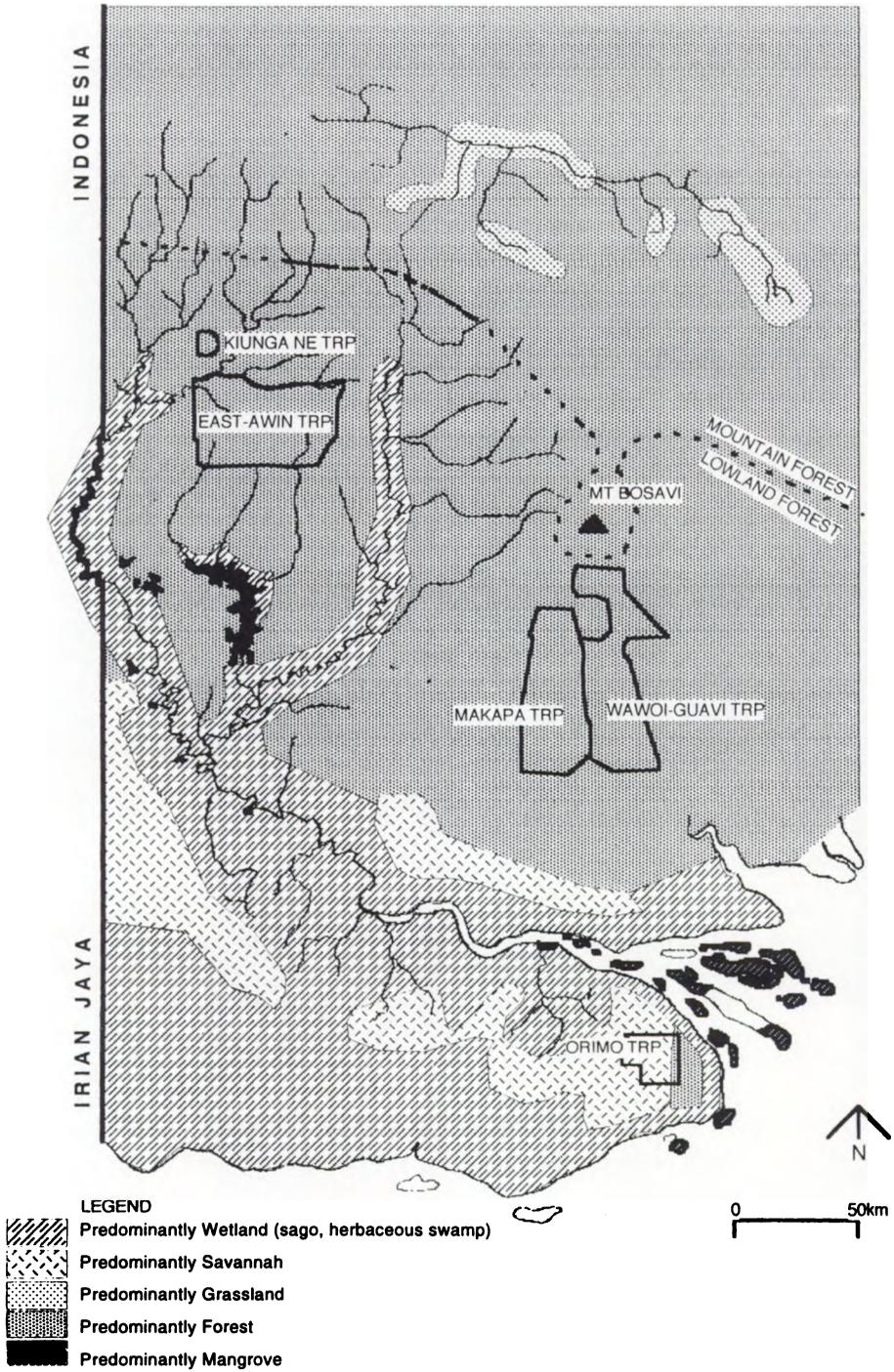
Each environmental zone is categorised by distinct biological communities and social groups with distinct socio-economic activities (Hyndman, 1976).

In the lowlands of the middle Fly, the very flat topography combined with a high level of rainfall has resulted in a predominantly swampy environment with a mosaic of lakes, alluvial forest, swamp grassland and swamp savannah (Figure 3). In the lower Fly region, mangroves and sago swamps are the dominant vegetation zones adjoining the Fly River and delta.

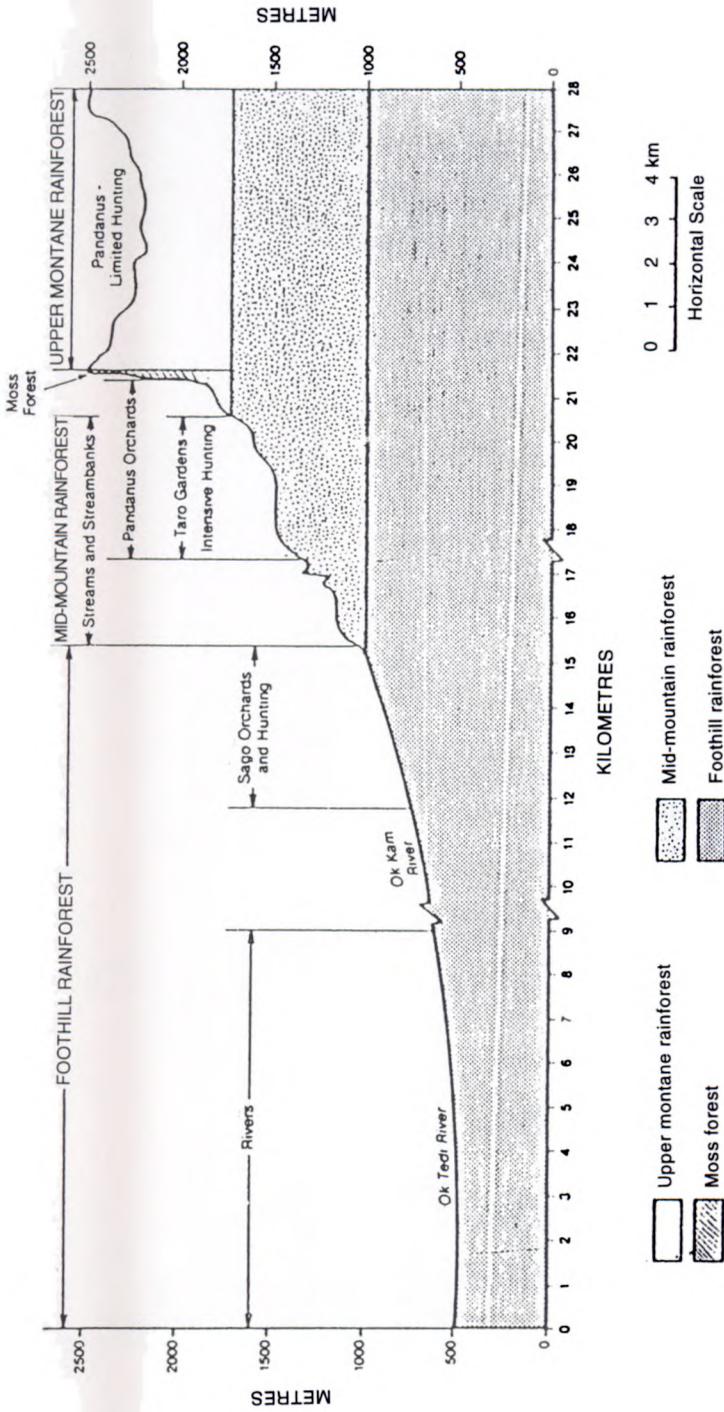
## Human population

**Distribution** The Western Province has a population of approximately 110,000. The overall population density is low ( $1.14/\text{km}^2$ ). Nearly 25% of the total population are urban dwellers. The main urban centres are Tabubil (12,000) and Kiunga (4,000) within the Fly catchment, and Daru (8,490) and Balimo (2,264) which lie outside the Fly catchment (Figure 5). The urban population grew at a rate of over 13% per annum during the 1980s. This was caused primarily but not exclusively by the establishment and expansion of Tabubil, the town servicing the Ok Tedi mine.

The 1990 census indicated that the population of the Fly catchment is approximately 151,500. More than half of the total population (88,000) lives in the upper Strickland catchment (Table 3). The population density in the catchment as a whole ( $1.99/\text{km}^2$ ) is low by comparison with the national average ( $8.6/\text{km}^2$ ). However, the density of the upper Strickland catchment ( $8.23/\text{km}^2$ ) is close to the national average.

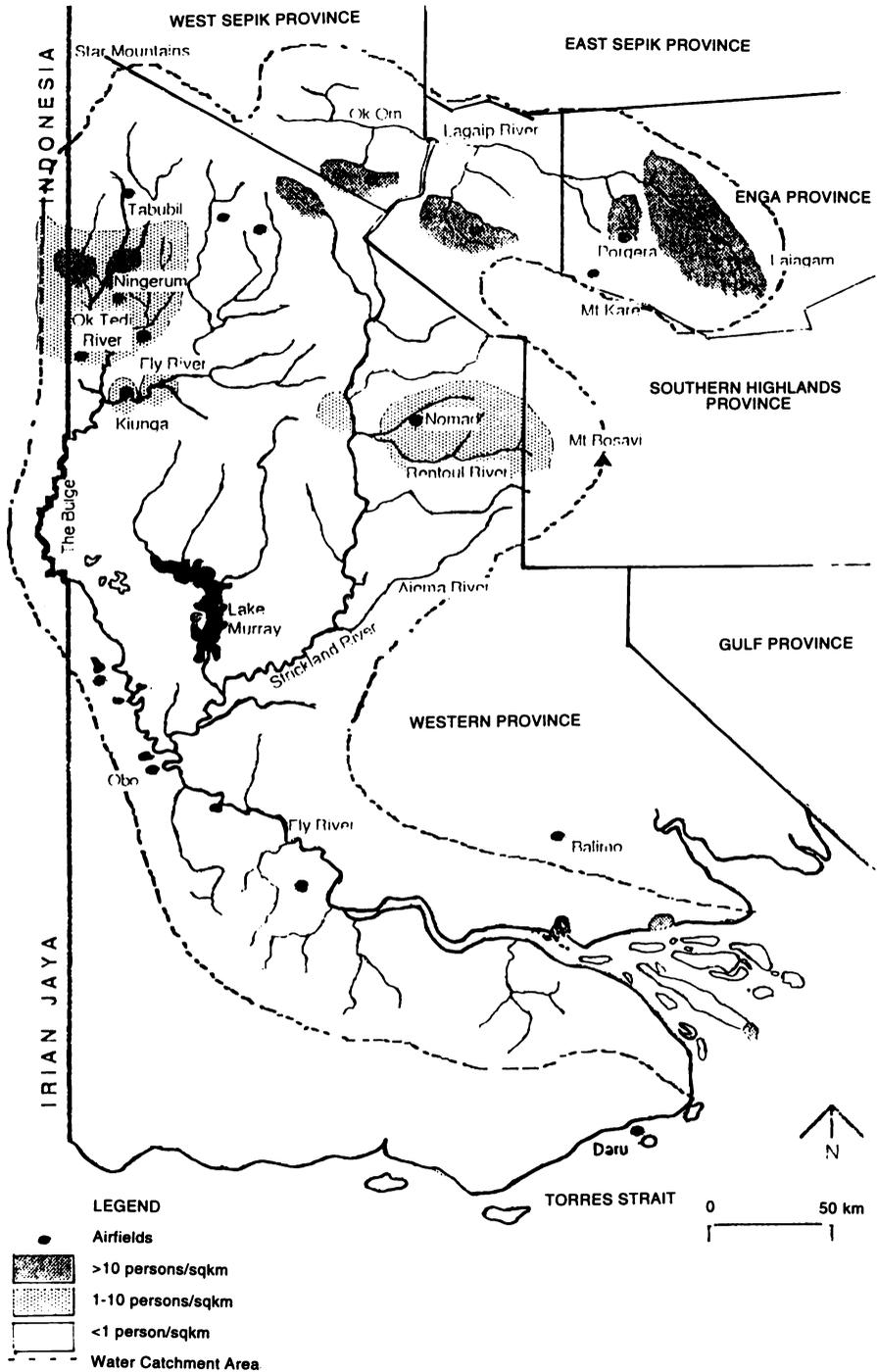


**Figure 3** Major vegetation zones and timber rights purchase areas



**Figure 4** Star Mountains ecological zones  
Source: Hyndman (1976)

# The Fly River catchment



**Figure 5** Population distribution (approximate only - 1971 census)

Approximately 30,000 people live in the Fly River corridor between the Ok Tedi mine site down to and including the delta. A further 12,000 people live in the Tabubil township.

Population growth in the Fly catchment as a whole is currently very high at 3.66% per annum. This is considerably higher than the national average of 2.03% and can be attributed to a combination of several factors including immigration, a high fertility rate and a large reduction in infant mortality; the latter factor being influenced by medical services provided by the mining company (Tables 2 and 3).

**Table 2 Selected population statistics for the Western Province**  
Source: NSO Port Moresby

	Census		Increase over 10 years %	Annual growth rate %
	1990	1980		
Total population	108,705		38.3	3.30
Density (/km <sup>2</sup> )	1.14	0.81		
Urban population	26,754	7,763	244.6	13.17

**Table 3 Selected population statistics for the Fly-Strickland catchment**  
Source: NSO Port Moresby

	Census		Increase over 10 years %	Annual growth rate %
	1990	1980		
Western Province	63,383	44,900	41.2	3.51
Enga Province	67,215	43,636	54.0	4.41
Southern Highlands Province	11,732	9,768	20.1	1.85
West Sepik Province	9,086	7,370	23.3	2.12
Total population	151,416	105,674	43.3	3.66
Density (/km <sup>2</sup> )	1.99	1.39		

Note: Due to enumeration area boundary configurations, these figures include some small areas outside the Fly catchment

**Cultural setting** The geographical distribution of the ten distinct cultural groups which inhabit the Fly catchment is illustrated in Figure 6.

The Mountain Ok or Min people live on the Southern Highland Fringe. This is a distinctive mountainous terrain with high rainfall, infertile soils, high faunal diversity and endemic malaria. Traditional human existence is difficult in this zone and is considered possible only through a diversified hunter-horticultural subsistence (Hyndman, 1979). In the upper Ok Tedi region, fish diversity is low with most fish confined to tributaries and branches of the main river (Gwyther, 1980). This provides a small but significant protein resource for the inhabitants of the area (Hyndman, 1979). Among the Min people, the consumption of fish, frogs and reptiles is culturally restricted to the women and children. These foods are an important protein component in the diet of this section of the community who are culturally excluded from eating marsupials (Hyndman, 1979; Hyndman & Pernetta, 1982). Following the commencement of mining at Ok Tedi, virtually the entire Min peoples of the Star Mountains have relocated to the vicinity of the mine, placing considerable strain on traditional tenural and cultural relationships.

The Lowland Ok and the Awin-Pa occupy a far less harsh and less varied environment than their mountain counterparts. They are primarily sago processors in the mountain foothills. This diet is supplemented by settled gardening, fishing and hunting.

The Boazi-Zimakani and Suki peoples are hunter-gatherers. They rely to a large extent on processing sago, and on natural resources of the wetlands and savannah of the middle Fly. Habitable land is scarce in this region, with flooding a perennial problem. Cultivation is difficult and limited by acid and infertile soils, poor drainage and flooding.

At the mouth of the Fly River, the Kiwai people are also primarily hunter-gatherers, living on fish, crocodiles and dugongs, with the occasional cultivation of banana, coconuts and taro.

Traditionally, these peoples have suffered severe health problems caused by malnutrition and mosquito-borne, transmittable diseases, including malaria and filariasis.

## Administration and infrastructure

**Provincial administration** The Fly catchment is predominantly within the Western Province. However, the Lagaip-Om River catchments and the upper Strickland gorge are divided between three other provinces - the West Sepik, Southern Highland and Enga Provinces. The capital of the Western Province is at Daru, which is located on a small island off the southern coast (Figure 1).

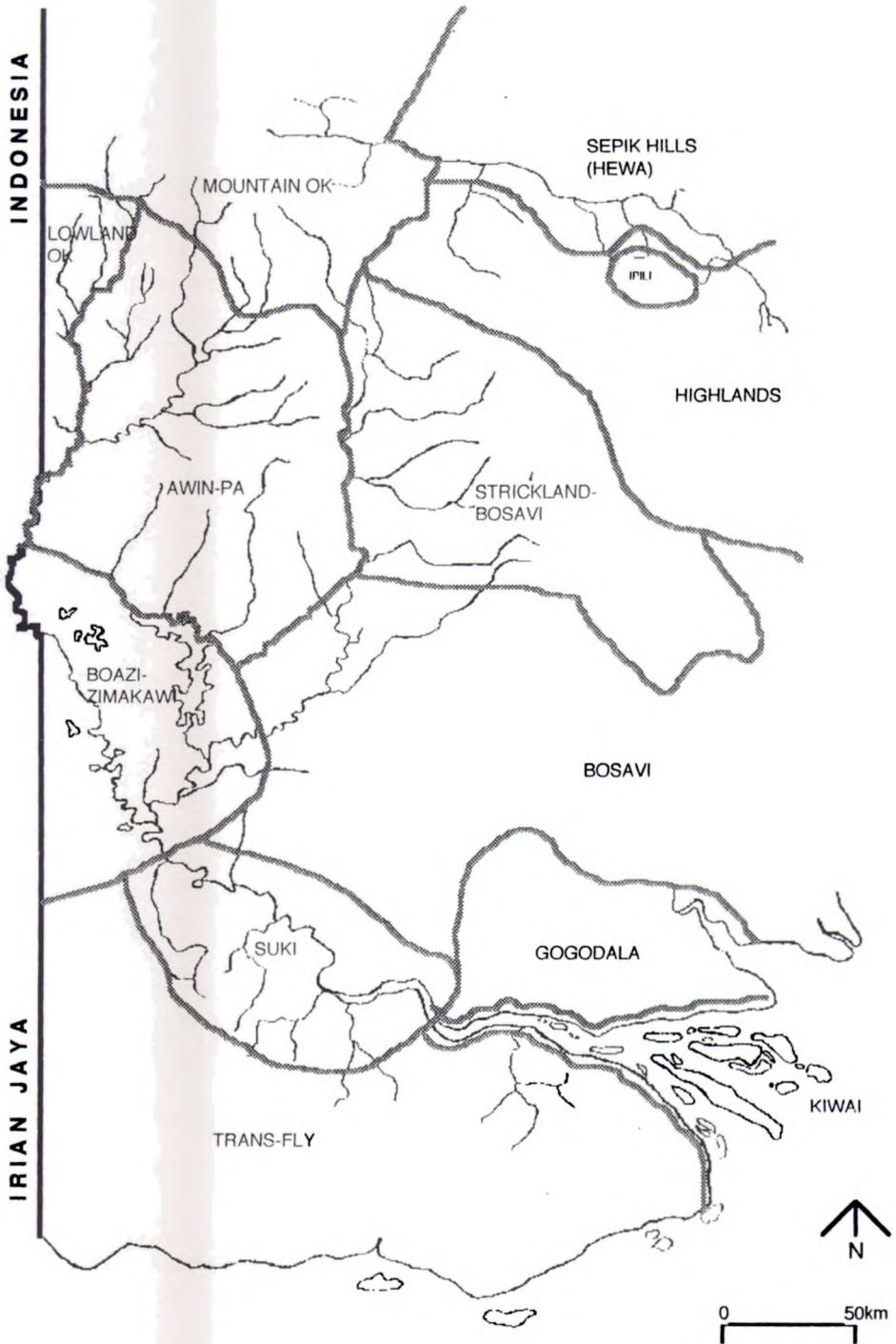


Figure 6 Principal linguistic groups of the Fly catchment

At the time the assessment was undertaken, the Provincial Government of Western Province was suspended as a result of administrative and financial mismanagement. An administrator was appointed by the National Government to undertake responsibility for administration of the province and prepare for the return of a Provincial Government. The Provincial Government of Western Province was subsequently reinstated although the general future of Provincial Government is a matter of political debate and remains uncertain.

The Department of Western Province is not well resourced and staff skills and experience, while substantial, are not adequate for the demands of resource use planning and management that have been placed upon them.

**Infrastructure and services** The enormous distances, low population density and difficult terrain makes the provision of an adequate road network inappropriate throughout much of the catchment. Long distance movement will continue to be either by air or boat and hence relatively expensive and limited. These factors make the provision of services, such as health, education, power, as well as the delivery of goods, generally inefficient and expensive.

The Fly River is navigable for the 800 km distance to Kiunga for specially designed tankers. Traditionally, this method has been used for all transport and access needs in the Western Province. The development of the OK Tedi mine has made a major contribution to infrastructure in the north Fly region of Western Province. To the end of 1993 over 300 million Kina had been spent on town development in Tabubil and Kiunga and on power, education, health, water systems and communications. Many of the basic services now established are available to local villagers in this area. With the advent of the mine, an all weather road was constructed from Tabubil to Kiunga and a network of tracks is being extended from this road. Other road networks are very limited except in the portion of the catchment in Enga Province. Long-distance travel is now mostly by air and the network of airfields is quite extensive (Figure 5).

## Development of renewable resources

**Fisheries** The Fly River system is believed to support Papua New Guinea's largest population of barramundi. Historically, catches of barramundi have reached nearly 400 tonnes per annum with a present value of K2.5 million. Present catches are lower as a result of overfishing of the young fish and less fishing of adults. The potential to expand the fishery is considered to be significant (OTML, 1993).

A new barramundi fishery has recently started to operate at Obo in the middle Fly. In 1993, this fishery shipped a tonne of fillets per month to Tabubil, where it was sold to the OTML catering facility, and to Daru the provincial capital. Another barramundi fishery operates on Lake Murray and supplies the Porgera Joint Venture catering facility. The Gulf of Papua prawn and Torres Strait lobster fisheries lie south of the Fly River. These are respectively the largest and second largest domestic fisheries in PNG with a total value in excess of K10 million per annum (OTML, 1993).

A fish and crustacean processing facility servicing the estuary and coastal region is operating in Daru.

*Potential fisheries development*

The potential to expand the capture fisheries in the Fly estuary and coastal waters is difficult to evaluate clearly as there are insufficient resource data presently available. It is widely believed that there is considerable potential. There is also believed to be potential for small scale fisheries elsewhere in the lower and middle Fly, similar to the one currently operating at Obo. However, in developing these, precedence needs to be given to the subsistence and artisanal needs of the river bank communities, the majority of whom substantially rely on the river's fisheries. Research is essential to determine the resource potential in order to ensure sustainable use through the introduction of sound management practices.

**Agriculture**

There is no significant commercial agricultural development in the Western Province. There are reported to be some 2,000 ha of rubber planted as smallholdings, principally in the Kiunga region. A small rubber-processing facility is operating at Kiunga. Smallholder production of coffee is being developed in areas of the upper Strickland which have road transport.

*Potential for agricultural expansion*

In the Western Province, the potential for commercial agricultural and livestock development is severely constrained by the lack of infrastructure, processing and market facilities. Infertile soils, poor drainage and widespread flooding are additional significant constraints. The production of rubber has potential because it can be readily stored and transported. Many of the current trees are becoming over mature and production is likely to fall unless further plantings are made in the near future.

**Forestry**

Major logging activities are currently operating in the east of the Western Province based on the Guavi and Wawoi River systems. These are planned to move to the Aramia catchment in the near future (Provincial Administration, Daru). At present, there are no major

## The Fly River catchment

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forestry initiatives in the Fly catchment itself. Timber Rights Purchase (TRP) agreements are being processed for at least two locations (Figure 3) but neither of these is operating. A small timber mill is reported to be operating from Stuart Island in the lower Fly. This services local needs.

### *Potential forestry development*

With the Fly River navigable to over 800 km up stream, there seems to be major potential for logging operations in the near future. The Department of Forest Timber Resources have mapped the Possible Forestry Potential of the Western Province at 1:500,000. This is summarised in Table 4.

### **Conservation**

The Department of Environment and Conservation (DEC) has no institutional presence in the Western Province. There are no established protected areas which lie completely within the Fly catchment. Two Wildlife Management Areas occur adjacent to the catchment - the Tonda WMA and the Maza marine WMA. It is not certain whether the Tonda WMA extends into the Suki area of the Fly catchment, because the boundaries are poorly defined.

The Gulf of Papua is the most productive fishery area in Papua New Guinea. This fishery is ultimately sustained by the major rivers which drain to the Gulf, of which the Fly is the largest. The maintenance of the integrity of these rivers and their catchments is of major significance, not just in the catchments themselves but for preservation of the most important fisheries in Papua New Guinea.

### *Potential conservation development*

Papua New Guinea ratified the Ramsar Convention in July 1993 and one of the first wetlands nominated is the Tonda WMA.

Current knowledge of conservation requirements in the Fly catchment is limited to the summary provided by the Conservation Needs Assessment report (CNA, 1993). This summary offers a useful but preliminary perspective on areas of conservation significance in the Fly catchment (Figure 7). Nine sites are of specific importance:

**Table 4**

### **Forestry Resources in Western Province**

Source: DF - Western Province Timber Resources; Map - 9/03/93

<b>Forest type</b>	<b>km<sup>2</sup></b>
Timber Rights Purchase	170
Mountainous forest	3,940
Possible forestry potential	50,000
Other areas	39,000

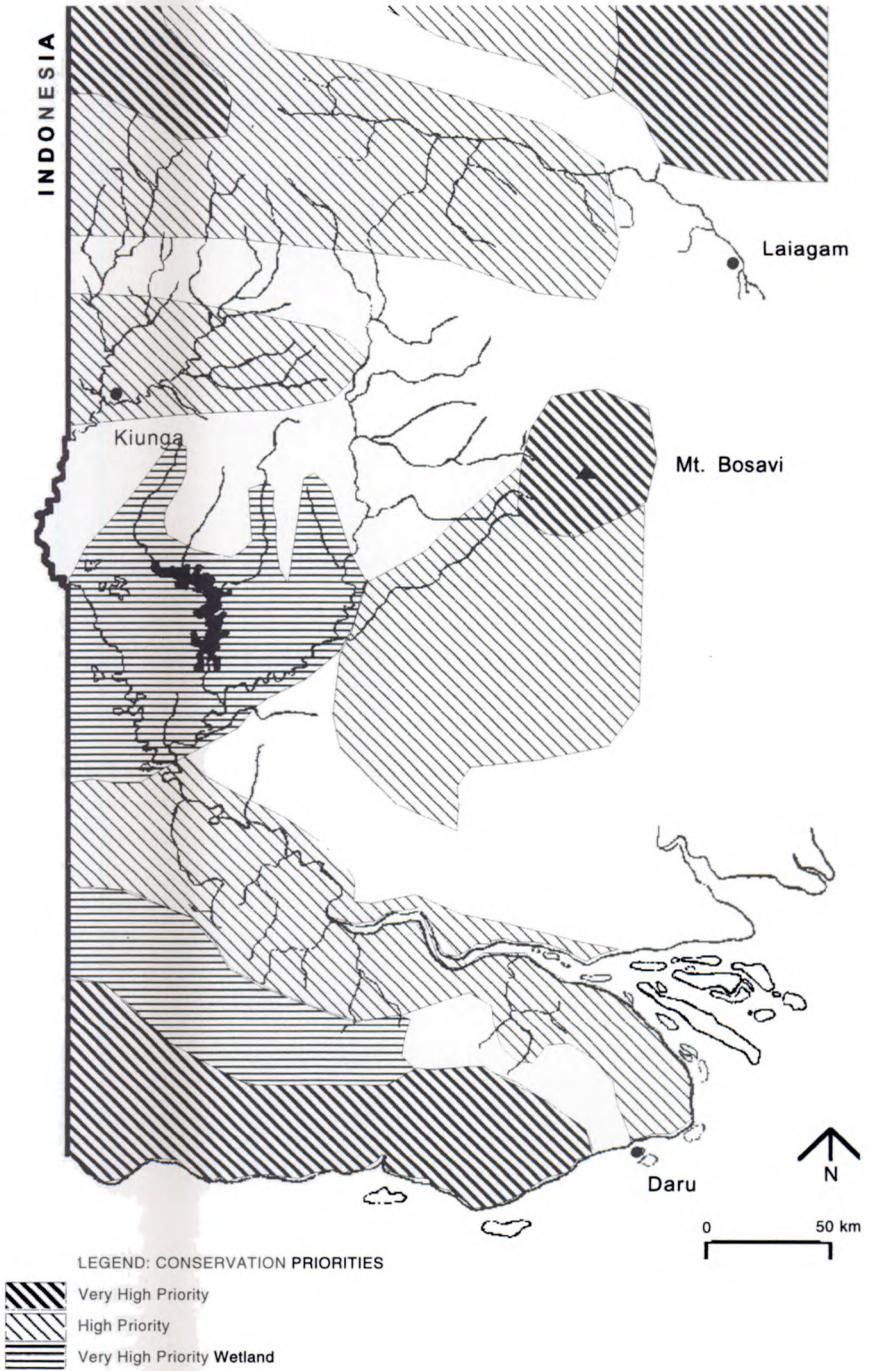


Figure 7

**Biodiversity priorities**

Source: Conservation Need Assessment (1993)

## The Fly River catchment

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### Very high priority

- Mount Bosavi/ Aramia watershed* An outlying Pleistocene volcano and vast alluvial plain. Virtually uninhabited. Proposed for National Park status more than a decade ago. The forests of the slopes to the west and southwest drain to the Strickland River and are faunistically rich and virtually undisturbed.
- Tonda/Bulla Plain* The Tonda/Bulla Plain is savannah and riverine gallery forest, unique in PNG. The large areas of savannah and seasonally flooded grasslands and marshes constitute a globally significant wintering ground for migratory waders and waterfowl from Australia and the Palearctic.

### High priority

- The Star Highlands* Includes pristine alpine and montane environments descending to mid montane valleys, foothills, and fringing lowlands. They support a diverse montane and high altitude vegetation including many plant species also found in the mountains of Irian Jaya. The subalpine forests are home to a significant population of MacGregor's Bird of Paradise. The environmental transect from the summit heights northward to the Ai River lowlands has been documented as having the richest known mammal fauna in New Guinea. While the forests of the upper Fly are amongst those which support the richest forest avifauna in PNG with 165-170 resident forest birds.
- Upper Fly lowlands* This area of lowland and hill forest is delimited by the Palmer River on the east and the Irian Jaya border on the west, and the southern scarp of the central cordillera on the north. There are extensive settlements related to the Ok Tedi mine in the west. Otherwise this area is a large expanse of old growth wet rainforest that supports a small human population and is characteristic of the extraordinary rich and highly endemic biota of the upper Fly platform (Hyndman & Menzies, 1990).
- Northern Trans Fly* The Northern Trans Fly is unsurveyed seasonal forest and woodland that is probably a habitat formation unique in PNG. An under collected flora closely related to that occur in the Cape York Peninsula.
- Middle Fly wetland* The middle Fly floodplain is 15-20 km wide. This area is a mosaic of lakes, alluvial forest, swamp grassland and swamp savannah. These include PNG's largest lake, Lake Murray. Roberts (1978) documents the extraordinary diversity of the freshwater fish species of the Fly wetlands, with at least 105 species from 33 families which make the fish fauna of the Fly River system the most diverse in the Australasian region.
- Lower Fly wetland* Swamps, open water, savannah and gallery forest. The area has abundant wildlife and is an important potential eco-tourist destination. It is a very important wetland both for migrating birds and resident waterfowl. In Australian drought years, it becomes an important refuge for Australian wetland birds.

- Maza-Fly delta marine area** Important mangrove and associated nursery habitats with seagrass beds, green sea turtle foraging habitats, and dugong habitat. Possibly threatened by overfishing and river borne pollutants.
- Doma Peaks/Leiwaro Highlands** The northern drainage of this highland area drains to the upper Strickland. The whole location contains rich highland environments with high scenic and biotic value. The Doma Peaks and Tari Gap have been considered for national park status. These comprise mid-montane and upper montane tracts of uninhabited forest exceedingly rich in birds of paradise.

### Non-renewable resource developments

Two of the most significant mines in the world occur within the catchment area. The OTML's mine at Mt Fubilan (20 km north-west of Tabubil) is one of the world's largest open cut copper mines, while the PJV mine at Porgera is mining one of the world's largest known gold deposits (Figure 1).

**The Ok Tedi copper mine** In 1993, equity in the Ok Tedi mine was held by a consortium of shareholders, namely:

Papua New Guinea Government	20.0%
Broken Hill Proprietary Co. Ltd, Australia	30.0%
Amoco Minerals Co., United States	30.0%
Deutsche Investitions- und Entwicklungsgesellschaft mbH, Germany	5.0%
Metallgesellschaft, Germany	7.5%
Degussa AG, Germany	7.5%

More recently, this shareholding has been restructured and as a result the current equity is:

Broken Hill Proprietary Co. Ltd, Australia	52.0%
Papua New Guinea Government	30.0%
Metall Mining Corporation, Canada	18.0%

The Ok Tedi mine commenced operations in 1984. For the first few years, the mine used a cyanide-based gold circuit which was designed to treat 22,000 tonnes per day of the gold-rich ore which capped the copper ore deposit. The gold circuit was closed in 1988 following depletion of the gold capping ore. Facilities to allow copper ore to be treated separately from the gold were commissioned in 1987.

The current Ok Tedi operation is a conventional, open-cut pit operation which uses heavy mobile equipment to mine the ore and overburden. OTML is currently mining 160,000 tonnes of material per day of which approximately 50% is waste rock. After crushing and milling, the

tailings are released into the river system. The waste rock is too weak to be stored in stable dumps and is stored so as to continuously erode into the river system. Overburden and tailings from the mining operation add some 58 million tonnes to the Ok Tedi River. This has increased the sediment load of the Ok Tedi about 6 times and adds about 50% more sediment to the already significant load of 100 million tonnes per annum in the Fly River below its junction with the Strickland.

The copper concentrate from the mill is piped for 150 km to Kiunga as a slurry. At Kiunga this slurry is de-watered and shipped via a fleet of purpose designed tankers to a bulk handling vessel which is permanently located in the Fly estuary. The residue is shipped from this vessel to customers.

The opening of the Ok Tedi mine has resulted in major social changes and changes in infrastructure. This locality was previously one of the least known and most inaccessible areas in Papua New Guinea. The mine directly or indirectly employs about 3,700 people. The resultant changes have been dramatic and include the establishment of a township of approximately 12,000 people, an airfield, an expanding road network, employment opportunities and greatly improved services.

Development of the Ok Tedi mine is determined by its own statutory Act - the Mining (Ok Tedi Agreement) Act 1976. The rights and obligations of OTML are, therefore, not determined by normal Papua New Guinea legal provisions.

Until recently, State responsibility for environmental monitoring and management at Ok Tedi was vested in the Department of Mining and Petroleum (DMP). This department was also responsible for the promotion of mining. This conflict of interest has drawn widespread criticism. In September 1993, the State responsibilities for environmental management at Ok Tedi were transferred to the Department of the Environment and Conservation (DEC).

Mining at Mt Fubilan is currently planned to cease in 2008.

### *Ok Tedi's mining activities and environmental obligations*

The environmental obligations of Ok Tedi are determined by the Sixth Supplemental Agreement between OTML and the State (Government of Papua New Guinea). This agreement instituted an Acceptable Particulate Level (APL) as a compliance point to be agreed upon between OTML and the State. This level, together with various associated environmental conditions form the 'Predictions' which were established in late 1989. This followed the completion of a series of environmental studies undertaken in the preceding three years. These studies covered six areas of investigation:

- sediment transport;
- geochemical investigations;
- biological monitoring and toxicity testing;
- socio-economic implications;
- impact prediction; and
- cost benefit analysis of waste disposal alternatives.

The Sixth Supplemental Agreement determines OTML's monitoring programme. The State can call for an immediate re-evaluation of the mine waste disposal system if any of the conditions and/or predictions attached to the APL agreement are exceeded.

The monitoring programme covers the following:

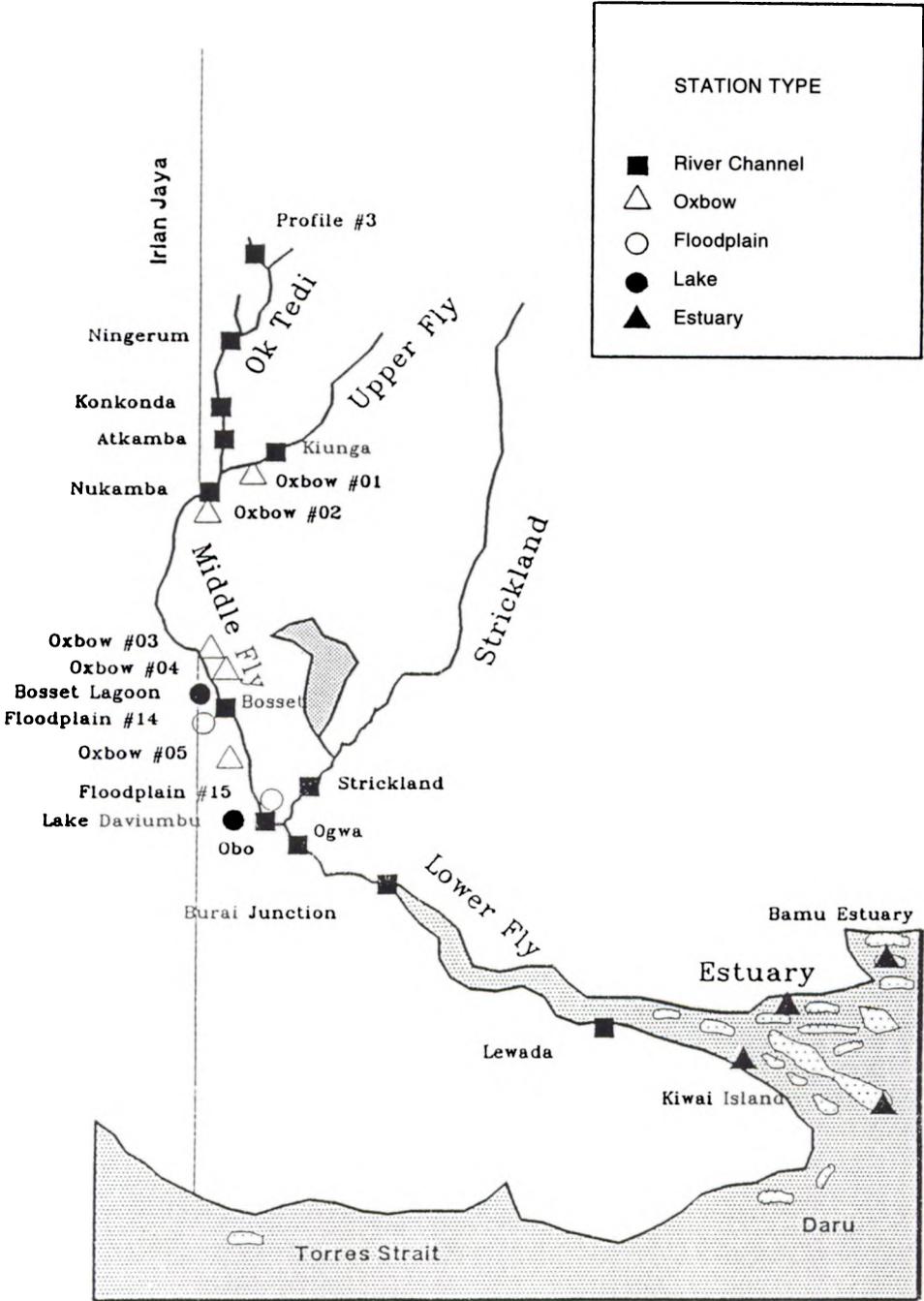
- monitoring of suspended sediment concentrations in the Fly River resulting from the Company's mining operations;
- the maintenance of a useful and viable fish resource in all parts of the Fly River channel by ensuring that:
  - actual fish catches at sites reasonably specified by the State do not decline below those predicted;
  - copper contamination of the Fly River channel does not exceed the predicted level;
- protection of the capacity of off-river water bodies to ensure the recovery of the Fly River fish resource;
- protection of the biological resources of the Fly River delta, the Gulf of Papua and the Torres Strait by ensuring that the concentration of copper entering the Fly River delta does not exceed that predicted;
- maintenance of the navigability of the Fly River by ensuring that the actual aggradation of the Fly River does not exceed that predicted.

The OTML Environmental Department has an annual budget of approximately US\$3.5 million and a full time staff of 35. The Department's staff are highly qualified and experienced with over 50% holding tertiary qualifications, including advanced degrees. The compliance monitoring programme is summarised in Table 5. The monitoring locations are shown on Figure 8. OTML is carrying out nine special projects designed to improve the monitoring programme in conjunction with its own consultants (Table 6).

### **The Porgera gold mine**

In June 1992 the Porgera mine had proven reserves in excess of 10.3 million ounces of contained gold. Gold production commenced in 1990. Current operations include both an open pit and an underground mine. Two waste dumps are in operation. Waste ore is stored in a permanent spoil dump which currently contains 11.33 million cubic metres of

# The Fly River catchment



**Figure 8** OTML monitoring locations  
 Source: OTML, Tabubil

**Table 5 APL and conditions monitoring programme of Ok Tedi Mining Ltd**  
Source: OTML (1990)

Sampling location	Site	Frequency	Purpose
Fly River	Kuambit/Nukumba	Weekly Monthly Quarterly	SS.pCu, dCu Fish Catch Bed Level
Fly River	Obo/Ogwa	Monthly Quarterly	SS.pCu, dCu Fish Catch
Off-river waters	Middle Fly	Annually	pCu (deposited sediments)
Estuary	3 sites Umada, Lewada	Quarterly	pCu (deposited sediments)

SS suspended sediment  
pCu particulate copper  
dCu dissolved copper

**Table 6 OTML special projects to improve monitoring capability**  
Source: OTML (1993 - unpublished mss.)

- **Hydroacoustic fish sampling**  
Use of hydroacoustic fish sampler (echo sounder and echo signal processor) for rapid, non-destructive replicate estimates of fish abundance and biomass
- **Macro-invertebrate monitoring**  
Development of an appropriate invertebrate sampling methodology for off-river water bodies of the Fly
- **Fish behaviour study**  
Using a laminar-flow fluvium to determine if fish exhibit a behavioural avoidance response to soluble or particulate copper
- **Freshwater mussels**  
Evaluation of freshwater mussels as archival monitors of copper by comparing copper concentrations in shell laminations of mussels from control and affected sites
- **Fish ageing study**  
Use of fish otoliths to age fish to determine if fish populations are undergoing reductions in recruitment strength
- **Freshwater prawns**  
Monitoring changes in abundance of *Macrobrachium* prawn species at riverine sites as it is an important food item for many fish and local people
- **Tissue metal analyses**  
Heavy metal levels in fish, mussels, mud clams, mud crabs and barnacles are being monitored
- **Fish dietary studies**  
Comparison of species from riverine and lacustrine sites and a proposed intensive study in conjunction with the macro-invertebrate project
- **Juvenile fish**  
Investigation of techniques to monitor larval/juvenile fish as part of fish recruitment studies

spoil. Colluvium and black sediment is stored in an eroding dump which progressively enters the river system. The tailings are first treated in a neutralisation circuit and then disposed of in the river system.

Gold production in 1991, the first full year of operation, was 1.2 million ounces with 1.4 million estimated for 1992. Production is expected to decrease with a falling grade of ore over the 20 year planned life of the mine. 1,600 people are employed by the project.

The opening of the mine at Porgera has not resulted in social and infrastructure changes in the region of the magnitude of those at Ok Tedi. This is because more than 17,000 people lived in the region prior to the opening of the mine and because the current policy of PJV is to fly employees in and out.

In contrast to Ok Tedi, operation of the Porgera mine is within the normal Papua New Guinea legal framework. This means that the DEC is responsible for monitoring and other environmental matters.

*Porgera Joint  
Venture's  
(PJV) mining  
activities and  
environmental  
obligations*

The developers at Porgera undertook a major environmental study over a number of years to provide baseline data and information for the design of the extraction process. This culminated in an Environmental Plan (NSR, 1988) and thereafter an Environmental Management and Monitoring Program (NSR, 1990). These documents outline the environmental management intentions and obligations of PJV.

The EP documents the baseline conditions and proposed mine operation together with predictions of the effect of the project on a variety of environmental parameters. The EMMP ensures that the mine operates in the described manner and assesses whether the effects are as predicted. As with Ok Tedi, the mine tailings are discharged to the river. The rugged topography and unstable terrain in the mine locality make the construction of a tailings dam uneconomic.

The Porgera ore contains relatively high concentrations of base metals. Cyanide is used in the hydrometallurgical process. To ensure that potentially toxic cyanides and concentrations of dissolved metals are not introduced to the river system a tailings neutralisation circuit has been designed and commissioned.

The important components of the PJV's Environment Management and Monitoring Programme in the river system and Lake Murray are:

- river hydrology;
- meteorology;
- water quality;
- suspended sediments;
- bed sediments;
- fish population survey;

- subsistence fisheries survey;
- fish consumption survey;
- fish tissue metal concentration;
- aquatic macrophyte - Lake Murray only;
- human scalp hair metal concentrations - Lake Murray only; and
- social, demographic and economic survey.

**Mt Kare gold mine**

Mt Kare is located in Enga Province, 18 km southwest of Porgera (Figure 1). Mining operations are currently suspended as a result of violent disagreements between the mining company, landowners and claimants. It is expected that mining will resume under a new arrangement under which the landowner company will own 100% of the mine. They will give a management contract to a joint venture of West Australian mining companies, Ramsgate Resources and Menzies Gold. The reserves are extremely uncertain. A recent study indicated a recoverable reserve of less than 100,000 oz. The gold is contained in colluvial material which is the result of a landslide or mudflow. The hard rock source of the colluvium has not been found.

During its brief period of operation, gold extraction was carried out with methods using gravity. Cyanide or other hazardous chemicals were not used and the colluvial material itself is not toxic. The waste products were coarse reject (pebbles and rocks) and a tailing slurry which was discharged to the river system. The only significant effect was the physical impact of tailing sediment on the downstream river system. Villagers who had previously relied on this source were supplied with an alternative water source.

The Mt Kare mining project is very small by comparison with either Porgera or Ok Tedi. It is of minor overall significance to the Fly water catchment. However, considerable damage to Mt Kare's fragile, high altitude, environment has been caused by the effects of an uncontrolled 'gold rush', with up to 5,000 miners at certain times.



# 3

## Environmental and social impacts in the Fly catchment

### Impacts of renewable resource development activities

Economic development in the agricultural, forestry and fisheries sectors in the Fly catchment is not substantial. With a few exceptions, these resources are essentially being used for subsistence, traditional lifestyle requirements and minor cash income needs. Overall, this level of activity is causing minimal adverse impact.

One exception may be significant. This involves the shift from traditional low intensity fishing methods to more intensive methods using gill nets and outboard motor boats. The recent significant increase in the availability of outboard motor boats combined with unrestricted gill net use may well be responsible for changing composition in fish species and in size distributions reported in the delta and lower Fly regions.

The loss of forest cover in the upper Strickland catchment through traditional agricultural and burning practices may also be regarded as an issue of concern.

### Impacts of the Ok Tedi mine

There are only three sources of information available for a general appraisal of the impacts of the Ok Tedi mine:

- The OTML interpretation of the results of its own sophisticated monitoring programme. These are distributed to interested parties and available to the public as annual reports;
- Discussions with interested third parties who provide generally unsubstantiated but compelling accounts. Some of these accounts differ markedly from OTML's data and interpretation;
- Reports and publications. There is now a considerable volume and a wide variety of literature stemming from mining activity at Ok Tedi (see 'Alternative views on the impact of mining activities', in this chapter).

In the absence of an audit of OTML's environmental management and a field survey of affected areas and people, an assessment of the situation would have to be based on information from the more accessible third parties. As a result any attempt at an objective assessment is likely to be misleading and controversial. This report does not

attempt to make a comprehensive and objective assessment of the impacts of the mining activities. An attempt is made to summarise the perceived or known impacts and to identify the general issues relevant to the formulation of the Sustainable Livelihoods Strategy.

### **Economic and social changes**

The establishment of the Ok Tedi mine has transformed a remote wilderness area with a sparse population of traditional subsistence dwellers which was previously almost completely isolated from services and development. A classical enclave development has resulted. This includes a technologically advanced urban centre with good services and a wide range of opportunities available to all. It is clear that the government would not have been able to provide these opportunities and services in such a remote location in the absence of the mine. The rapid transformation has not been without its casualties and some do not regard the changes as improvements. However, the project has brought a positive change to many communities, in one of the country's least developed areas, including improvements in life expectancy, educational opportunities and regional infrastructure.

OTML contributes directly to the government through four main channels:

- taxes paid on purchased inputs;
- royalties paid to the government;
- dividends paid to the government through part ownership of the mines; and
- income tax paid on profits and on wages earned.

The OK Tedi mine provides over 45% of PNG's export earnings (CIE, 1991). Mining operations, such as the Ok Tedi, Misima and Porgera mines, together with oil and gas extraction projects are likely to be the mainstay of the Papua New Guinea economy throughout the 1990s (CIE, 1991).

The national and regional benefits flowing from the project are shown in Table 1. Although these benefits appear substantial, many of the local communities down river from the mine consider they have to bear a high cost from the project in terms of such matters as the inundation of garden areas, loss in water quality and reduction in fish. Claims have been made that there has not been adequate compensation for these costs.

OTML established a development trust in 1990 to bring long term benefits to communities living alongside the Ok Tedi and Fly River system. These villages are outside the mine lease area and do not receive royalty or land lease payments. The trust operates in 102 villages over 800 river kilometres along the Ok Tedi/Fly River system. OTML has contributed K10.8 million to the Trust between 1990 and 1993. Over the life of the mine, funding is expected to total more than

**Table 1**                    **Some financial indicators of the Ok Tedi mine**  
Sources: OTML (1994); CIE (1991)

<p><b>National benefits</b></p> <ul style="list-style-type: none"> <li>• export earnings of K381.1 million; 15.6% of PNG's total export earnings in 1993</li> <li>• payments to the National Government of K20.7 million through income tax on wages, taxes on imported goods, withholding tax and dividends in 1993</li> <li>• purchases of goods and services in PNG of K76.2 million in 1993</li> <li>• an investment of K11.8 million (excluding salaries and direct fees) in a wide range of education and training programmes which are ensuring the localisation of skilled and professional positions, from 1981-1993</li> </ul> <p><b>Regional benefits</b></p> <ul style="list-style-type: none"> <li>• payments to the Western Province Government through a share of royalties of K3.2 million in 1993</li> <li>• payments to landowners through land lease payments and a share of royalties of K2.5 million in 1993</li> <li>• direct and indirect employment of about 3,700 mine workers, local contractors; of 1,800 directly employed in December 1993, 88% were from PNG and out of these 36% from the Western Province</li> <li>• establishment of regional infrastructure, including town development, airstrip, roads, power, water systems and communications amounting to K 301 million to 1993</li> <li>• assistance in the development of over 50 landowner businesses providing over 1,080 local jobs in 1993</li> <li>• improved health and education with reduction in incidence of malaria and infant mortality rates</li> <li>• establishment of a development trust which has invested K10.9 million in community infrastructure and business development projects</li> </ul>
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80 million. The trust originally focused on community infrastructure but has recently directed funding towards sustainable rural development projects including fishing at Obo and the development of a rubber industry in Western Province. It is this form of sustainable development that will be needed to sustain the livelihood of communities beyond the life of the mine.

**Environmental impacts of the Ok Tedi mine** OTML's analysis of environmental impacts from the Ok Tedi mining operation reveal increased sediment loads and elevated copper levels in the river. In respect of other metals and processing reagents, OTML regards the effluent as clean and not representing an environmental

issue. OTML believe that the high carbonate content of the ore and limestone dominated catchment maintain potentially toxic contaminants in an insoluble form which is not biologically available. It has been suggested by some researchers that the lower pH of the soils of the Fly wetlands and off-river water bodies may mean that these contaminants could be markedly increased in these critical habitats (see 'Off-river water bodies', in this chapter). However, the findings of OTML's routine monitoring programmes, undertaken in association with the Australian Commonwealth Scientific and Industrial Research Organisation does not support this hypothesis. The available data indicate that dissolved copper levels in the off-river water bodies are substantially lower than in the adjacent river channel and release of dissolved copper does not seem to be significant.

It should be noted that the natural condition of the Fly River is turbid. At Tabubil, the Ok Tedi carries approximately 4 million tonnes of material annually under normal conditions, although this volume may be much larger depending on climatic conditions and the presence of major landslips in the catchment.

### *Elevation of riverbed levels*

There is major elevation of the Ok Tedi River between the mine and its confluence with the Fly River. This is highly visible and reaches over five metres in some locations. The river and its immediate riparian habitats are experiencing a new regime which is affecting normal and flood flows and levels. This has resulted in significant erosion of channel banks with overtopping in other areas. Both of these factors have resulted in the loss of traditional gardens. Some areas of bank forest which are now subject to flooding are affected by die back probably because of water logging or sediment inundation. OTML attribute some of these affects to a major natural landslide in the upper Ok Tedi catchment in 1989 which caused 166 million tonnes of material to be washed into the river. The company, however, acknowledges that mine derived sediments have resulted in aggradation and the overbank deposition of sediments in localised areas adjacent to the Ok Tedi.

Aggradation in the Fly River itself is restricted to areas immediately downstream of its confluence with the Ok Tedi. There is no evidence of significant bed aggradation. This is not predicted to occur in the middle, lower or Fly estuary.

### *Sediment levels*

As a consequence of the mine, total and suspended sediment loads have increased about 6 times in the Ok Tedi, doubled in the Fly River and increased about 50% in the Fly below the Strickland River confluence. These levels comply with the APL level, in spite of the additional contribution of the 1989 landslip.

*Copper levels* The dissolved copper levels in the upper and middle Fly and particulate copper levels in the upper Fly currently exceed the APL levels. The Department of Mines and Petroleum is aware of this failure to comply with the APL levels and is currently studying the biological significance before taking further action. Total dissolved copper concentrations average 12 parts per billion in the middle Fly. This level is considerably lower than international drinking water standards which are in excess of 1,000 parts per billion (Eagle, 1993). However, the issue is not specifically related to potable water supplies. The Ok Tedi and Fly Rivers were never traditionally used to draw water because of their high natural turbidity. The important concerns are:

- The impact on fish and other aquatic fauna which may be affected by much lower levels than humans;
- Elevated copper levels have been detected in the livers and kidneys of a number of edible fish in both Ok Tedi and the Fly River, while flesh concentrations have remained at background levels indicating that active regulation is occurring. Based on dietary studies of Fly River villagers, it has been calculated by OTML that consumption of whole fish, including liver and kidney, would contribute no more than 10% of the Australian National Health and Medical Research Council's maximum tolerable weekly intake.

Detailed investigations of the mine derived sediments in the delta and off-shore have been conducted by the Australian Institute of Marine Science, and the Institute for Soil Fertility Research (The Netherlands) together with OTML. This study is reported (Eagle, 1993) to have found no evidence of elevated mine-derived metal levels in delta sediments. Dissolved and particulate copper in the estuary and near off-shore can be expected to become elevated during the life of the mine. However, these increases are likely to be ecologically insignificant.

An independent study has found that most heavy metal concentrations in the tissues of edible organisms in the Torres Strait are not elevated above the background concentrations of the Great Barrier Reef. The only exception is the level of Cadmium (Dight & Gladstone, 1993). In addition, copper levels appear to be elevated during the post-monsoon season at the most northerly sampling location, but only to a level slightly above that found at coastal locations in the Great Barrier Reef. The study found that the concentrations of arsenic, cadmium and selenium in the edible portion of foods consumed by Torres Strait Islanders repeatedly appear at levels close to or above the maximum concentrations permitted for seafood by the NH & MRC. However, none of these trace metals is believed to be associated with Fly River discharge to any appreciable extent (Dight & Gladstone, 1993).

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*Fish catches* Monitoring undertaken by OTML in the Ok Tedi within 20 km of the mine has confirmed that fish continue to be present, although numbers and species richness are significantly lower than under premining conditions. All species which are now absent in the Ok Tedi still occur in the Fly River and/or tributaries of the Ok Tedi. Fish catch numbers show a reduction in all three monitoring stations in the middle Fly (see Figure 8) but they are above the APL predicted levels. OTML claim that there is no quantifiable change in species composition. They conclude it would not be difficult to return the composition of the fish assemblages to their former state on the cessation of mining.

*Off-river water bodies* The off-river wetlands and water bodies act as refuges. OTML considers these refuges to be crucial to the recovery of fish stocks and the ecological health of the Fly and Ok Tedi Rivers on the cessation of mining. However, copper concentrations in sediment samples from such locations currently exceed the Acceptable Particulate Levels (APL) by a substantial margin (Eagle, 1993; OTML, 1992). The significance of this is uncertain as the target is an arbitrary value (no more than 20% of samples to exceed 200 µg/g of pCu) without, in the view of OTML, any ecotoxicological basis (OTML, 1994).

### **Alternative views on the impact of mining activities**

Alternate views on the impacts of OTML mining were strongly expressed by provincial authorities and community members at Daru. These can be summarised as:

- poor mine and mine related accident record;
- periodic fish kills along the length of the Fly and views that fish are poisoned;
- absence of fish resources in areas where they were formerly plentiful;
- polluted water extending to wells near the near river banks;
- flooding of bank side gardens;
- contaminated sago palms and bank gardens;
- changes to the river course and navigation problems; and
- accelerated erosion of banks.

In combination, these factors, whether perceptions or observable facts, are reported to have resulted in:

- uncertainty and fear in many bank dwellers causing them to leave their former homes;
- migration of some communities to urban centres such as Daru and Tabubil;
- the impoverishment of some lifestyles; and
- absence of, or inadequate, compensation.

OTML's environmental management has drawn national and international criticism from community and environmental organisations, academic institutions and an official international authority. This is demonstrated by:

- An independent evaluation of the Ok Tedi Sixth Supplemental Agreement Environmental Study by the University of Papua New Guinea (UPNG, 1989).
- A petition submitted to Prime Minister Namaliu in 1990, on behalf of communities living along the Fly River (Bosset Village Development Committee, 1990).
- A publication from the Papua New Guinea Wau Ecology Institute (WEI, 1991).
- A well publicised attempt to collate an 'alternate' view on environmental impact of Ok Tedi mine is contained in the 'Starnberg Report' (Starnberg Institute, 1991). The study disputes the overall financial and economic benefits of the development and reports elevated metal levels in the Fly and Ok Tedi Rivers, far higher than those reported by the OTML monitoring programme.
- Strong criticism by the International Water Tribunal in 1992 of OTML's waste ore and tailings management (in ACF, 1993).
- A report by the Australian Conservation Foundation (ACF, 1993).

OTML has questioned some of the conclusions in these reports and IUCN itself has criticised some of the findings of the Starnberg Report which it said could not be supported by the data collected by the authors.

It is clear that the Ok Tedi mine has had a substantial impact on the physical environment but the environmental monitoring programme suggests some of the claims made about the harm done are exaggerated. In the absence of a sufficient level of independent monitoring by the Department of Environment and Conservation, which now has the regulatory responsibility, public doubt will remain about the significance of the environmental impacts.

### **Impacts of the PJV mining development at Porgera**

PJV's EP (NSR, 1988) predicted the following effects on the river system:

- depressed fish and invertebrate populations in the Lagaip River upstream of the Ok Om confluence (approximately 100 km), caused by the physical effects of mine-derived sediment;
- no overriding or separate effects from toxicants, such as residual process reagents or heavy metals in the river systems;

- an increase in mercury entering Lake Murray via occasional reversals of its normal outflow to the Strickland River. This in turn could lead to elevated mercury levels in components of the food chain, ultimately affecting people.

In contrast to Ok Tedi's operations, mining at Porgera has elicited relatively minor public comment and censure. The reasons for this include:

- the relatively small size of the operation, especially in volume of rock movement, by comparison with Ok Tedi;
- the compensation agreement between landowners and affected parties on the Lagaip is still under negotiation;
- PJV has separate local, provincial and national share holdings.

The elevated mercury levels in the Lake Murray environment (including some human inhabitants) together with the known high mercury content of the Porgera ore, is an issue of heightened concern. PJV is currently operating a more rigorous monitoring programme than originally envisaged at the request of the Government. The objective is to establish the mercury and arsenic budget between the Strickland and Lake Murray.

## Biodiversity

The existing resource-based developments in the Fly catchment are very small and, apart from the mines pose little threat to the biodiversity of the catchment. However, protection and management of biodiversity in the Province is, with the exception of the Tonda Wildlife Management Area (WMA) in the south-west of the Province, essentially absent. The Tonda WMA has a high diversity of wetland habitat which is of international importance for resident and migrant waterfowl. It lies outside the Fly catchment and is not affected by mining activities.

The adverse impact of the mines on the riverine and wetland fauna and flora is currently believed, on the basis of the mines monitoring programme, to be confined to limited locations and to be reversible once the mining has ceased. If correct, this would have no serious implications for the conservation of biodiversity. The more serious threat to biodiversity is the possibility of large scale commercial forestry operations. Pressure for these will continue to grow, particularly as forestry offers an important alternative source of income beyond the life of the mines. If logging is to take place, commensurate policies would need to be pursued that find an appropriate balance between the conservation of biodiversity values and sustainable forest management.

## Social impacts

**Dimensions of social impact** Two broad categories of social impact can be distinguished at both Ok Tedi and Porgera. These are the direct impacts on landowners and other affected residents at a local level, and the far broader socio-economic impacts caused by a massive revenue earner in a newly independent nation which is heavily dependent on the revenue from the mines.

The national and regional financial benefits flowing from the Ok Tedi mining operation have been detailed in Table 1. These financial benefits reflect the beneficial social impacts of the project. It is quite clear from this information that the mines have played a major role in the economic development of Papua New Guinea and have also brought substantial economic benefits to the areas within which they are located. In Table 2 some of the specific benefits for land owners and communities affected by the Ok Tedi mine are listed. But this listing does not give a full picture of the social implications of the mine.

One of the characteristics of large scale, enclave, resource developments, is that their benefits (and costs) are not evenly distributed amongst communities. The principal benefits have accrued to land owners and communities directly affected by the mining operations. These have received land lease payments, a share of royalties and have had direct access to the employment opportunities and services offered by the mining company. Other, more distant communities along the river corridor have borne high costs without commensurate benefits. The operation of the Ok Tedi Development Trust and the settlement of some compensation claims is, however, helping to address this imbalance.

**Table 2** Benefits for landowners and affected communities at Ok Tedi  
Source: OTML (1993, 1994)

- land lease payments and royalties
- direct employment opportunities
- establishment of regional infrastructure
- development of landowner businesses directly associated with the mine
- substantially improved health, education and other services
- payment of royalties to the Western Provincial Government
- establishment of a development trust to assist develop community infrastructure and businesses, and
- payment of a Special Support Grant to the Provincial Government by the State

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The social benefits from the large scale mining activities are substantial but the adverse social effects are also significant and could be difficult to manage in the long term. These impacts stem from rapid population increases, cultural disintegration and new health problems. These issues are discussed below.

### Population growth

The population in the Fly catchment increased by about 46,000 people at an annual rate of nearly 3.7% between 1980 and 1990. This increase is equivalent to 43% of the 1980 population. At Ok Tedi and to a lesser degree Porgera, the high growth rate can be attributed to immigration to the development enclave together with a substantial drop in infant mortality (33% to less than 6% at Ok Tedi) and an increase in life span (30 to 50 years).

Immigration by mine workers and by people looking for work at both the Ok Tedi and Porgera mines has significantly contributed to the population growth. There has also been refugee emigration from Irian Jaya. 12,000 refugees entered the middle Fly area in 1985. About 5,000 of these refugees are believed to have returned. The remainder have either been settled with State assistance in 16 settlements in the East Awin area or have independently made their own settlements on the banks of the lower Ok Tedi.

### Health and services

Health problems in the Ok Tedi region were chiefly due to malnutrition and mosquito-borne, transmittable diseases. Currently health levels have improved markedly through the provision of efficient health services provided by OTML at Tabubil and in the surrounding communities.

Table 3

### Health statistics of the Wopkaimin People of the Star Mountains/ Ok Tedi Region

Source: OTML Health Department

	1990	1982
Crude birth rate (per 1,000)	30.3	32.0
Infant mortality rate (per 1,000)	24.4*	52.6

\* Whole of PNG - 72.0 per 1,000

New health issues have arisen over this period. These include the life-style diseases, STDs and new diseases and strains of diseases brought to the area by outsiders. Along the Fly River, village health services and infrastructure support is being provided by the Ok Tedi Development Trust and a Government initiative to the Western Province in the form of an annual Special Support Grant of over K4 million in both 1992 and 1993.

### **Cultural disintegration**

The rapid and enclave nature of development associated with mining in the Fly catchment has resulted in marked changes in traditional settlement patterns. Accompanying these are profound social changes including the introduction of alcohol and an increasing reliance on imported food items. For many of the landowners, the transition from a harsh subsistence existence to one essentially reliant on monetary income has been very rapid. For the landowners in the immediate vicinity of the mines, there is also the permanent loss of land which, although small in relative terms, is nonetheless very significant given its cultural value. The sudden appearance of relatively large amounts of lease and compensation money also leads to disputes and grievances because traditional social structures and customs of ownership and sharing are ill-equipped to accommodate such a commodity.

The social fabric of mining communities is tempered by the rigid administrative and legal framework of mining operations which are generally inconsistent with the fragility of traditional social structures and the flexibility within which they function. As a result, some members of the community are perceived to be disadvantaged or ignored in the distribution of lease and compensation payments or access to services and opportunities. Such social imbalances give rise to grievances and discontent and need constant attention to prevent escalation.

The 30 year expected life of the mine will cover an entire generation. It is doubtful that, by the expected time of the closure of the mine, the landowners and local communities will have retained a traditional inheritance which would enable them to attain a tolerable livelihood in the absence of an assured cash income. Social turmoil can be expected unless substitute and sustainable sources of economic activity can be developed.



# 4

## Sustainable development issues

### Introduction

This section draws from the review of current developments and their impacts presented in the preceding chapters, and analyses the linkages and cumulative impacts. This provides the necessary background for the development of the 'scenarios for change' in the Fly catchment which are discussed in Chapter 5.

### The legacy of current mining activities

The environmental studies undertaken over the past decade together with the current on-going monitoring in the Fly River system and delta provide an unprecedented level of biophysical knowledge. It is clear that, if not already, this system will soon be amongst the best studied of the world's major rivers. Nonetheless, the complex relationships between the biological and physical components of the system are only superficially understood at the present time. Despite the good-faith of the mining companies, it should not be taken for granted that the river system will quickly return to normal on the cessation of mining.

In planning for the future, it is appropriate to adopt a conservative position with respect to the potential and actual environmental impacts of continued unrestricted waste discharge. This would include the following assumptions:

- that the worst case scenarios for the impact on the fisheries of the lower Fly will arise;
- that the river and fish faunas will not recover quickly following cessation of mining and that such a recovery may take several generations, if it occurs at all;
- that some contamination of the floodplain lakes may well occur with the resultant adverse effects on fish stocks both within those lakes and in the river system as a whole;
- that the Ok Tedi River may never regain a fish fauna comparable to the pre-mining condition, even if mining were to cease immediately;
- that insufficient data are available from which to determine an acceptable level of contamination by sediments and heavy metals derived from mining in order to ensure minimal environmental impact. Any decision relating to compliance criteria and acceptable particulate levels should be regularly reviewed;

- that, without an adequate and proper social-economic analysis and action plan, strong reactions will occur amongst the peoples of the middle and lower Fly as fish yields decline and environmental contamination increases in magnitude.

### Conservation and biodiversity

Within the Fly catchment there is no managed protected area. The Maza marine WMA and the Tonda wetland WMA adjoin the catchment. Both areas are scheduled for attention in the forthcoming Western and Gulf Coastal Zone Strategy to be funded by AIDAB. The lack of conservation development within the catchment is not a reflection of the overall absence of significant sites. Instead, this reflects an inadequate level of knowledge about the biodiversity of a large and generally inaccessible area. The previously low level of development pressure and lack of resources have resulted in a low priority status for conservation.

The Conservation Needs Assessment (see Chapter 2) has identified certain general areas and preliminary priorities for conservation management. Within the Fly catchment several areas of high conservation priority have been identified. These include the slopes of Mt Bosavi which drain into the Strickland River and the Trans Fly wetlands which includes Lake Murray (Figure 7).

The principle issues affecting protected area establishment in Western Province are:

- a paucity of knowledge about the location of significant biodiversity centres within the catchment;
- the absence of a successful precedent for management once sites have been identified. A considerable amount of attention is currently being paid to this issue by numerous projects which have either been planned or are in the initial stages of implementation;
- a lack of resources - institutional, technical and financial - which are necessary to identify and subsequently manage such sites.

### Development and administration

**Development models** The Fly catchment has, by comparison with other remote areas in Papua New Guinea, experienced relatively rapid development and, arguably, progress. However, this has been brought about almost exclusively through the spin-offs of technologically intensive and commercially dominated enclave developments. No other development models have received anything other than cursory attempts at

application within the Fly catchment. The knowledge that the current enclave developments are likely to be transitory and the lack of tried and tested alternatives is the crux of the current dilemma.

**Land ownership**

About 97% of the land in PNG remains under the control of traditional owners. The land is important not only for day to day subsistence but for the significant role that this plays in wealth and status values. Experience in PNG has shown that development projects which lack opportunities for meaningful participation with landowners are liable to be unsuccessful.

Landowners are increasingly frustrated by what is seen to be bureaucratic interference by both Provincial and National Governments. These are seen to hinder implementation of development initiatives and provide opportunities to filter off benefits which the landowners believe should be coming directly to themselves. The landowners have a highly developed sense of individual and community identification. As a result they tend to see no objective difference between Provincial and National Governments except as separate sources of regulation and control.

The variability and complex nature of land use and values by different social groups makes:

- distant planning of suitable development options highly uncertain;
- large scale development options highly vulnerable.

Together these establish the need for local level participation in the planning of any sustainable development objectives.

**Provincial administration**

*Conflicting responsibilities*

The decentralisation of administrative and development responsibility to Provincial Governments was formerly a National Government Policy. This policy is currently under review in the wake of numerous shortcomings of a number of Provincial administrations. These relate principally to the failure to deliver services such as health and education and to initiate and/or to control local developments. In certain cases, the failures have resulted in suspension of the Provincial Governments concerned.

The Fly River Government of the Western Province was suspended during 1993-94. This suspension has contributed to an intense and politically charged atmosphere which pervades the provincial administration. There is no doubt that the Ok Tedi mine is inextricably entwined in this wider political debate as it is closely identified with the National Government. The reasons for this include:

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- the independent legal status of the Ok Tedi mine which essentially removes it from the Provincial administration;
- OTML's environmental monitoring and management programme, which is determined by the National Government, does not involve the Provincial administration and, in its opinion, lacks credibility;
- the National Government is perceived as reluctant to control the environmental impacts of the mine and has a conflict of interest between is environmental protection and shareholder interests;
- the National Government is perceived as reluctant to compensate adequately the landowners, other affected people and the Provincial administration for the impacts of the mine.

A consequence of the current strained relationship between the Provincial administration and the National Government is that any development initiative with strong centralised control or direction will be unlikely to receive Provincial support.

In contrast, the view of some of the Departments in the National Government is that implementation of projects are most successful if undertaken directly between central Government and landowners. They see the Provincial administration as commonly providing delays and extra costs without any useful or necessary contribution.

### *Regional dependence on Ok Tedi Mining Ltd*

In the absence of a cooperative relationship between OTML and the Provincial Government, OTML appears to have assumed many of the responsibilities expected of the Provincial Government within its sphere of operations. This is particularly evident in infrastructure, health and education. The situation may also be influenced by the fact that Daru, the capital of Western Province, is on a small island on the south coast and geographically distant from mining operations. Since 1983, the Ok Tedi mining town of Tabubil has, with OTML encouragement, become the focus for regional commercial activity. However, Kiunga is a more strategically located centre and one which would be more relevant to the Western Province in a post-mining era.

### **The Ok Tedi Development Trust and Special Support Grant**

Two current initiatives for communities along the Ok Tedi and Fly Rivers and in the delta are:

- The Ok Tedi Development Trust (OTDT). This provides community infrastructure and business development services to communities outside the mine lease which do not receive lease or royalty payments. The Trust was founded and is funded by OTML.
- It is operated by OTML in conjunction with both the National and Provincial Governments. The Trust operates with an annual budget of about K3 million which is escalated each year. Funding between 1990 and 1993 totalled K10.9 and over the life of the

mine, funding is expected to total K80. The Trust undertook 254 village projects between 1990-92.

- The National Government is providing a Special Support Grant to be administered by the Provincial Government in the South Fly region. The current SSG programme involves the provision of small grants on the basis of applications received from communities and individuals. In the current programme 200 grants have been approved with a value of K1.7 million.

These are valuable sources of funds but their end use and the expectations they generate have important implications. Community infrastructure developments, such as water tanks and individual purchases, such as outboards to facilitate fishing, bring direct benefits. But the continuance of these benefits depend on a flow of income for maintenance of the initial capital. This is not assured.

Grants can create expectations that follow-up activities will be funded on the same basis. They can also reduce the incentive on individuals to be reasonably sure that development activities are economically sustainable. These issues are particularly important for communities without an established knowledge of markets and with a limited business background.

**The role of women**

Women have a low status in Papua New Guinea as a result of a combination of cultural, social and economic factors. They receive less education than men and their health, especially at child-bearing age, is significantly worse than men's. Law and order problems and domestic violence restrict their participation in education and employment. Nonetheless, women play a major role in the productive sectors. They are critical to the maintenance of biodiversity, not only in growing subsistence crops but for their interest in sustaining biological resources.

NGOs such as The Ideas Resource Centre, which works out of Daru, have recognised the crucial role of women and are already targeting adult women to link literacy with environmental, health and productivity issues in their rural programmes.

**The role of Non-Government Organisations**

Non-Government Organisations (NGO) are extraordinarily abundant in Papua New Guinea. This is a reflection of the highly opinionated and individualistic nature of its people. Currently NGOs are favoured 'development agents' and are seen to have a major role as links between traditional development agents and landowners or resource holders. In effect, the link is seen to provide the opportunity for local communities to participate in the development process. There is no question that PNG NGOs have accomplished much in this area of concern. However, few, if any, of the NGOs have successfully

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coordinated and run major development programmes or initiatives. Although there is a general belief amongst them that they have such abilities, for the majority these remain to be demonstrated.

Any projects which rely entirely on the administration of inexperienced NGOs are likely to be unsuccessful unless the NGOs have access to considerable assistance and back up resources.

## Renewable resource developments

**Agriculture** Agriculture is regarded as having very limited development potential with the possible exception of rubber at the smallholder level. Potential for livestock development in the lower Fly may be more feasible but the overall constraints of small population, infertile soils, poor drainage, distance from markets and poor access all combine against major agricultural developments. At the smallholder level, there are suitable conditions for rubber and certain spices such as chillies, pepper and vanilla (Table 1) but the lack of infrastructure combined with the economics of transport and marketing is, again, a major constraint.

Irrigated rice would appear to be technically possible in many locations but significant trials have not yet been attempted and prior experience with rice elsewhere in PNG has been less than successful.

**Table 1** Percentage of available land area in the Western Province suitable for various smallholder crops  
Source: Department of Agriculture and Livestock

Crop	Land available		
	Highly suitable %	Moderately suitable %	Marginally suitable %
Rubber	0.0	49.0	7.6
Oil palm	0.1	16.5	64.3
Cardamom	0.0	0.01	53.3
Chillies	0.0	30.8	24.5
Pepper	0.0	36.1	5.8
Vanilla	0.0	36.1	10.9

**Fisheries**

The potential for various small scale commercial fisheries is widely believed to exist. These include barramundi, prawns and yabbies. The economics of processing and transport currently make such operations marginal unless they have assured markets.

The potential for a major expansion of commercial fisheries of the Fly River and delta should not be automatically assumed to exist. The New Guinea floodplains are considered to have a very low productivity of natural fish production compared to similar sized rivers elsewhere in the world.

The resource is likely to be adversely affected at the local level by uncontrolled exploitation using new technology. Important among these may be the widespread use of nets without a minimum 'gill-size' and the increased mobility of fishermen because of the availability of outboard motors.

**Forestry**

Logging appears to have considerable potential in the middle and upper Fly region but again long distances from the coast and the lack of any road infrastructure make such areas unattractive in comparison with more accessible coastal regions. However, it is only a matter of time before such considerations recede and the current surge in international prices for hardwood timber could be the catalyst.

The logging industry in Papua New Guinea has received widespread national and international criticism for its corruption and gross social and environmental impact. Such criticism continues (Henderson, 1993) even though there have been some major reforms in the Forestry Sector following the Barnett Commission of Inquiry into the timber industry, which completed its report in 1989. Such reforms and initiatives include:

- a new National Forest Policy in 1990;
- a National Forestry and Conservation Action Plan (NFCAP) in 1991;
- a new Forestry Act in 1992 which created a new National Forestry Authority and National Forest Service.

Although such initiatives may indicate that forestry malpractices are an issue of the past, it is unlikely that logging practices will actually change rapidly in the forest. The same companies and individuals remain in control. In addition, the 1993 level of log exports is expected to quadruple the 1992 level without a commensurate increase in forestry staff and resources for monitoring purposes (Henderson, 1993).

Unless there is an effective effort to introduce some form of control and more participation of landowners, such as through the use of Wokabout Somils (Walkabout Sawmills), the ability of the large logging companies to dictate the pace and the progress of the industry

is likely to remain. This situation is likely to have unfavourable repercussions for sustainable development in the Fly River water catchment as it has elsewhere in Papua New Guinea and it will need to be cogently addressed in the Sustainable Livelihoods Strategy.

Eco-tourism and the marketing of eco-timber are much discussed development initiatives. These may have significant potential in the Fly River catchment, especially as catalysts for beneficial local involvement in practical forms of sustainable development and biodiversity protection.

## Industrial development

**New mines** The existing infrastructure and expertise being developed at both of the existing mines will provide a base for usage by other mines in their localities. This may stimulate and facilitate such ventures. However, currently both the Ok Tedi and Porgera mines are planned for closure about 2010.

At Ok Tedi, mineral exploration is continuing in the mine area and in the region in general but the prospects of new, commercially viable, discoveries are uncertain.

**Petroleum and gas** Exploration for petroleum and gas is continuing at a high level in the catchment and the results are termed encouraging. PNG's first petroleum and gas extraction development at Lake Kutubu, lies immediately to the east of the middle Strickland River.

**Closure of the mines** Although there is some prospect that new discoveries or increases in the price of gold and copper will delay the closure of the mines, their continuation beyond their currently assumed economic life cannot be guaranteed. In any event, they will eventually close and the consequences require considerable thought and planning to reduce the social and economic impact of mine closure. In anticipation of this, the Department of Finance and Planning has recently drawn up Terms of Reference for a 'Long Term Economic Development Plan for village communities affected by OTML activities in the lower Ok Tedi/Fly, Western Province'.

This study could complement the Sustainable Livelihoods Strategy project proposal emanating from this report and linkages should be made between these proposals.

The extent of OTML's responsibility in respect of continued environmental monitoring and management after mine closure also needs to be established at an early stage. Currently OTML appear to project an image of continuing environmental impacts until mine closure after

which the river systems will quickly revert to normal, pre-mining conditions. This is probably an unrealistic although convenient scenario. Even if the physical system reaches an equilibrium relatively rapidly, the ecological effects of elevated copper/metal levels, either actual or perceived, are likely to be an issue in the Fly for many years after the closure of the mine.

## Population

The present population density of less than 2 persons/km<sup>2</sup> in the Fly catchment can be considered very low. However, the nation's current population growth rate of 2.3% per annum is a threat to the provision of essential services and the attainment of adequate health care throughout the country. A reduced population growth rate would allow the government to provide more resources to promote development initiatives and may be considered an essential component of sustainable development.

The rapid growth of Daru's population in the last decade through urban in-migration can be attributed to a lack of infrastructure development and provision of services in the rural sector.

The Fly water catchment's growth rate during the 1980s (3.7% per annum) is well above the national average (Chapter 2, Tables 2 and 3). This is a consequence of immigration together with a major improvement in health care in the case of OTML in the Ok Tedi region. The issues of the next two decades will not be population numbers or natural resource levels *per se*, but the social consequences of unstable community structures and the vulnerability of people to circumstances entirely beyond their control. These include the closure of mines, polluted water bodies, immigration of refugees and urban migration.

## Health

Traditionally, the Wopkamin inhabitants and their neighbours of the Ok Tedi region of the Highland Fringe faced formidable problems of survival at the subsistence level. Sickness in the form of malaria and filariasis was endemic and debilitating. Infertile soils and very high rainfall made for impoverished agricultural potential, which resulted in widespread malnutrition. Subsistence was only made possible through a well adapted form of diversified hunter-horticulture subsistence (Hyndman, 1979). It is only through thorough interventive medical care undertaken largely by OTML that the people of the Ok Tedi region currently enjoy a relatively healthy existence. This will only continue as long as the well-planned and implemented health programme is maintained. Continuing good health for the region is thus an additional major issue after mine closure.

Although the National and Provincial Governments participate in the delivery of health care, in the Ok Tedi region there is an almost overwhelming dependence on OTML which is an issue of concern for forward planning. Health issues, both positive and negative, can have far reaching implications for natural resource management and sustainable livelihood options. Box 1 illustrates some of the impacts and linkages between logging, a likely development option, and health.

The ease and rapidity with which lifestyle diseases (heart problems, diabetes, STDs) have appeared and become common among urban inhabitants at, for instance, Tabubil poses other serious problems. The commonly held belief that employment or participating in the cash economy will bring with it improved health standards is clearly mistaken.

A Sustainable Livelihoods Strategy for the inhabitants of the Fly catchment will necessarily have to devote considerable resources to the maintenance of adequate health standards through the provision of both access to health care and to the education and awareness raising of health values.

### **Box 1 Linkages between logging and health**

Logging (not necessarily sustainable logging) can offer the following opportunities:

- logging income can be used to expand health service;
- logging income enable choice of medicine and health care;
- roads constructed for logging offer improved access for clinics and patient travel;
- better access to choice of food, water and shelter.

Logging can also have the following negative health aspects:

- logging is associated with high level of work-related injuries;
- more travel by village people will hasten the spread of some diseases, e.g. STDs and (potentially) aids. These can also be brought to the remote rural locations of logging camps from where they can spread to local communities;
- accessibility and income from logging can lead to increased consumption and reliance on alcohol, tobacco and processed 'junk' foods;
- longer term increased rates of non-communicable diseases can become a problem (e.g. diabetes, cardio-vascular diseases);
- downstream effects of logging and milling activities can effect aquatic ecology and fish populations causing inconvenience or malnutrition to riparian communities;
- logging activities and road construction can create breeding grounds for mosquito vectors of malaria.

## Related projects and programmes

There are several proposed or actual projects or programmes concerned with sustainable development or conservation activities which are directly relevant to the development planning in the Fly catchment either through their geographic proximity or their institutional framework:

- Long Term Economic Development Plan proposal for the Tabubil District, Western Province. Department of Finance and Planning, Government of Papua New Guinea.
- Western and Gulf Coastal Zone Management (WGCZM) Plan. AIDAB.
- Trans-Fly Tenure and Resource Mapping Program. AIDAB.
- Kutubu Joint Venture Project. World Wide Fund For Nature.
- The National Forest and Conservation Action Programme. Ministry of Forestry, Government of Papua New Guinea, World Bank/UNDP.
- A National Sustainable Development Strategy. UNDP, New Zealand Government.
- Strategic Plan, Department of Environment and Conservation, Government of Papua New Guinea.
- Conservation Needs Assessment. Department of Environment and Conservation, Government of Papua New Guinea, USAID.



# 5

## Scenarios for future development

### Introduction

The preceding chapters have described basic prevailing conditions in the Fly River catchment and a number of issues relevant to sustainable development in Western Province. This information is used in this chapter to generate a range of possible scenarios for the year 2010. The assumptions made for each scenario are listed in Appendix 1. Scenarios, at best, are simple 'snapshots' of extreme but possible outcomes based on stated assumptions - usually the most likely scenario lies somewhere between the extremes. The purpose of such scenarios is to highlight the key issues which will require policy directives, planning, design and implementation measures to achieve the goal of ecological sustainability and thus provide the framework for sustainable development planning. These scenarios focus on Western Province. They do not discuss the undisputed benefits that large scale mining activities bring to the economy as a whole.

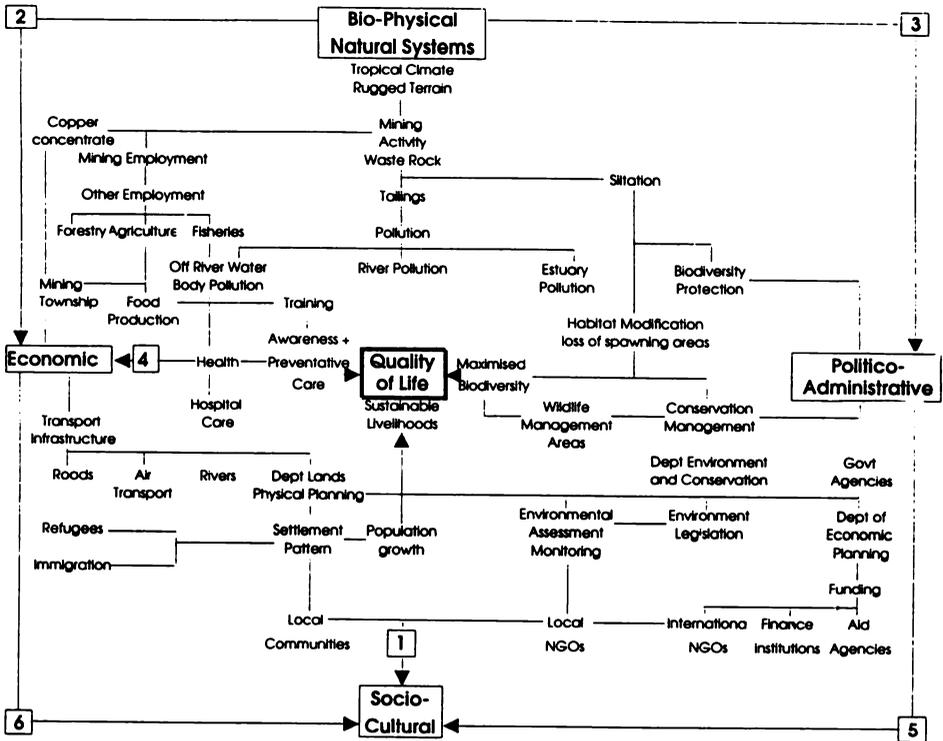
### Parameters adopted for scenarios

The basis of scenario analysis is the complex interdependence and linkages of biophysical, economic, political-administrative and socio-economic issues (Figure 9). The information available on which to develop scenarios for the Fly River catchment is limited. The growth and shifts of population under the range of assumptions behind each scenario simply demonstrates the scale of impacts within the Fly River catchment. They are by no means sophisticated or accurate. This, together with our superficial knowledge of the linkages, makes the development of scenarios somewhat general. Thus the adoption of precise criteria would be misleading - the key parameters specified in Table 1 enable simple comparisons between scenarios to be made.

### Appropriate planning unit for scenario analysis

The whole catchment is traditionally accepted as the most suitable planning unit. It is a natural ecosystem with a convenient and easily identified principal nutrient pathway. However, in practical terms the whole Fly River catchment has several important disadvantages as a planning unit.

# The Fly River catchment



**Figure 9 Linkage mosaic**

Western Province, rather than the Fly River catchment, has been used as the most appropriate planning unit for the scenario analysis because:

- the catchment is very large with a small, highly dispersed population;
- there are marked differences in the ecological attributes and human activities in each of the three principal catchments - the upper Fly, Lake Murray and the upper Strickland;
- although the bulk of the catchment is in one province, the remainder is distributed in three other provinces (Chapter 2, Figure 1).

**Table 1 Key parameters used in scenario development**

Parameter	Comment
Economic activity	<ul style="list-style-type: none"> <li>• Key factor in growth, mobility and settlement pattern, and level of environmental impacts.</li> </ul>
Population, health/welfare	<ul style="list-style-type: none"> <li>• Long term cumulative effect on employment, quality of life and expectations.</li> </ul>
Settlement pattern/infrastructure	<ul style="list-style-type: none"> <li>• The attraction of one centre over another exerts a powerful cumulative effect on long term sustainable development, catchment-wide.</li> </ul>
Government policy	<ul style="list-style-type: none"> <li>• Government policies have to be made explicit and mutually supportive in the endeavour to achieve participatory sustainable livelihoods.</li> </ul>
NGO involvement	<ul style="list-style-type: none"> <li>• NGOs offer a potentially valuable bridge between local participatory action, government policy and sustainability.</li> </ul>
Environmental sensitivity and biodiversity	<ul style="list-style-type: none"> <li>• The key parameter in assessing the cumulative effects of the above parameters, making it essential to monitor and adjust policies/practices to secure sustainability.</li> </ul>

## Scenario descriptions

**Background** Three scenarios are selected as representing the most likely possible development trends:

- Business as usual;
- Expansionist;
- Contracting.

In the following sections an outline of the assumptions behind each scenario is presented and the likely outcomes are summarised. More detailed analyses of the assumptions behind each of these scenarios are presented in Appendix 1. The projected population figures in each scenario are for Districts, as used in the National Census, and not urban or township figures.

### Scenario 1 - Business as usual

*Brief*

*description*

The 'Business as usual scenario' sees a steady population growth driven by mining activity, health improvements and inward migration. These factors are expected to consolidate the growth of northern mining townships in Kiunga District at the expense of the more southerly rural areas of Nomad, Morehead and Daru. The rural centre of Balimo is expected to derive secondary benefits from continuing mining growth, including marketable produce for northern settlements. The assumption is that further small local copper (and possibly) gold finds will maintain the slowly declining mine-related economy. Population Growth Rate 3.7% down to 3.5%.

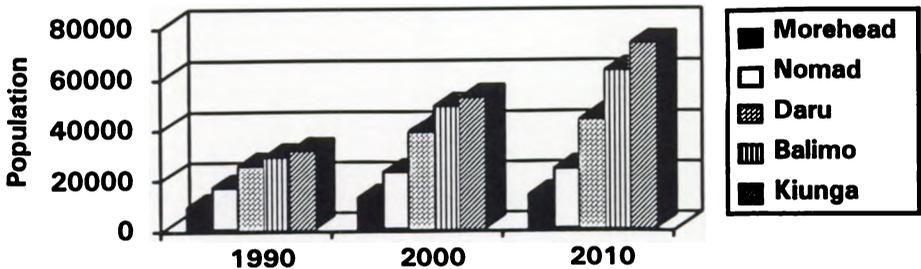


Figure 10

Population trends. Scenario 1 - Business as usual

*Summary of risks*

In the 'Business as usual scenario', mining retains its pre-eminent economic position. Government commitment to mining success creates a dependency, which limits local participation and diversification. Wealth continues to improve whilst mines are operative but subsequent closure could lead to a spiral of social/economic decline post-2010 and increasingly unsustainable use of remaining resources - fisheries and forest - for quick profit. Regional imbalance remains with no effective economic 'trickle-down' as a counterbalance.

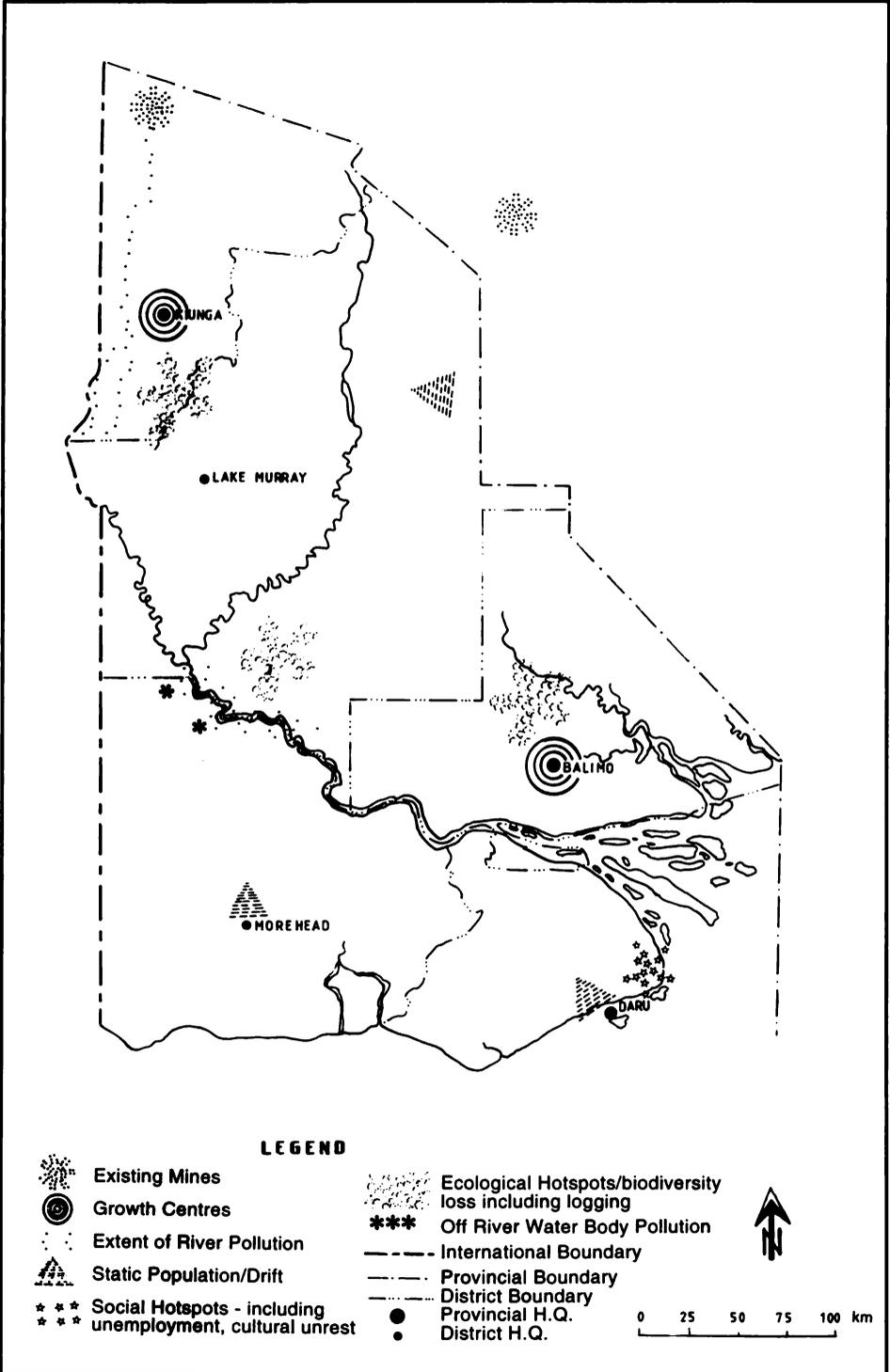


Figure 11 Growth factors. Scenario 1 - Business as usual

## Scenario 2 - Expansionist

*Brief description*

The 'Expansionist scenario' is an open-ended scenario depending on the extent of new development of mineral and perhaps petroleum or gas resources in the Kiunga District. A more exaggerated settlement pattern is envisaged. This would involve growth of the established centres of Kiunga and Balimo at the expense of Daru (urban) and the rural communities of Nomad and Morehead as the drift away from more remote and increasingly polluted river systems takes effect.

Population growth rate at 3.7%.

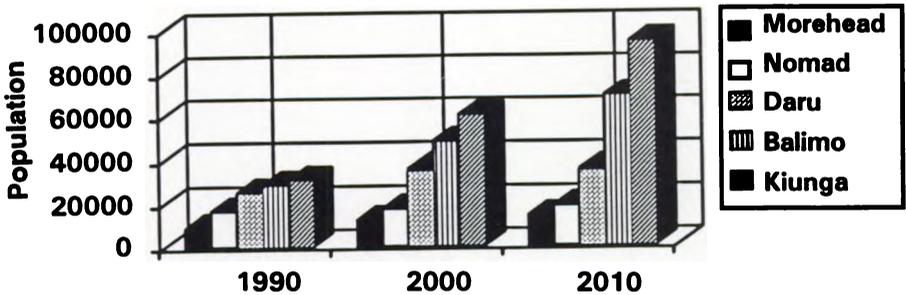


Figure 12 Population trends. Scenario 2 - Expansionist

*Summary of risks*

The extension of mining beyond 2010 would prolong the economic dependency of the Western Province on mine-related activities to the detriment of developing longer term sustainable livelihood options. The continued loss of river-based and forest-based biodiversity would make recovery beyond 2050 more difficult and expensive. This scenario involves a risk of social disruption on a greater scale with expectations of a considerably larger population. (See extrapolation of population figures for each scenario - Figure 16.)

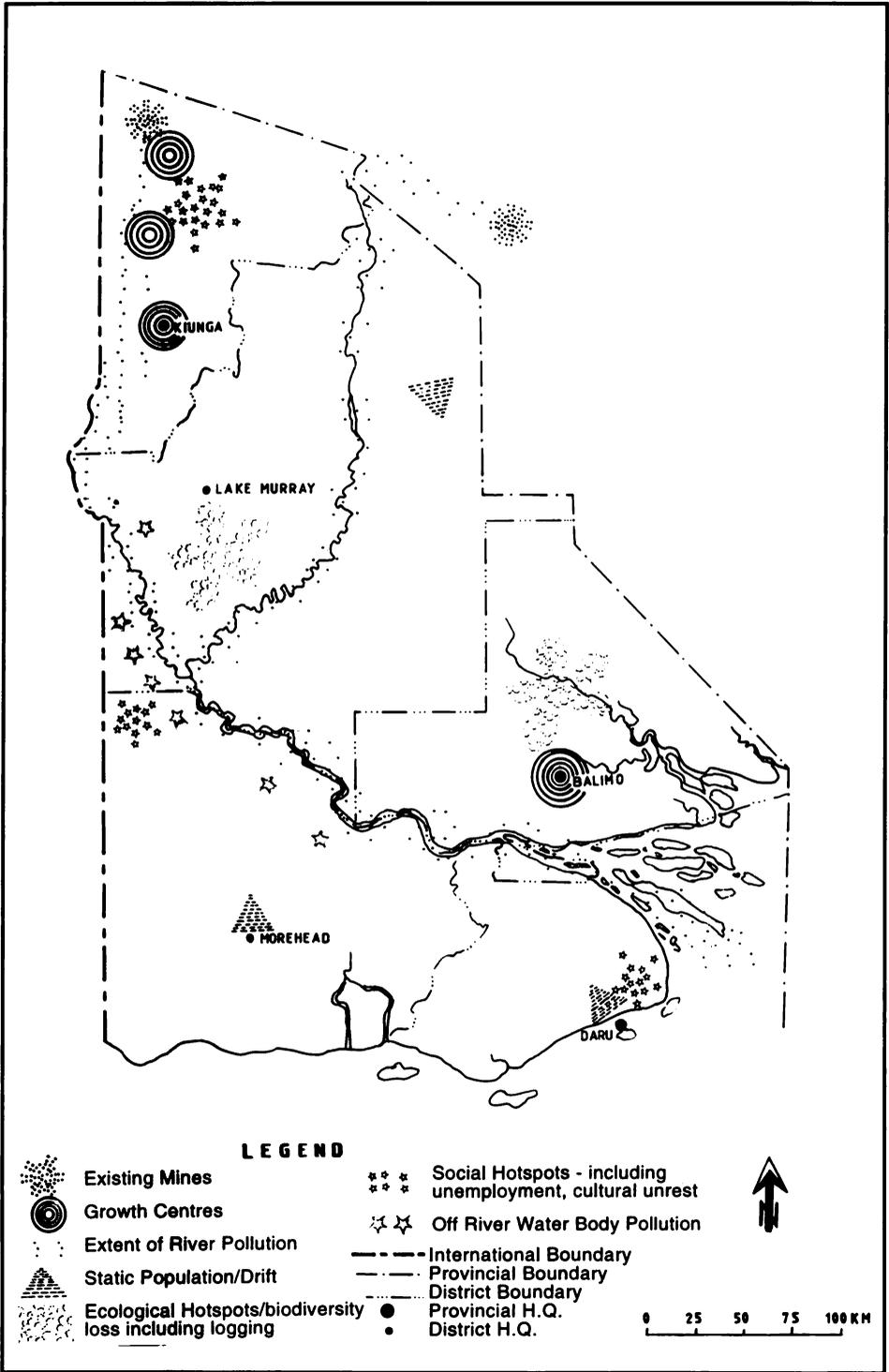


Figure 13 Growth factors. Scenario 2 - Expansionist

### Scenario 3 - Contracting

*Brief description*

A 'Contracting scenario' sees cessation of mining between 2005 and 2010. This would involve wide ranging repercussions, particularly if, as with this scenario, no alternative livelihoods are developed in advance. It is anticipated that a significant (but not dramatic) reversal of population could occur to southern and traditional subsistence areas, particularly as river aggradation and sedimentation will ease and pollution levels drop (longer term copper residue release from sedimentation not taken into account). The population at Balimo is expected to increase, especially if livestock markets in PNG and possibly rubber shipments develop.

Population growth rate - dropping from 3.5 down to 2.9%.

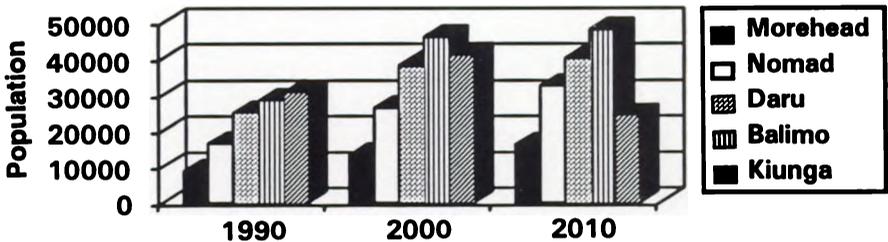


Figure 14 Population trends. Scenario 3 - Contracting

*Summary of risks*

Without immediate mining benefits or alternative livelihoods the options are limited. A small part of the population could return to the cultural demands of subsistence, others would opt to move elsewhere for retraining or to use mining-acquired skills. There is no guarantee that the remaining population would have any option other than to use the available natural resources for economic gain - or to face ill health and poverty. For many, the years of paid employment or royalty/compensation payments will have caused a loss of traditional knowledge and ecological stewardship, making a return to sustainable livelihoods based on natural resource use difficult or impossible.

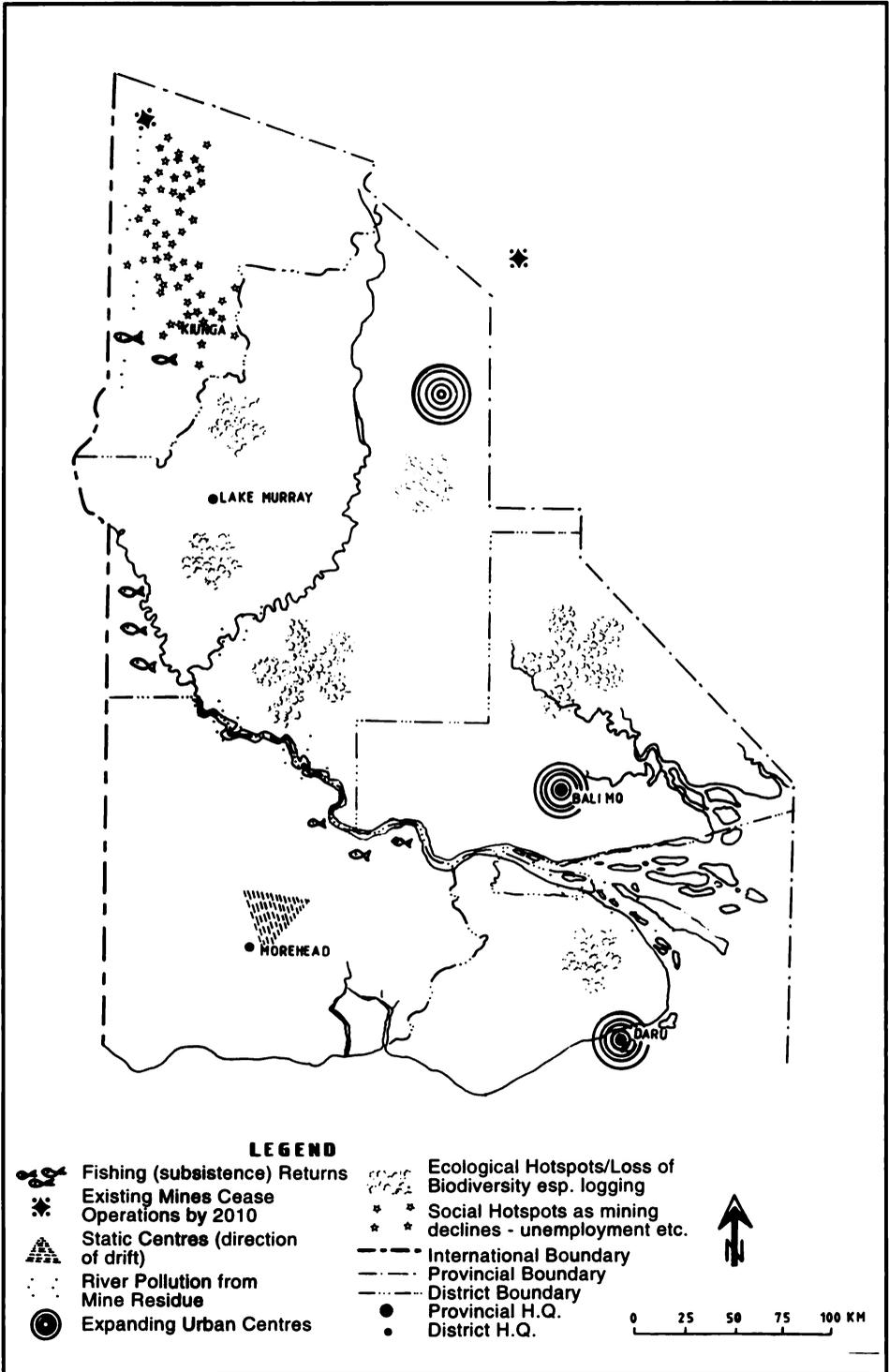


Figure 15 Growth factors. Scenario 3 - Contracting

## The Fly River catchment

**Discussion** The 'Business as usual' or 'Expansionist scenario' are unsustainable in terms of population, quality of life and biodiversity. The 'Contracting scenario' sees the bulk of the population contracting to a semi-subsistence level. This is politically and culturally unrealistic, and serves to illustrate that inaction is a decision with the potential consequence of social instability.

All three scenarios are, to some extent, unsustainable and carry the risk of social instability. For these reasons a fourth 'Sustainable scenario' has been generated. The first three scenarios are essentially forecasts, based on the extrapolation of trends. The fourth 'sustainable' scenario is more of a 'backcast' from 2010. The means of arriving at this sustainable picture have yet to be developed. These may involve the use of the proposed participatory management options approach specified in the Sustainable Livelihoods Strategy.

However, it is clear that a switch from the 'Business as usual' to Sustainable development options will require conscious policy decisions and adherence to agreed and acceptable 'sustainability criteria'.

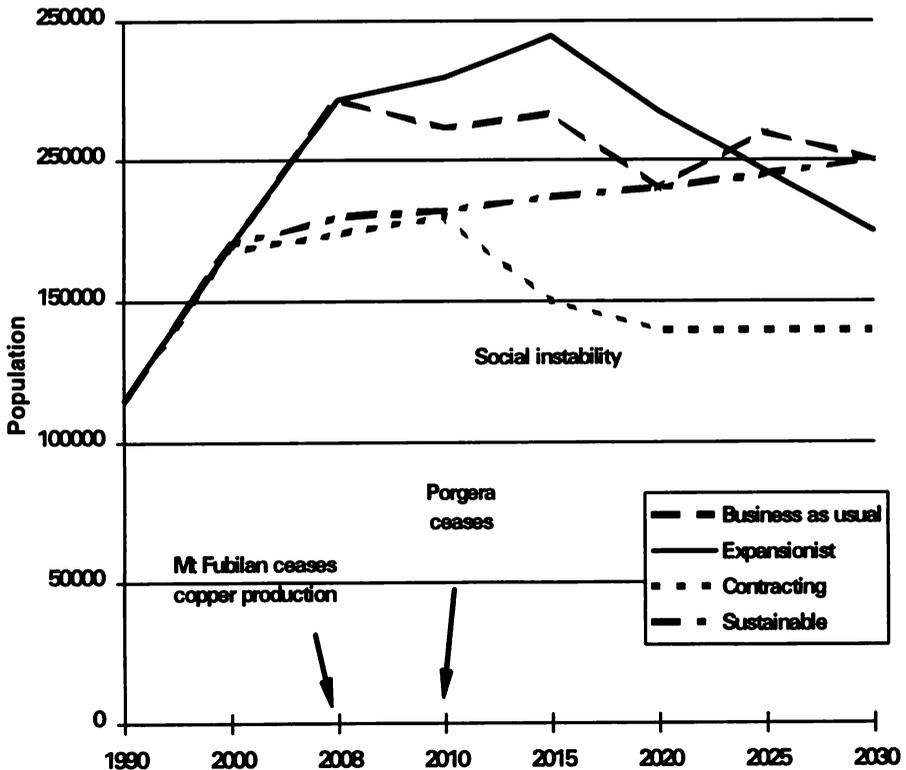


Figure 16 Population extrapolation for each scenario

These criteria must be met in order to prevent further damage to the environmental capacity of the Fly River catchment.

Such criteria would address:

- depletion of stocks of non-renewable and renewable resources;
- limiting emissions and the accumulation of environmentally deleterious substances;
- damage to natural structures and systems (including biodiversity).

The route towards a sustainable development scenario will not only need to be purposeful but gradual. The needs of the Fly River communities will need to be actively addressed well before the closure of the mines. Government needs to demonstrate a commitment to local provincial level participation and awareness of the long term risks of unsustainability, if any option is to succeed.

Figure 16 is an extrapolation of population figures which summarises the scenarios.

### Scenario 4 - Sustainable livelihoods

*Brief description*

A deliberate policy shift to complement mining with a mix of subsistence - marketable products, relying on the multi-track development of sustainable livelihoods from now until the year 2010 will help the Western Province overcome its dependency on mining and provide a more equitable spread of tangible benefits and improved quality of life for the rural areas and Daru, Morehead, Balimo and Nomad.

Population growth rate at 3.5% declining to 3.3%.

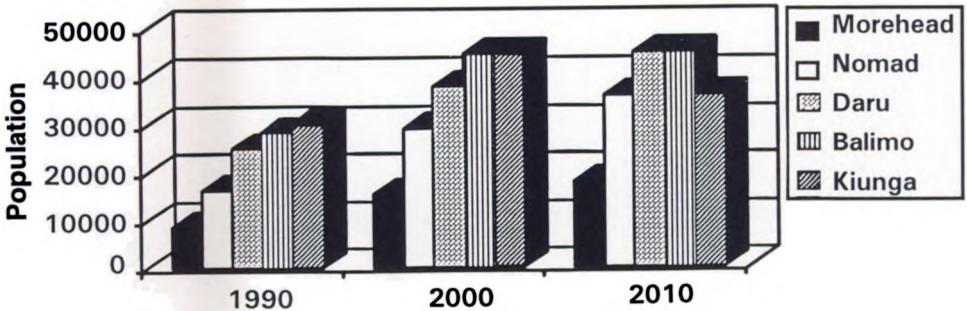


Figure 17 Population trends. Scenario 4 - Sustainable

# The Fly River catchment

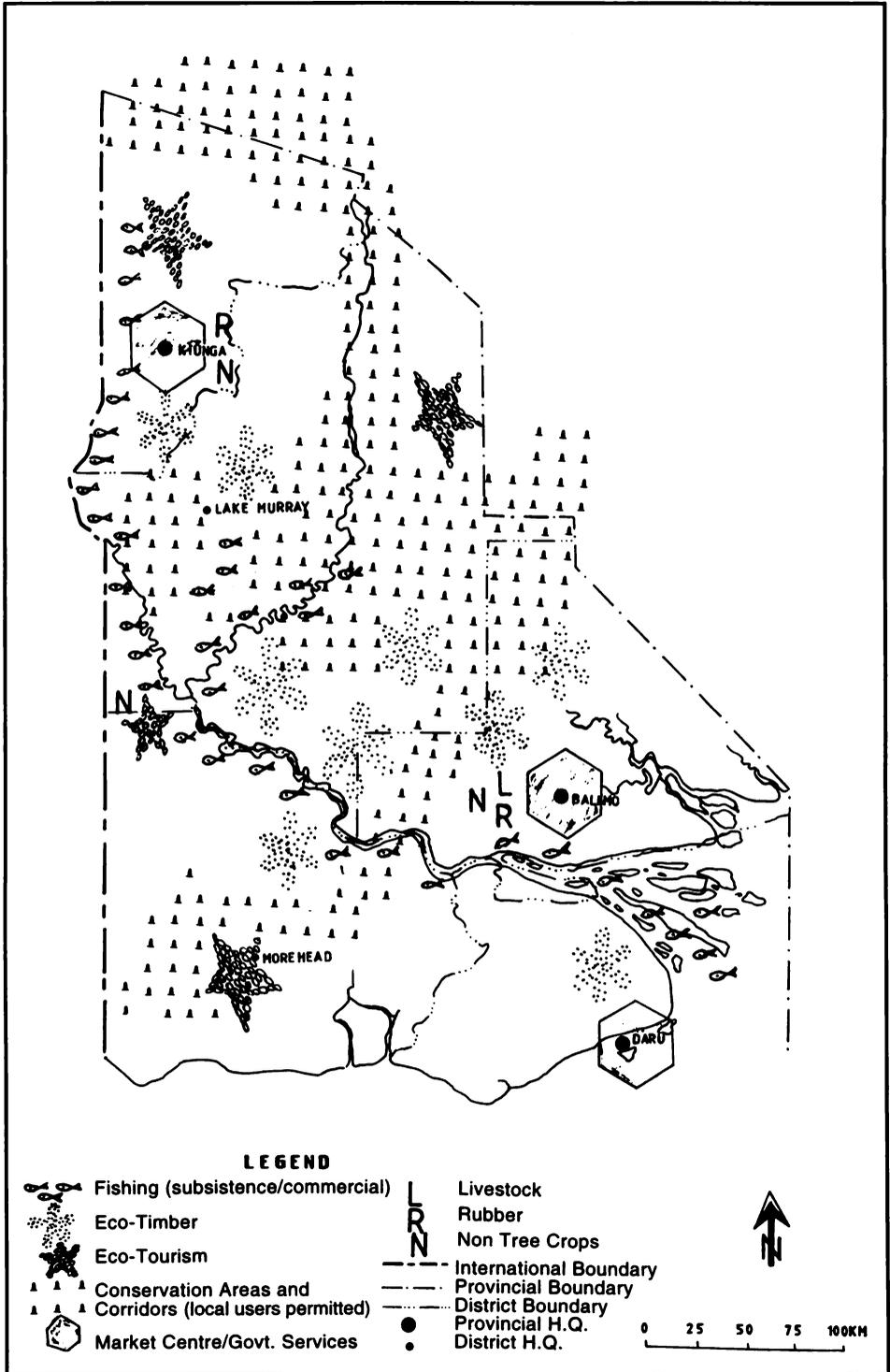


Figure 18 Growth factors. Scenario 4 - Sustainable

### *Summary*

There is clearly an urgent need to initiate appropriate strategic planning for regional development well before the closure of the mines. The initial step could be the preparation of a Sustainable Livelihoods Strategy for the Fly catchment.

Community participation will be central to the success of initiatives for the development of sustainable livelihoods. The variability and complex nature of land use and values by different social groups in the Fly catchment makes distant planning of suitable development options highly uncertain and large scale development options highly vulnerable. In any sustainable development initiative, local communities need to be able to develop their own livelihoods whilst protecting ecosystems and biodiversity upon which those livelihoods ultimately rely. In order for this to be possible, Government will need to considerably enhance its environmental and conservation management capability.

This scenario will require the recognition of its worth by Government, private enterprise (including OTML), educational institutions, local communities and NGOs. Too little too late will create a vacuum in which social disharmony, crime and violence could thwart genuine efforts for the development of sustainable livelihoods.



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## The Fly River catchment

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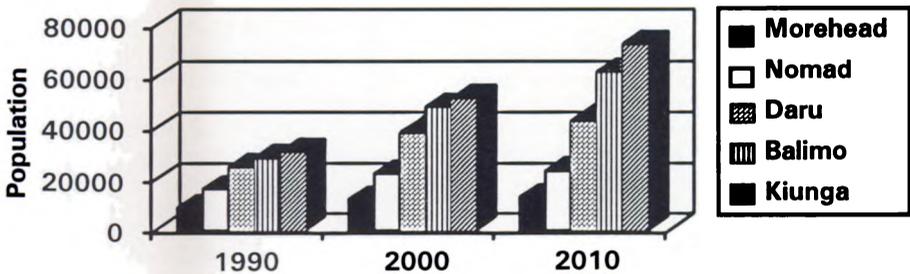
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# Appendix 1

## Scenario 1 - Business as usual

The steady population growth driven by mining activity, health improvements and inward migration will consolidate the growth of northern mining townships in King District at the expense of the more southerly rural areas of Nomad, Morehead and Daru. The rural centre of Balimo is expected to derive secondary benefits from continuing mining growth, including marketable produce for northern settlements. The assumption is that further small local copper (and possibly) gold finds will maintain the slowly declining mine-related economy.

Population Growth Rate 3.7% down to 3.5%.



Population trends. Scenario 1 - Business as usual (see Figure 10, page 58)

Issue	Assumption	Effect
Economic activity	• Copper mining continues at Ok Tedi	• Current output (20,000 tons ore/day) at Mt Fubilan ceases in 2008
	• Gold mining continues at Porgera	• Current output (10.3 million ounces/year) ceases in 2010
	• Minor proven copper reserves exploited	• Mining continues at reduced level until 2040

<b>Issue</b>	<b>Assumption</b>	<b>Effect</b>
	<ul style="list-style-type: none"> <li>• Small scale manufacturing, packaging and service industry associated with mining grows slowly</li> <li>• Livestock market improves</li> <li>• Logging gathers momentum</li> <li>• Tree crops including rubber marketable</li> <li>• Non-tree crops, including spices marketable</li> </ul>	<ul style="list-style-type: none"> <li>• Kiunga reinforced as market centre for supply of fish, vegetables, meat, basic household items and services - diversification to non-mine related activities may occur after 2005, by which time Kiunga's population would be around 6,000, remaining steady at 6,500 by 2010.</li> <li>• Balimo develops as secondary centre</li> <li>• Erosion and siltation increases</li> <li>• Kiunga and Balimo benefit economically</li> <li>• Improved infrastructure and packaging</li> </ul>
Population, health and welfare	<ul style="list-style-type: none"> <li>• Infant mortality rate (24.4/1,000) continues to drop but more slowly</li> <li>• Crude birth rate(30.3/1,000) also drops slightly</li> <li>• Influx of refugees from Irian Jaya ceases</li> <li>• Mine-related in-migration continues</li> </ul>	<ul style="list-style-type: none"> <li>• Continued health awareness programmes sponsored by mining companies, together with Health Centre funding and greater Provincial awareness</li> <li>• As above</li> <li>• Existing refugees continue to have high birth rate</li> <li>• Overall Fly catchment population grows continues at around 3.5% with downturn post-2005 depending on mining prospects</li> </ul>

Issue	Assumption	Effect
Settlement pattern/ infrastructure	<ul style="list-style-type: none"> <li>• Existing key settlements will continue to grow</li> <li>• Resettlement away from river food sources</li> <li>• Roads upgraded to serve growing centres</li> <li>• Siltation and river aggradation continues at present rate</li> <li>• Airfields remain vital links, existing airfields upgraded, smaller runways developed</li> </ul>	<ul style="list-style-type: none"> <li>• Kiunga experiences steady growth</li> <li>• Tabubil's growth slows as mining slows</li> <li>• Kiunga and Balimo benefit from improved road links</li> <li>• River navigability adversely affected</li> <li>• Kiunga, Daru and Balimo airfields improved</li> </ul>
Government policy	<ul style="list-style-type: none"> <li>• Existing policy unchanged on matters relating to:               <ul style="list-style-type: none"> <li>- income opportunities in rural areas</li> <li>- increased domestic food supply</li> <li>- development of processing/ manufacturing based on domestic products</li> <li>- rural community participation, particularly women</li> <li>- protection of natural environment</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Reliance on mining</li> <li>• Supplies to mine workers</li> <li>• Improved packaging, some rubber, some spices, a little beef, a few tree crops</li> <li>• Limited to a few NGOs</li> <li>• Continuing loss of river productivity, loss of timber ameliorated by improved legislation and controls</li> </ul>
NGO involvement	<ul style="list-style-type: none"> <li>• The National Alliance of Non-government Organisations (NANGO) secures limited involvement in Government Policy decisions</li> </ul>	<ul style="list-style-type: none"> <li>• A few local NGOs participate in small scale village projects, particularly church groups and women's groups</li> </ul>

## The Fly River catchment

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Issue	Assumption	Effect
Environment/ biodiversity	<ul style="list-style-type: none"> <li>• Tailings Dam trialled and effective for existing level of waste</li> <li>• Accelerated logging</li> <li>• Small extensions of existing Wildlife Management Areas (Tonda etc.) and limited protection of key off-river water bodies</li> </ul>	<ul style="list-style-type: none"> <li>• Gradual lowering of toxicity, improved fishing</li> <li>• Some local revenue, Wokabaut Somils offer alternatives</li> <li>• Negligible long term effect. Possible basis for extensions and limited eco-tourism opportunities</li> </ul>
Related national actions	<ul style="list-style-type: none"> <li>• Continuing decentralisation of responsibilities to Provincial Government</li> <li>• Oil/petroleum extraction to east of area</li> </ul>	<ul style="list-style-type: none"> <li>• Limited by capacity/ capability of officers</li> <li>• Upgraded infrastructure/services for joint usage</li> </ul>

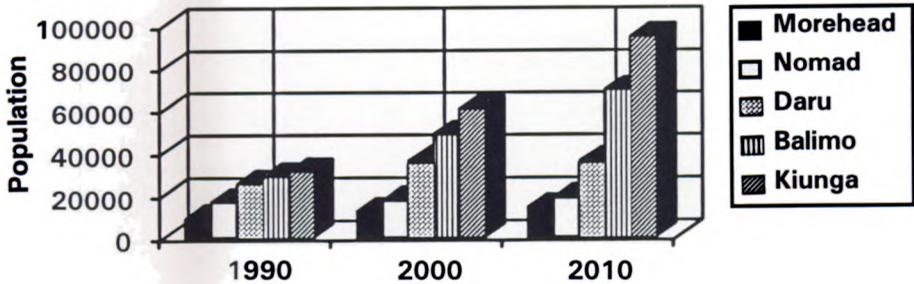
### Scenario 1 - Business as usual: summary of risks

Mining retains its pre-eminent economic position. Government commitment to its success creates over dependency, stifling local anticipation and diversification. Wealth continues to improve whilst mines are operative but subsequent decline of quality could lead to a spiral of social/economic decline post-2010 and increasingly unsustainable use of remaining resources - fisheries and forest - for quick profit. Regional imbalance remains, with no effective economic 'trickle-down' to act as a counterbalance.

## Scenario 2 - Expansionist

An open-ended scenario, depending on the extent of new development of mineral resources. A more exaggerated settlement pattern benefiting growing established centres of Kiunga and Balimo at the expense of Daru (urban) and rural communities of Nomad and Morehead as the drift away from more remote and increasingly polluted river systems takes effect.

Population growth rate at 3.7%.



Population trends. Scenario 2 - Expansionist (see Figure 12, page 60)

Issue	Assumption	Effect
Economic activity	<ul style="list-style-type: none"> <li>Mining continues at Ok Tedi and Porgera</li> <li>Substantial new deposits in vicinity of both existing mines</li> <li>Small medium scale manufacturing and service industry grows steadily, in response to mining</li> <li>New large scale logging controlled side by side with local growing eco-timber activity</li> </ul>	<ul style="list-style-type: none"> <li>Current output ceases between 2005 and 2010, switching to new reserves</li> <li>Mining continues at current levels to beyond 2050</li> <li>Kiunga population would be around 7,000 by 2010 and continue to grow at a slower but steady rate thereafter</li> <li>Encourages some stability in village development</li> </ul>

<b>Issue</b>	<b>Assumption</b>	<b>Effect</b>
	<ul style="list-style-type: none"> <li>• Rubber, limited in quantity, grown near Kiunga and exported via Balimo where more rubber is grown: along with livestock</li> <li>• Balimo interacts economically with Daru and Kiunga</li> </ul>	<ul style="list-style-type: none"> <li>• Balimo develops as a strong secondary centre with rubber, livestock and as centre for eco-tourism</li> <li>• Daru continues decline as provincial centre</li> </ul>
Population health and welfare	<ul style="list-style-type: none"> <li>• Overall population growth/health and welfare similar to Scenario 1, due to financial input of mining companies to health-related programmes</li> </ul>	<ul style="list-style-type: none"> <li>• Steady population growth and mine-related immigration maintains regional population beyond 2010 but increased dependency on mine activities</li> </ul>
Settlement pattern	<ul style="list-style-type: none"> <li>• Steady growth of key centres will continue with more money for mine-related infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>• Key centre growth will accelerate village depopulation except where logging option exists. Fishing still depressed through mine pollution</li> </ul>
Government policy	<ul style="list-style-type: none"> <li>• Similar to Scenario 1, but relatively low level of genuine community participation</li> </ul>	<ul style="list-style-type: none"> <li>• Increased population and economic dependency on mining further weakens effective Provincial Government welfare/infrastructure activities</li> <li>• Government dependency on mining makes environmental protection less determined and lessens long term sustainability beyond 2050</li> </ul>

<b>Issue</b>	<b>Assumption</b>	<b>Effect</b>
NGO involvement	<ul style="list-style-type: none"> <li>• NANGO becomes stronger due to involvement at Government policy level but still over-ruled by mining concerns on environmental issues relating to river pollution</li> </ul>	<ul style="list-style-type: none"> <li>• No real incentive to foster alternatives to mining whilst productive: Slowly improving forestry and environmental legislation helps NGOs, on logging issues in particular</li> </ul>
Environment/ biodiversity	<ul style="list-style-type: none"> <li>• Tailings Dams Lukwi 420/ Lukwi 477 ineffective for retention of new loads of tailings beyond 2006 - increased sedimentation although increased sulphadisation reduces copper losses to river system</li> </ul>	<ul style="list-style-type: none"> <li>• Feral animals a biodiversity problem. Toxicity remain high and river system less productive creating social tension and more demands for compensation over a broader area. Logging adds to river sedimentation through runoff</li> </ul>
Related national issue	<ul style="list-style-type: none"> <li>• Central Government involvement in the area increases as partner in mining</li> </ul>	<ul style="list-style-type: none"> <li>• Local representation/ participation in provincial affairs declines. Greater emphasis on research and training for mining</li> </ul>

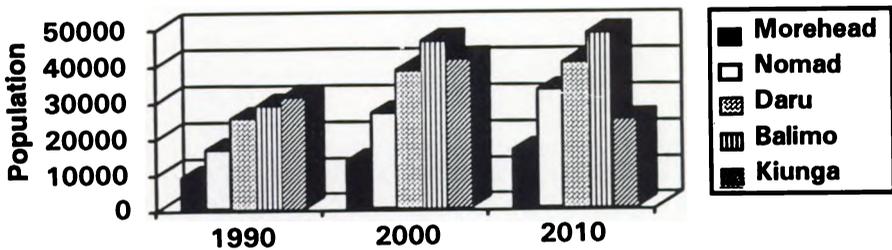
**Scenario 2 - Expansionist: summary of risks**

The extension of mining beyond 2010 would prolong the economic dependency of the Western Province on mine-related activities to the detriment of developing longer term sustainable livelihood options. The continued loss of river-based and forest-based biodiversity makes recovery beyond 2050 more difficult and expensive. Risking of social disruption on a greater scale with expectations of a considerably larger population. (See extrapolation of population figures for each scenario - Figure 7.)

**Scenario 3 - Contracting**

The cessation of mining between 2005 and 2010 will have wide ranging repercussions, particularly if, as with this scenario, no alternative livelihoods are developed in advance. It is anticipated that a significant (but not dramatic) reversal of population could occur to southern and traditional subsistence areas, particularly as river sedimentation will ease and pollution levels drop (longer term copper residue release from sedimentation is not taken into account). Balimo could again be a beneficiary, especially if livestock markets in PNG and possibly rubber shipments develop.

Population growth rate - dropping from 3.5 down to 2.9%.



Population trends. Scenario 3 - Contracting (see Figure 14, page 62)

Issue	Assumption	Effect
Economic activity	<ul style="list-style-type: none"> <li>• Mining at Ok Tedi and Porgera declines and ceases by 2010 with no new mining ventures planned or operational</li> <li>• Small, mining-reliant manufacturing/service industry quickly declines</li> </ul>	<ul style="list-style-type: none"> <li>• Greater emphasis on Central/Provincial Government solutions and responsibility towards Fly catchment population</li> <li>• Kiunga in particular experiences social effects of reduced economic activity. Ningerum to slow down whilst Tabubil becomes a serious social problem as mining ceases</li> </ul>

Issue	Assumption	Effect
	<ul style="list-style-type: none"> <li>• Logging becomes an obvious exploitative alternative</li> <li>• Fishing slowly improves but not as rapidly as mining companies would believe, logging causes further deterioration in river system</li> <li>• River pollution and socio-economic effects of mining makes a return to subsistence economy difficult. Skills have been lost</li> </ul>	<ul style="list-style-type: none"> <li>• Urgency to maintain economic activity denies sensible, long term sustainable planning in favour of clear-felling and further, rapid decline of resource base, including fishing</li> <li>• Whilst fish productivity improves, longer term release of copper from sediments could counteract benefits. Extensive and detailed monitoring essential despite cost. (Who bears this cost?)</li> <li>• Drift away from province by younger, more skilled population (see below)</li> </ul>
<p>Population health and welfare</p>	<ul style="list-style-type: none"> <li>• Population grows but more slowly, greater number of dependents in work force</li> <li>• Health service, long bolstered by mining-money and skills declines</li> </ul>	<ul style="list-style-type: none"> <li>• The start of a vicious cycle of economic/ social decline unless halted by Government policies to develop belatedly, sustainable livelihoods and subsidise the transition</li> <li>• Partial return to village beliefs (animism, shamanism etc.) causing socio-cultural confusion and not benefiting clan community unity</li> </ul>

<b>Issue</b>	<b>Assumption</b>	<b>Effect</b>
	<ul style="list-style-type: none"> <li>• Young people move away for education, training and employment</li> </ul>	<ul style="list-style-type: none"> <li>• Some may return after qualification but any benefits are very long term and ill-defined</li> </ul>
Settlement pattern	<ul style="list-style-type: none"> <li>• Main centres grow more slowly following impetus of mining and immigration</li> <li>• South fails to regain dominance over northern settlement</li> </ul>	<ul style="list-style-type: none"> <li>• Kiunga may only reach 5,500 by 2010</li> <li>• Daru may barely reach 9,000 as northern migration exceeds inward migration of fishing clans. Balimo may be the exception as its opportunities are spread between livestock, rubber, river transport and even tourism</li> </ul>
Government policy	<ul style="list-style-type: none"> <li>• Government will have to re-think its mining driven response to socio-economic progress</li> <li>• Little other than livestock offers processing/ packaging requirements. Rubber limited in location/ market. Spices unreliable</li> <li>• Government may refocus on Fly River fish productivity</li> </ul>	<ul style="list-style-type: none"> <li>• Involvement of NGOs, provincial councils and local clan community leaders essential</li> <li>• Switch to logging as revenue earner may not be balanced by ecological sustainability concern</li> <li>• Re-establish river based communities</li> </ul>

Issue	Assumption	Effect
NGO Involvement	<ul style="list-style-type: none"> <li>• Government could turn to NGOs to help deliver social welfare and infrastructure in absence of mining involvement - but will need to provide financial incentives</li> </ul>	<ul style="list-style-type: none"> <li>• Opportunity for local NGOs to demonstrate small scale sustainable option</li> </ul>
Environment/ biodiversity	<ul style="list-style-type: none"> <li>• Less river disturbance through mining waste</li> <li>• More pressure on existing timber resources</li> <li>• Some interest but little opportunity for eco-tourism</li> </ul>	<ul style="list-style-type: none"> <li>• Revert to fishing but population means more pressure on fish resources, encouraging unsustainable practices</li> <li>• Mixed effects depends on NGO/ local community impact on awareness and training in eco-timber practices</li> </ul>
Related national issues	<ul style="list-style-type: none"> <li>• Decentralisation/ bolstered Provincial Government forced upon Central Government to turn around declining status of Western Province</li> </ul>	<ul style="list-style-type: none"> <li>• More small village grants administered by NGOs</li> </ul>

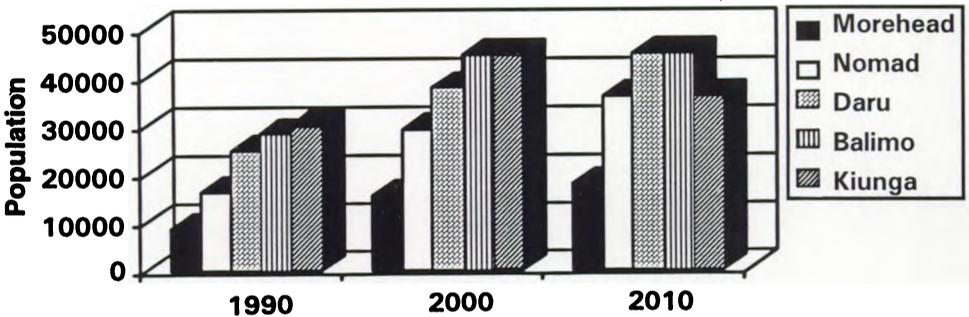
**Scenario 3 - Contracting: summary of risks**

Without immediate mining benefits or alternative livelihoods the options are limited. A part of the population could return to the cultural demands of subsistence, while others would opt to move elsewhere for retraining or to use mining-acquired skills. There is no guarantee that the remaining population would have any option other than use available natural resources for any economic gain - or face ill health and poverty.

**Scenario 4 - Sustainable, mixed alternatives**

A deliberate policy shift from mining to a mix of subsistence - marketable products, relying on the multi-track development of sustainable livelihoods from now until 2010 will help the Western Province overcome its dependency on mining and provide a more equitable spread of tangible benefits and improved quality of life for the rural areas for Daru, Morehead, Balimo and Nomad.

Population growth rate at 3.5% declining to 3.3%.



Population trends. Scenario 4 - Sustainable (see Figure 18, Page 66)

Issue	Assumption	Effect
Economic activity	<ul style="list-style-type: none"> <li>Mining activity winds down and ceases by 2010, however well before then a mix of long term livelihood options is developed using Government, private enterprise and community initiatives (including NGOs)</li> </ul>	<ul style="list-style-type: none"> <li>Improved research, training, better grading standards. Integrated pest management. Increased liaison with Food Technology Groups Unitech especially re business plans for manufactured food</li> </ul>

Issue	Assumption	Effect
	<ul style="list-style-type: none"> <li>• Alternative export crops, e.g. mint oil/black pepper/ nutmeg/mace requiring careful packaging and processing(pyrethrum, chillies have not proved as successful)</li> <li>• Tree crops risky without more research, extension and support from industry, especially palmoil, copra, some rubber</li> <li>• Livestock - based on smallholder semi subsistence, e.g. beef cattle in selected grassland areas</li> <li>• Deer ranching of feral populations feasible - medicinal by-products, dried meat, venison</li> <li>• Eco-timber enterprises developed</li> <li>• Artisanal fishing, fish farming developed</li> </ul>	<ul style="list-style-type: none"> <li>• Opportunity to develop small scale, sustainable agriculture limited by soil resources and climate</li> <li>• Long term research, research/training opportunities in conjunction with university and technical institutions</li> <li>• Balimo is well located for trials. More credit facilities for smallholders</li> <li>• Alternative sustainable option with export potential</li> <li>• Awareness/practical training in sustainable use of Wokabaut Somils essential</li> <li>• Developing current subsistence practices</li> </ul>
<p>Population, health and welfare</p>	<ul style="list-style-type: none"> <li>• As mining slows, some population drift occurs, but anticipatory Government programmes help focus on links between rural producers and urban market/packaging and processing</li> </ul>	<ul style="list-style-type: none"> <li>• Mining companies to set aside money for longer term health plans at Government insistence</li> </ul>

<b>Issue</b>	<b>Assumption</b>	<b>Effect</b>
Settlement pattern	<ul style="list-style-type: none"> <li>• Whilst urban areas maintain momentum, emphasis on rural sustainable livelihoods helps encourage a slow decentralising effect so that riverside villages/class/communities start to gain population again, e.g. middle Fly and Tomu Rivers. East Awin could become an influential off-river semi-subsistence local economy</li> <li>• River transport remains the key means of cheap movement</li> </ul>	<ul style="list-style-type: none"> <li>• The separate catalytic effects of sustainable livelihood trials start to merge into a web of small scale, mutually supportive enterprises</li> <li>• Possible introduction of appropriate local boat building</li> </ul>
Government policy	<ul style="list-style-type: none"> <li>• Formal recognition of the partnership role with NGOs, including policy to protect small sustainable livelihood activities until effective</li> <li>• Foster local needs and small surplus in forestry, fisheries, agriculture, conservation and eco-tourism</li> <li>• Focus on reliable local funding, awareness raising conservation measures and institutional strengthening</li> </ul>	<ul style="list-style-type: none"> <li>• Policies designed to merge top-down, with bottom-up approaches to participatory sustainable livelihoods, linking with international aid/ NGO funding and credit research/ training with private enterprise money, local institutions</li> <li>• Closer cooperation between private enterprise, NGOs and universities on research/training needs</li> <li>• With development of suitable off-shore credit/Green Technology Transfer Fund the bottom-up/top-down funding can be further enhanced</li> </ul>

Issue	Assumption	Effect
NGO involvement	<ul style="list-style-type: none"> <li>• NGOs willing and able to participate in government-led initiatives for sustainable livelihood options</li> </ul>	<ul style="list-style-type: none"> <li>• Interactive, slow paced growth of appropriate and sustainable livelihoods</li> </ul>
Environment/ biodiversity	<ul style="list-style-type: none"> <li>• Forestry becomes the mainstay of sustainable livelihoods revival but requires greater reliance on NGO involvement in awareness raising/ demonstration projects and marketing</li> </ul>	<ul style="list-style-type: none"> <li>• Small community enterprises safeguarding biodiversity and river integrity. Eco-tourism a viable alternative to logging</li> </ul>
Related national actions	<ul style="list-style-type: none"> <li>• Mining/petroleum activities still continue but only if they reinforce the non-dependency sustainable livelihood approach</li> </ul>	<ul style="list-style-type: none"> <li>• Mining becomes a social as well as economic asset, rather than a divisive force in the community</li> </ul>

#### Scenario 4 - Sustainable, mixed alternatives: summary of risks

The lead time to establish participatory livelihoods is lengthy and requires the positive recognition of its worth by Government, private enterprise, educational institutions and local communities/NGOs. Too little too late will create a vacuum in which social disharmony, crime and violence could thwart genuine efforts of sustainable livelihoods.

## Appendix 2

### Strategies for sustainable development

As a follow-up to the Regional Environmental Assessment of the Fly River Catchment, the Papua New Guinea Department of Environment and Conservation, with assistance from IUCN, developed a draft project proposal for a sustainable development strategy for the Fly River catchment. This was done in consultation with many of the parties interested in the future of the region, including central government agencies, the Department of Western Province, OTML and community leaders.

Three main goals would be pursued through this project. These are:

- the development of sustainable livelihoods for the communities of the region;
- the conservation of biodiversity; and
- effective environmental management.

The project would focus on one area within the Fly River catchment and include communities that have been affected by mining activities. But the project would also assist national and regional organisations build the skills and undertake the planning that would be required when the support of the project comes to an end.

Several principles would guide the project. These principles are based on the accumulated experience of IUCN and other agencies in undertaking strategies for sustainability (Carew-Reid *et al.*, 1994). For the proposed project the most important of these principles are:

- to maximise the participation of communities whose values, knowledge and institutions are critical to achieving the project goals;
- to build capacity within the communities and the organisations that support them and to do this in a way where responses are developed according to local conditions and by the people who need to implement these responses; and
- to be adaptive, learning from experience gained on this and related projects and to bring this experience back into project design and management.

A key underlying assumption is that the overall goal of sustainable development will not be successfully pursued unless national, provincial as well as local resource management capacity is enhanced. For this reason, several project activities are directed at building institutional capacity at the national and provincial levels. They are also directed at building linkages with PNG's National Sustainable Development Strategy and with national programmes in forestry and other sectors. This approach will help enable the goals of the project to be pursued beyond the life of the project itself and beyond the boundaries of the project area.

The project proposal acknowledges the work already started by the Ok Tedi Development Trust and the Government of Western Province to invest in development activities that are sustainable. The work undertaken through the project would complement and reinforce these measures.

The implementation of the project is dependent upon obtaining external sources of funding and will be considered by the Government of Papua New Guinea as a project for development assistance.

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This report is one of a number of guidelines, reports and case studies being produced by IUCN and forming part of a series of publications of the Environmental Assessment Service. The objectives of this publication series are:

- to communicate to a wider audience the experience gained by IUCN and collaborating organisations in environmental assessment and management;
- to learn from experience; and
- to enhance environmental assessment and management.

IUCN welcomes assistance and collaboration in the production of these publications such as has been contributed by IRISH AID, The German Ministry of Economic Cooperation and Development and the Oil Industry International Exploration and Production Forum - the E&P Forum.

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As a Union, IUCN exists to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. A central secretariat coordinates the IUCN Programme and serves the Union membership, representing their views on the world stage and providing them with strategies, services, scientific knowledge and technical support they need to achieve their goals. Through its six Commissions, IUCN draws together over 6000 expert volunteers in project teams and action groups, focusing in particular on species and biodiversity conservation and management of habitats and natural resources. The Union has helped many countries to prepare National Conservation Strategies, and demonstrates the application of its knowledge through the field projects it supervises. Operations are increasingly decentralized and are carried forward by an expanding network of regional and country offices, located principally in developing countries.

The World Conservation Union builds on the strengths of its members, networks and partners to enhance their capacity and to support global alliances to safeguard natural resources at local, regional and global levels.

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