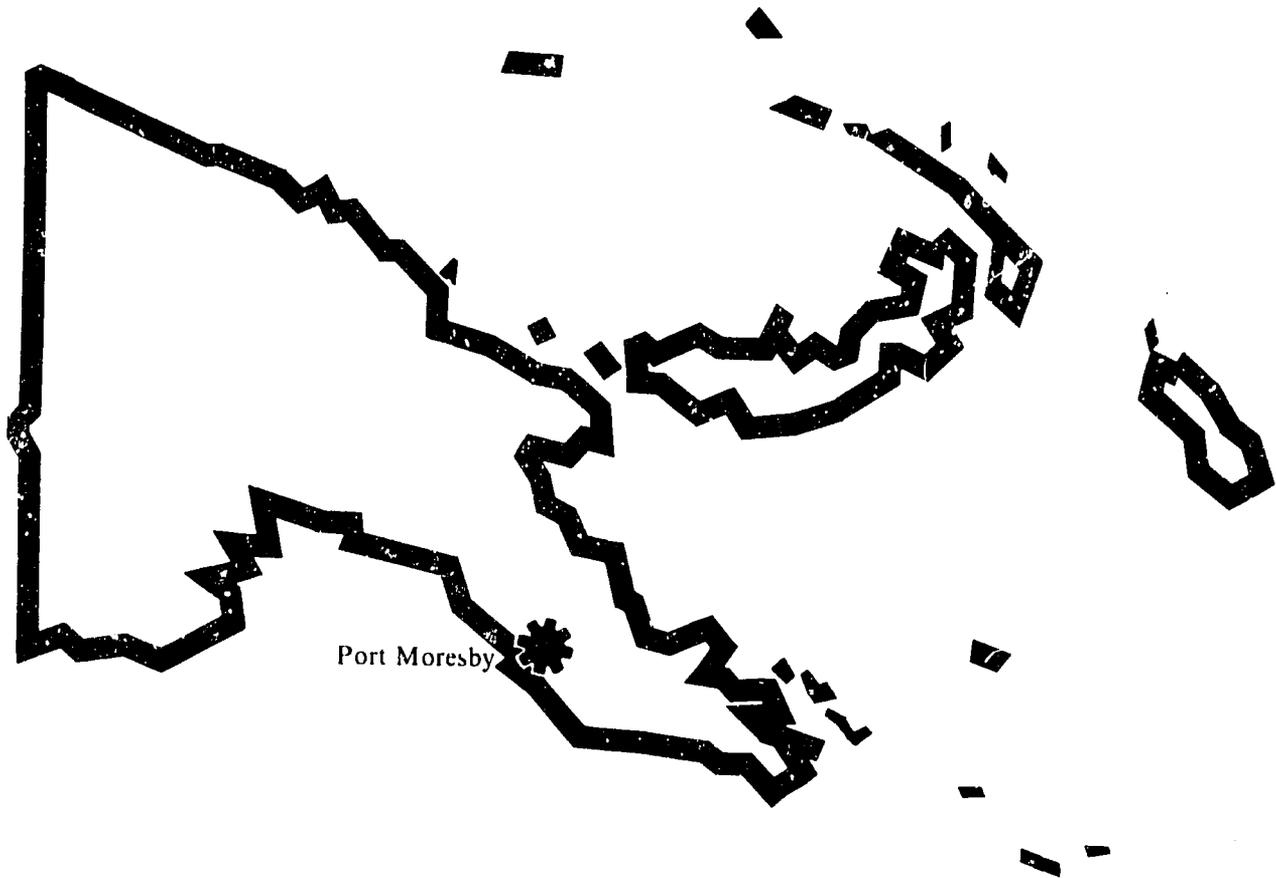
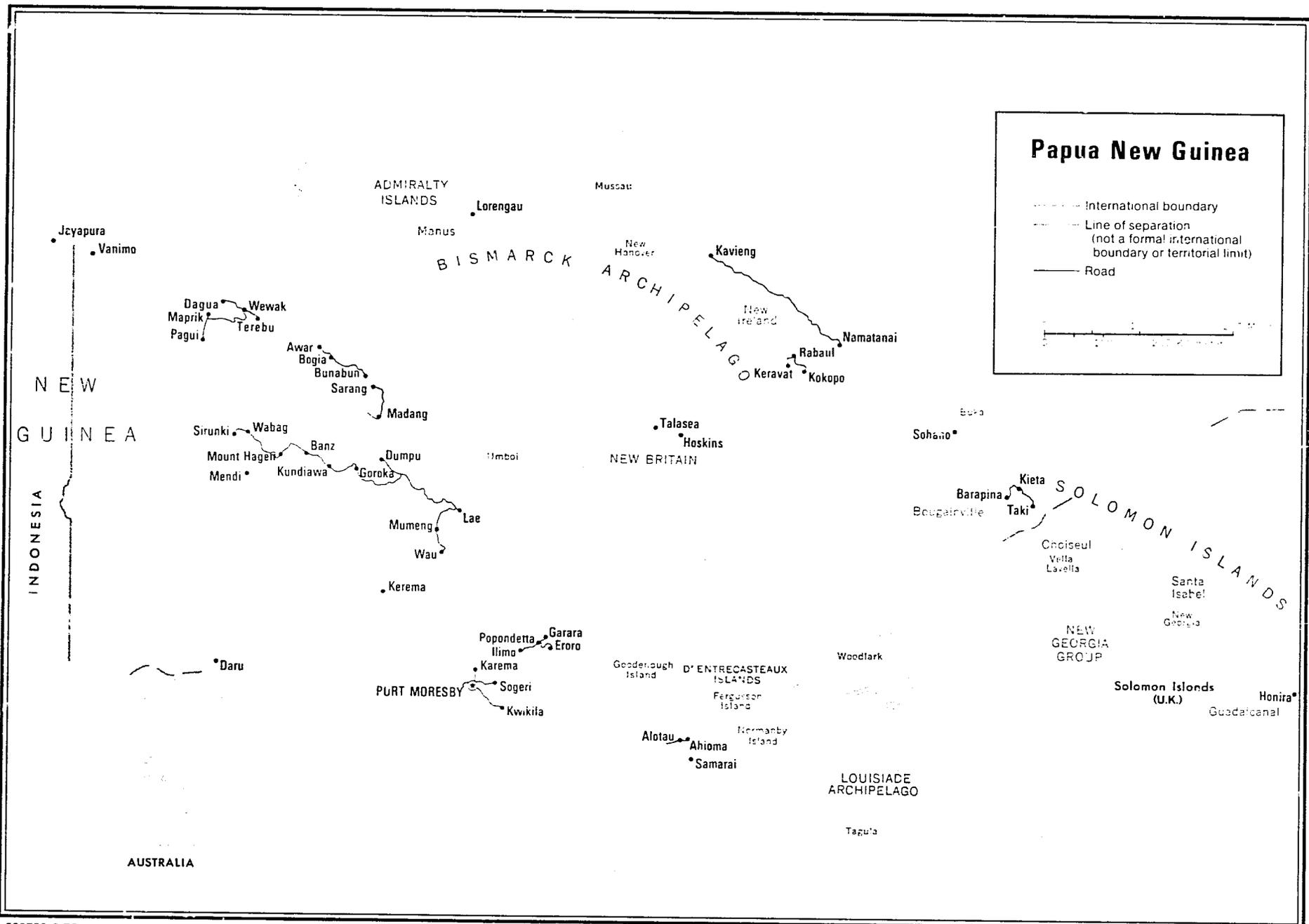


Papua New Guinea

A Country Profile





PAPUA NEW GUINEA: A COUNTRY PROFILE

prepared for

The Office of U.S. Foreign Disaster Assistance
Agency for International Development
Department of State
Washington, D.C. 20523

by

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Evaluation Technologies, Inc.
Arlington, Virginia
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The country profile of Papua New Guinea is part of a series designed to provide baseline country data in support of the planning and relief operations of the Office of U.S. Foreign Disaster Assistance (OFDA). Content, scope, and sources have evolved over the course of the last several years and the relatively narrow focus is intentional.

We hope that the information provided will also be useful to others in the disaster assistance and development communities. Every effort is made to obtain current, reliable data; unfortunately it is not possible to issue updates as fast as changes would warrant.

We invite your comments and corrections. Address these and other queries to OFDA, A.I.D., as given above.

November 1985

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1. General Information1.1 Geographic Codes

AID Standard	889
State Region	ASIA

1.2 Host Mission to the U.S.

Embassy of Papua New Guinea
Chancery: 1140 19th St. N.W.; Suite 503
Washington, D.C. 20036
659-0856

For current information on the Papua New Guinea staff in the United States, refer to the U.S. Department of State, Diplomatic List.

1.3 U.S. Mission to Papua New Guinea

Port Moresby (E), Armit St.
P.O. Box 1492
Tel.: 211455/594/654
Telex: 70322189

For current information on the U.S. diplomatic staff in Papua New Guinea, consult the most recent edition of the U.S. Department of State, Key Officers in Foreign Service Posts.

1.4 Time Zones

GMT+10; EST+15

1.5 Currency

.9840 Kina (K) = U.S. \$1.00 (September 1985)
The kina is made up of 100 toea.

1.6 Travel and Visa Requirements

- Passport and Visa: Passport and visa required. Check Embassy, Washington, D.C. 20036 (202-659-0856) for specific requirements.
- Health Requirements: Yellow fever vaccination certificate required of travelers over one year of age arriving from infected areas.

1.7 Calendar and Holidays

New Year's Day.....	January 1
Good Friday.....	*
Easter Saturday.....	*
Easter Sunday.....	*
Queen's Birthday.....	June 10
Remembrance Day.....	July 23
National Constitution Day.....	August 28
Independence Day.....	September 16
Christmas Day.....	December 25
Boxing Day.....	December 26

* moveable religious holidays. Each of the 19 provinces also has a provincial holiday.
Fiscal year: January 1 - December 31.

1.8 Treaties and Agreements

Aviation, Consuls, Extradition, Investment Guaranties, Peace Corps, and Postal Matters.

1.9 International Organization Memberships

ADB, ANRPC, CIPEC (associate), Commonwealth, ESCAP (associate), FAO, G-77, GATT (de facto), IBRD, ICAO, IDA, IFAD, IFC, ILO, IMF, IMO, INTELSAT, INTERPOL, ITU, South Pacific Bureau for Economic Cooperation (SPEC), South Pacific Commission, South Pacific Forum, UN, UNESCO, UPU, WHO, WMO.

1.10 Geography

Location and Area:

The territorial boundaries extend from the equator to 12° S latitude and from 141° to 160° E longitude. With a land area of about 462,000 sq. km, Papua New Guinea comprises the eastern half of the island of New Guinea (Indonesia's province of Irian Jaya occupies the western portion), the Bismark Archipelago (New Britain, New Ireland, Manus), the northernmost Solomon Islands (Bougainville and Buka), and several small islands off the easternmost part of the mainland (the Trobriand, D'Entrecasteaux, and Louisiade groups).

Geographic Type:

Papua New Guinea has a highly varied terrain. A complex system of high mountain ranges forms the central core of the main island. Peaks towering to 4,500 meters are interspersed with broad intermontane valleys. Between the central cordillera and a series of narrow ranges on the northern coast lies a great depression comprising the basins of the Sepik, Raru, and Markham rivers. Southwest of the central mountain chain, an extensive area of alluvial plains and swamps is crossed by the Fly and Strickland rivers. This lowland abuts the limestone and alluvium covered Oriomo Plateau. A chain of volcanic islands, including the Bismark Archipelago and the Solomon Islands, extends in an arc to the north and east of the main island.

Climate:

The climate is monsoonal, with wet and dry seasons influenced by southeasterly and northwesterly wind systems. Some analysts suggest that a three season division is more accurate: a wet season over much of the country (January - April); a dry period (May - August); and a transitional season (September - December). Topographic influences alter rainfall patterns, however, to create exceptions to this regime, and the south coast of New Britain and southern Huon Peninsula receive maximum precipitation during the otherwise dry season. Differences in altitude and configuration produce local micro-climates, especially in the highlands.

The average annual rainfall is between 2.0 and 2.5 meters, but there are wide variations. The highlands receive 2.5 to 4.0 meters annually, while the Port Moresby area receives only about 1.0 m and the more easterly highland valleys about 1.5 m. As in other tropical regions, seasonality is determined more by rainfall than by temperature which varies little throughout the year. The mean temperature ranges from about a 22°C minimum to a maximum of 31° C in the lowlands. Absolute temperatures are lower in the highlands and the diurnal range is wider. Night frosts occur above 1,200 meters.

1.11 History and Government

Historical and Political Background:

Little is known about the origins and pre-history of the people of New Guinea. Archaeological evidence suggests that sedentary agriculture was practiced in some parts of the highlands at least by 7,000 B.C., but authorities speculate that the earliest inhabitants of New Guinea may have migrated from Asia as long as 50,000 years ago. Colonization began in the early nineteenth century, some 200 years after the first European sighting of the island. The Dutch claimed the western half of New Guinea in 1828 and set up administrative posts in 1898. The northeast quadrant came under German control in 1884, the same year Great Britain established a protectorate over the southeastern quadrant.

Australia assumed a mandate over German New Guinea after World War I, having also administered British New Guinea as Papua since 1906. Civil administration was suspended in both territories in 1942 when Japan invaded New Guinea. After World War II, Papua and New Guinea were combined under Australian administration as a U.N. trust territory, and in 1972 the name of the territory was changed to Papua New Guinea. The territory became self-governing in 1973 but, because of separatist movements, did not achieve full independence until September 16, 1975. The western half of the island, mean-

while, came under Indonesian control in 1963 and became the province of Irian Jaya in 1969. The Pangu Party, under Michael Somare, has led the PNG government since independence, with the exception of the years 1987-82 when the People's Progress Party had control.

Government Structure: Papua New Guinea is an independent parliamentary state within the Commonwealth. The one chamber Parliament consists of district and provincial representatives and up to three nominated members. The British sovereign is the head of state, represented by a Governor General who must be a citizen of Papua New Guinea. Executive power is vested in a Cabinet headed by a Prime Minister. An independent judiciary includes a Supreme Court, a National Court, and lower courts.

Regional Organization: In a move to decentralize administration, the central government has transferred specific functions to the 19 provincial governments. Each province has an elected assembly and a Cabinet and is responsible for provincial roads, some health matters, and various development projects. In addition, there are more than 160 local government councils.

1.12 Ethnic and Sociocultural Groups

Although some ethnologists refer to the people of the interior as Papuans and the coastal people as Melanesians, most indigenous Papua New Guineans are considered to be related to other Melanesian populations in the South Pacific. Wide variations exist, however, in skin color and height within this ethnically distinct group. In some of the outlying islands, small minorities are predominately Micronesian or Polynesian. The expatriate population, commonly referred to as "European", makes up about one percent of the total population. This group, which is largely Australian, tends to be an elite minority, predominately urban, and transient rather than settlers. A small Asian popula-

tion makes up a more stable non-indigenous group.

Exposure of the coastal people to western culture began with colonization in the late nineteenth century, but the highlanders' first contact with the outside world came only in the 1930s or later. The various groups were isolated even from one another by the rugged mountainous terrain - a fragmentation which remains an obstacle to the development of a sense of national unity. The clan was the primary social unit in the traditional society. Recurrent warfare between highland groups and the customary separation of the sexes in some tribes tended to define roles: men were the warriors and leaders of ritual, and women were the child rearers and the principal agents of food production. The prohibition against warfare by the colonial administration deprived men of a major social role and created a challenge for contemporary society in channeling that manpower into productive avenues.

1.13 Languages

The more than 700 languages spoken in Papua New Guinea come under two broad groups: the Melanesian or Austronesian sub-family found mainly in coastal regions and the non-Austronesian group found in the highlands. The isolation of the various tribes accounts for the great diversity. It has been estimated that there is a separate language for each 14,000 sq. km. English is taught in the schools and its use is growing. English and Pidgin English are official languages. Motu is widely spoken in the southern part of the country.

1.14 Religions

About 80% of the population is nominally Christian; however, magico-religious beliefs and practices persist as an integral part of

the culture. Many Papua New Guineans adhere to traditional systems of belief based on ancestor and spirit worship.

1.15 Population

National Demographic Characteristics:

The September 1980 census recorded a total population (provisional) of 3,006,799. This figure had grown to an estimated 3,228,000 by 1984. The population growth rate is estimated at 2.1%.

Density per sq. km	6.6
Density per sq. km of agricultural land	644.4
Percent urban	16.8
Urban growth rate (percent)	6.6
Age structure (percent)	
0-14 years	41.8
15-64 years	54.9
65 and above	3.3

Source: World Bank estimates
(1980-82)

Regional Distribution: Papua New Guinea's population is overwhelmingly rural and widely scattered. The largest concentrations are in the highland provinces where 40% of the population lives. The administrative capital of Port Moresby had an estimated total of 144,300 in 1984. Other major cities had the following estimated populations: Lae 73,400; Madang 23,700; Wewak 22,100; and Goroka 20,900. The rate of rural-urban migration has grown significantly in recent years. Port Moresby grew nearly 9% between 1970 and 1980.

Provinces and Population

<u>Province</u>	<u>Admini- strative Center</u>	<u>Area (sq. km)</u>	<u>Population (1984 estimate)</u>
Central	Port Moresby	29,500	122,700
Chimbu	Kindiawa	6,100	183,600

<u>Province</u>	<u>Admini- strative Center</u>	<u>Area (sq. km)</u>	<u>Population (1984 estimate)</u>
Eastern			
Highlands	Goroka	11,200	296,000
East New			
Britain	Rabaul	15,500	138,400
East Sepik	Wewak	42,800	240,800
Enga	Wabag	12,800	174,900
Gulf	Kerema	34,500	67,600
Madang	Madang	29,000	228,700
Manus	Lorengau	2,100	27,500
Milne Bay	Alotau	14,000	137,900
Morobe	Lae	34,500	340,600
National			
Capital			
District	Port Moresby	240	133,300
New Ireland	Kavieng	9,600	70,800
Northern	Popondetta	22,800	83,800
North			
Solomons	Kieta	9,300	137,600
Southern			
Highlands	Mendi	23,800	250,900
Western	Daru	99,300	86,200
Western			
Highlands	Mount Hagen	8,500	287,800
West New			
Britain	Kimbe	21,000	98,700
West Sepik	Vanimo	36,300	120,200
Total		462,840	3,228,000

Source: Encyclopedia Britannica. Book of the Year 1985.

1.16 Health

Vital Statistics:	Births/1,000 population	40.1
	Deaths/1,000 population	13.4
	Infant mortality/1,000 live births	97.0

Life expectancy at birth/ years (1980-85)	
Male	53.5
Female	53.0
Population per physician (1980)	16,052
Population per hospital bed (1980)	243

Source: Encyclopedia Britannica. Book of the Year 1985. (1983 estimates)

Major Health Problems: Information on the health status of Papua New Guineans is very limited due to the isolation of a large portion of the rural population. The level of health is generally poorer in rural than in urban locations because of the low level of environmental hygiene and the lack of services and disease control programs in rural areas. Despite government attempts at control, malaria remains a major health problem among the indigenous population, increasing susceptibility to other ailments. The leading causes of morbidity and mortality are pneumonia, malaria, gastroenteritis, parasitic diseases, and tuberculosis.

Diet and Nutrition: Heavy reliance on starchy food contributes to poor nutrition, especially in children in less developed areas. Anemia is prevalent in both adults and children. The staple foods are taro in the lowlands, the sweet potato in the highlands, and sago in the swampy regions of the river deltas. With the poultry and livestock industries in an early stage of development, grubs and small game animals are the main sources of animal protein in the rural diet. Pigs are kept by most families in the highlands but are consumed mainly on ceremonial occasions.

1.17 Economy

Basic Indicators:	Gross National Product (1982)	\$2,280.8 million
	GNP per capita (1983)	\$800

Average annual growth rate (%) (1975-82)	1.7
Exports, NFS (1983)	\$918.2 million
Imports, NFS (1983)	\$1,367.0 million

Source: World Bank. West Sepik Development Project Report. October 11, 1984.

Overview:

Papua New Guinea's economy is highly dualistic, with only about 15% of the population employed in the monetary sector (mining, government, manufacturing, and services) and most of the remaining 85% engaged in traditional subsistence agriculture. Despite reasonably good soils, adequate rainfall, and extensive mineral, forestry, and fisheries resources, the country remains poor and underdeveloped. The relatively high \$800 per capita income is skewed by the inclusion of expatriate incomes and the value-added of such enclave enterprises as Bougainville Copper, Ltd. (BCL). With the exception of the years 1978 and 1979 when real GDP rose at over 5% per annum, the economy has experienced slow growth in the 1970s and 1980s. The estimated GDP growth of 2% in 1983 represented a slight improvement over the previous two years. BCL's value-added to GDP was about 10.5% in 1983. By 1987, the new Ok Tedi gold and copper mine is expected to raise the mining sector's share of GDP by 12.5%. Non-mining industry, largely limited to small scale manufacturing and construction, accounts for 9% of GDP, while government services and agriculture contribute about 25% and 35% respectively.

Balance of Payments:

The balance on current account, including an annual Australian grant, remained generally positive throughout the late 1970s due to copper earnings. However, a dramatic decline in the price of copper and other PNG commodities in the early 1980s, coupled with higher imported oil prices and increased imports, resulted in a current account deficit equal to about 20% of GDP in 1982. Though the deficit remained large (about 16% of GDP), the overall balance was positive in 1983 for the first time since 1979.

Production from the new gold and copper mine, which was scheduled to begin in 1984, is expected to help the balance of payments situation by the mid-1980s.

- Imports:** Food products and other consumer goods, mineral fuels and other intermediate goods and raw materials, and capital goods.
- Suppliers:** Australia, Singapore, Japan, U.S., and New Zealand.
- Exports:** Copper, gold, coffee, cocoa, copra, timber and timber products.
- Export Markets:** Japan, Germany (Fed. Rep.), Australia, U.K., and Spain.
- Agriculture:** Agriculture, including fisheries and forestry, employs over four-fifths of the population and accounts for about 50% of export earnings. The uncertainty of land tenure, a shortage of skilled manpower, and inadequate services for smallholders are obstacles to development, despite PNG's great agricultural potential. The agriculture sector includes three sub-sectors: the estates producing mainly tree crops for export; smallholders growing cash crops, mainly for export; and subsistence farmers growing root crops and vegetables for their own consumption. An estimated 40% of total agricultural output is from the subsistence sector, but the cash and subsistence sectors tend to overlap. Export crops include cocoa, coconut, rubber, coffee, tea, and palm oil. In addition, pyrethrum, chillies, and cardamom are grown for export, mainly by smallholders. The principal food crops are rice, sugar, taro, sweet potatoes, bananas, maize, and vegetables. Livestock, pig, and poultry production is dominated by large operations, although most rural families keep pigs.

1.18 Communications

Radio/Television: The National Broadcasting Commission of Papua New Guinea operates the radio network. Broadcasts are in English, Pidgin, Motu, and 14 other major indigenous languages. There were 215,000 radio receivers in the country in 1983 and 31 AM stations. Television was to be introduced in 1985.

Telecommunications: Telecommunications services, provided by the Department of Public Utilities, include radio-broadcast, radiotelephone and telegraph, coastal radio, and international radio communication. There were 50,050 telephones in use in 1982 (25,554 main phones and 24,496 extension phones).

Press: Papua New Guinea has two national newspapers: The Papua New Guinea Post Courier, published five days a week, Monday to Friday, and The Niugini Nius, published Tuesday to Friday.

1.19 Power

The total installed capacity in Papua New Guinea is about 327.6 MW, of which 99.5 MW is hydrobased. The Papua New Guinea Electricity Commission (ELCOM) operates in 22 local centers, with total installed capacity of 177.1 MW. The private sector, notably Bougainville Copper, Ltd. (installed generation capacity of 135 MW), provides electricity in industrial areas.

1.20 Transportation

Roads: The transport sector in Papua New Guinea is in an early stage of development. Land transport is especially difficult and highly fragmented due to the rugged terrain, sparse settlement patterns, and rural underdevelopment. The road network comprises some 19,000 km, of which 940 km are paved. For administrative purposes, roads are designated national or provincial. Trunk or arterial

roads total 5,000 km; collector and feeder roads make up 13,000 km; and urban roads account for 1,000 km. The major transport artery is the 600 km Highlands Highway extending from the port of Lae to Mendi via Mt. Hagen. The road system, otherwise, consists of a number of regional networks around population centers. The Department of Travel and Civil Aviation (DTCA) is responsible for transport planning, policy, and administration, while the Department of Works and Supply (DWS) is in charge of civil works and maintenance.

Railways:

None.

Inland Waterways:

Inland waterways total 10,940 km in length. Rivers on the south coast are generally navigable for longer distances inland than are those on the north coast. The exception is the Sepik River which is navigable for some 300-500 km. The country's largest river, the Fly, which drains into the Papuan Gulf, is navigable for nearly 800 km.

Ports:

Because of the limited overland system, PNG relies heavily on water transport for inter-island and coastal traffic. There are 18 major sea and river ports, of which 16 are managed by Papua New Guinea Harbours Board and two by mining companies. Some 400 small ports serve the coastal trade.

Shipping:

The government-owned Papua New Guinea Shipping Corp. (PNGSL) provides services to all main domestic ports and to points overseas. The New Guinea Australia Line Pty. Ltd. and the Papua Shipping and Stevedoring Co. operate shipping services in the Pacific region and to other overseas ports.

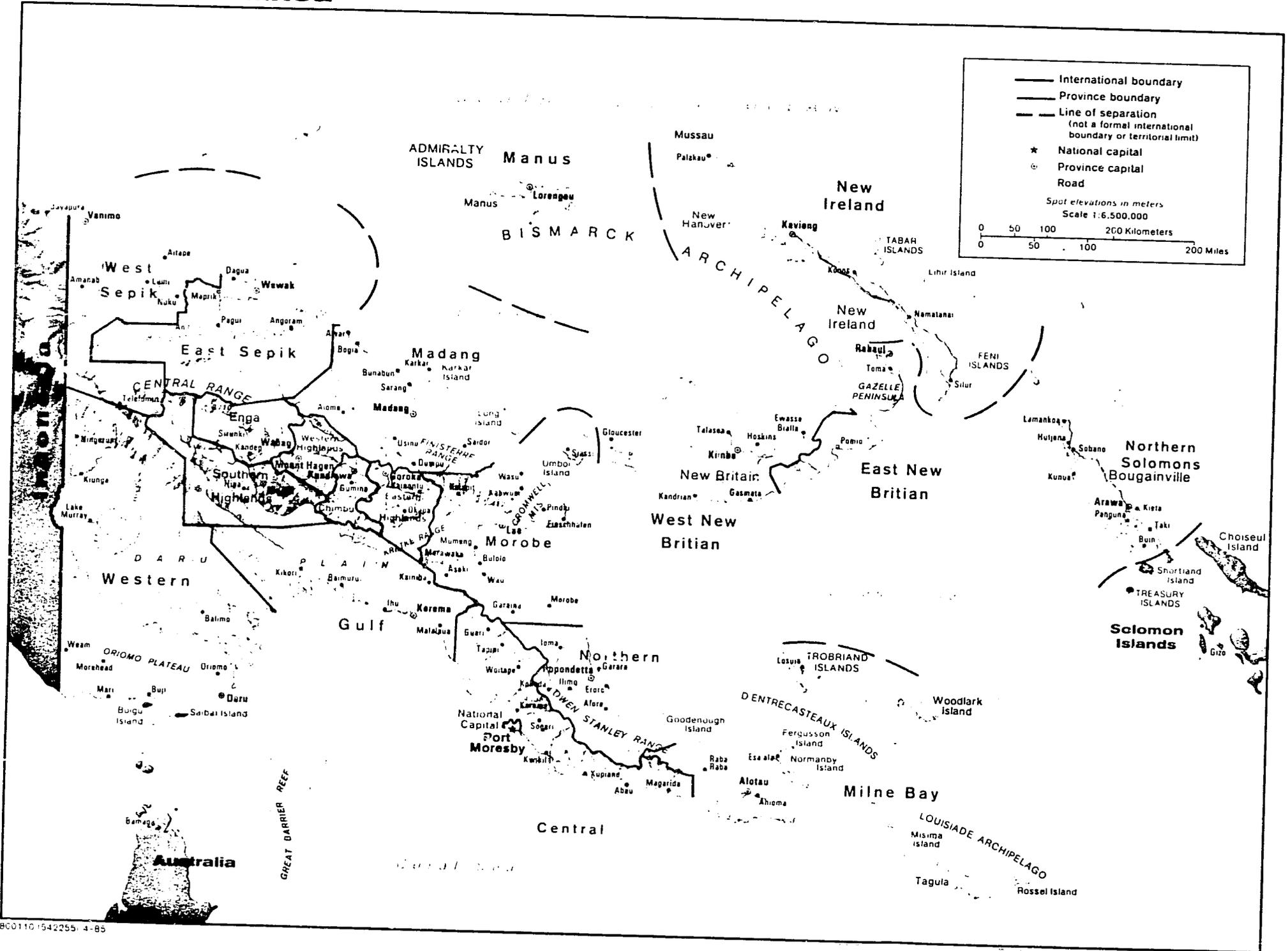
Airports:

Aviation plays a major role in domestic transport, providing the only link with many communities. The country has a total of 425 operational airports and airstrips. Jackson's International Airport at Port Moresby is the main airport. Six other airports are equipped to handle international flights but on a smaller scale.

Airlines:

Air Niugini, the national airline, operates flights to 18 internal airports as well as international services to Brisbane, Cairns, Sydney, Honolulu, Irian Jaya, Solomon Islands, and the Philippines. Small commercial operators service an additional 133 airports.

Papua New Guinea



2. Disaster Vulnerability2.1 Physical Environment

Though located in the equatorial latitudes, Papua New Guinea exhibits a great diversity of climatic types and physical phenomena as a result of the wide altitudinal range of the land mass - from sea level to 4,500 meters. The geologically ancient and eroded base rocks forming the island's core are an extension of the Australian shield which outcrops briefly in the southern part of the country. Most of the mountain building, however, has occurred within relatively recent geological times (within the last 100 million years) during periods of tectonic activity.

The landscape is rugged, dynamic, and unstable, characterized by volcanic activity, especially in the northern arc of islands, and by frequent earthquakes. Erosion, in an initial stage, is vigorous. Landslides are common where steep slopes, sharp ridges, and swiftly flowing rivers are features of the terrain. In lowland areas, the extensive deposition of alluvial material has created flood plains and vast swamps along meandering rivers. Coral reefs extend along the slowly rising northern coasts, but are generally absent from the southern coasts which are subsiding.

The dominant features of the landscape trend generally northwest/southeast in both the mainlands and the islands, with the notable exception of New Britain where the orientation is northeast/southwest. Five distinct regions can be identified. To the north and east of the main island, which contains about 85% of the total land area, lies an arc of volcanic islands including the Bismark Archipelago and the northernmost Solomon Islands. The largest islands in these groups - Manus, New Ireland, New Britain, and Bougainville - are all extremely mountainous, and many of the volcanic peaks are still active.

A broken series of ranges along the north coast of the mainland includes the Torricelli, Prince Alexander, Adelbert, Finisterre, and Saruwaged mountains. The ranges vary in height from 1,500 meters in the west to 4,000 meters in the Huon Peninsula. South of the coastal mountains, a deep structural depression is drained by the Sepik, Ramu, and Markham rivers. These main northward-flowing rivers originate in the central cordillera, a complex system of ranges that make up the mainland's central core. Peaks rise more than 4,500 meters in the central mountains which are recently glaciated and bear evidence of past volcanic activity. The principal units are the Hindenberg, Kubor, Schrader, Bismark, Kratke, and Owen Stanley mountains. The broad upland valleys and plateaus in the central complex have an average elevation of 1,500 meters.

The main rivers flowing south to the Gulf of Papua - the Fly, Strickland, Kikori, and Purari rivers - also have their headwaters in the central highlands. The deltaic plains built up by these rivers cover over 250,000 sq. km - an area described as one of the most extensive swamps in the world. The plains area abuts a long limestone plateau which is one of the wettest regions in Papua New Guinea and is covered by virtually impenetrable forests.

Much of the country's coastline is inaccessible because of swamps and steep cliffs extending to the sea. South coast rivers are generally navigable for greater distances than those on the north coast. The best harbors are also found along the southern coastline.

Despite the country's tropical location, climatic regions are quite varied due to the modifying influences of topographic alignment and altitude. Papua New Guinea is located in the latitudes through which the intertropical convergence zone progresses, and precipitation is dependent on the two wind systems associated with it. Southeasterly winds to the south of the zone are the strongest and most constant; variable north-westerly winds dominate in the north. The climate is seasonal: January to April is wet over much of the country; May to August is dry; and September to December is a transitional period. Not all areas fall into this three-season classification, however. Exceptions are areas of extremely high rainfall such as the more southerly valleys of the central cordillera and areas receiving maximum rainfall during the otherwise dry season (May-August). The latter areas, where mountains lie athwart the southeasterly air flow, include the south coast of New Britain, the southern Huon Peninsula, and the southeast tip of the main island. Port Moresby remains generally dry throughout the period of the southeasterlies since the air flow runs parallel to the coast. With the central cordillera acting as a barrier to the regional flow of air, climatic conditions in the rest of the country are influenced primarily by local circulation. Distinct micro-climates result from the combination of altitude and land configuration. This is especially true in the Highlands.

2.2 Volcanoes

Papua New Guinea has 14 active and 22 dormant volcanoes which threaten the lives of some 204,000 people living in a 16,000 sq. km area. In addition, more than 50 extinct volcanoes have been identified for which there is no historic record of eruptive or solfataric activity. Most of the active and over half the dormant volcanoes lie in the Bismark Arc extending from Kokeo through Kakar, Ritter Island, and Uluwan to Rabaul. Other areas at possible risk are Bougainville Island, East Papua, and the D'Entrecasteaux Islands. Disturbances of possible volcanic origin have also taken place in recent times at two submarine centers in the Bismark Sea. The type of eruption ranges from the catastrophic Krakatoa type to the mildly explosive lava flow. Most of the volcanoes have shown different types of eruptions at different times, making predictions difficult.

Eight of PNG's 14 active volcanoes have erupted violently in the past century, causing destruction and death or requiring evacuation of the people in the surrounding area. The eruption of the Ritter Island volcano in 1888 generated a 12-15 meter tsunami which killed hundreds of people on the coast of neighboring islands. In 1937, the eruptions of Vulcan and Tavurvur volcanoes in Rabaul killed 506 people. Most of the victims lived in the vicinity of Vulcan Island. Less catastrophic activity continued in the Rabaul volcanoes through 1943. A new volcano appeared at the foot of the Goropu Mountains in East Papua as a result of explosive eruptions which continued from September 1943 through August 1944. No fatalities were reported since the area was unpopulated. Mt. Lamington, which had not been active in over 1,000 years, erupted violently in January 1951. A catastrophic nuee ardente devastated a 230 sq. km area and killed 3,000 people. Major eruptions of Manam volcano in the early months of 1958 and again in 1960 caused extensive damage to villages, but, because of the timely evacuation of the island's population, no lives were lost. In March 1979, Karkar volcano in Madang Province erupted, killing two volcanologists. Eruptions in Bagana (1960, 1966) and in Uluwan (1970, 1973, 1978, 1980) volcanoes caused destruction over a wide area but did not cause injuries to the population.

The most recent threat to life and property occurred in 1983/84 when an increase in seismic activity and ground deformation signified that an eruption in one of the Rabaul volcanoes might be imminent. The second stage of a four-stage alert was declared in October 1983, indicating that an eruption was possible within a few months. When activity had subsided by November 1984, the alert was downgraded. The time period between eruptions in Rabaul volcanoes has historically been either 24/28 or 59 years. There was no volcanic activity in 1971, the shorter of the two periods; the longer of the two typical time intervals will expire in the year 2002. (See also Appendix A, Rabaul Volcano.)

A number of factors have been taken into consideration in determining the likelihood of future dangerous volcanic eruptions in Papua New Guinea. Six of those factors have been used to arrive at a hazard rating for the active and dormant volcanoes. [The following description is extracted from Problems of Volcanic Hazards in Papua New Guinea by P.L. Lowenstein. Geological Survey of Papua New Guinea, March 1982.]

- ° The volcano type and composition of recent eruption products. (Volcanoes which have discharged moderate to high silica products are more likely to erupt violently in the future than volcanoes with eruption products of low silica content.)
- ° The geological record of recurrent dangerous activity of the volcano. (The presence of lava domes, calderas, or extensive pyroclastic flows or outlying or strongly aligned satellite centers indicate that a volcano has previously experienced or may again show dangerous or more widespread activity.)

- ° The geological record of volcanic activity in the region in which the volcano is located. (An active or dormant volcano that is situated in a geotectonic region in which volcanic activity is currently widespread is more likely to be a threat in the future than one situated in an area where the majority of volcanoes are either dormant or extinct.)
- ° The historical records of recent dangerous eruptions of the volcano and the amount of damage and fatalities caused.
- ° The present stage of development of the volcano. (Mature volcanoes, especially those with relatively long periods of inactivity, present the greatest threat as historical record may not be long enough to indicate what type of eruption may be expected; however, youthful and senile volcanos may also be unpredictable.)
- ° The present level of activity of the volcano. (Active volcanoes that are not now erupting but produce continuous emissions of vapor are considered more likely to erupt dangerously in the near future than those which are at present completely quiet. Similarly, dormant volcanoes with fumaroles can be considered more likely to erupt than those with only mild or no thermal activity.)

An evaluation of these factors, together with a consideration of the number of people living within the area likely to be destroyed by an eruption, gives an indication, if not an entirely reliable assessment, of the potential danger of each volcano.

Hazard Ratings¹ of Active and Dormant Volcanoes in
Papua New Guinea

Active Volcano	Hazard Rating (less than 16)	Dormant Volcano	Hazard Rating (less than 10)
Rabaul ²	15	Loloru	9
Lamington ²	13	Doma Peaks	8
Manam ²	11	Galloseulo	7
Karkar ²	11	Balbi	7
Ulawun ²	10	Victory	7
Langila ²	7	Yelia	7
Bagana ²	7	Talo	7
Pago	7	Makalia ²	6
Long Is	6	Bamus	6
Ritter Is ²	5	Kadovar	5
Lolobau	4	Garove	5
Goropu	4	Blupblup	4
Bam	3	Sakar	4
Tuluman	1	Garbuna ²	4
		Oiau ²	4
		Lamonai	3
		Dobu ²	3
		Bola ²	2
		Lolo	2
		Kururi	2
		Narage	1
		Wagipa	1

1 Hazard ratings developed by P.L. Lowenstein have been assigned based on an assessment of the six factors discussed above. A rating of sixteen is the highest possible and indicates the greatest threat of imminent damaging volcanic activity.

2 Under surveillance

Source: Problems of Volcanic Hazards in Papua New Guinea.

Population and Areas at Risk Near Active Volcanoes

Region	Volcano	Hazard Area (sq. km.)	Population (1980)
Admiralty Islands	Tulman	1	0
Bismarck Volcanic Arc	Bam	7	674
	Manam	79	5,046
	Karkar	380	23,143
	Long Is	452	1,010
	Ritter Is	1	0
	Langila	314	2,270
	Pago	1,257	10,989
	Lolobau	79	493
	Ulawun	452	1,018
	Rabaul	804	68,964
Bougainville	Bagana	452	147
East Papua	Lamington	2,828	34,467
	Goropu	314	0
	TOTAL	7,418	148,221

Source: Problems of Volcanic Hazards in Papua New Guinea.

Population and Areas at Risk Near Dormant Volcanoes

<u>Region</u>	<u>Volcano</u>	<u>Hazard Area (sq. km.)</u>	<u>Population (1980)</u>
Bismarck Volcanic Arc	Blupblup	7	379
	Kadovar	1	291
	Talo	908	7,509
	Sakar	50	200
	Narage	3	0
	Garove	79	2,361
	Garbuna	154	815
	Bola	50	0
	Makalia	314	451
	Lolo	28	552
	Galloseulo	380	4,343
	Bamus	616	703
Bougainville	Balbi	707	2,408
	Loloru	1,257	14,733
East Papua	Kururi	314	4,150
	Victory	1,257	2,630
D'Entrecasteaux Islands	Wagipa	3	864
	Lamonai	154	775
	Oiau	50	1,599
	Dobu	13	843
New Guinea Highlands	Doma Peaks	1,964	6,166
	Yelia	314	3,652
	TOTAL	8,623	55,424

Source: Problems of Volcanic Hazards in Papua New Guinea.

2.3 Earthquakes

Papua New Guinea is situated in a highly active seismic area. Strong earthquakes capable of causing severe damage occur frequently. The country's relatively sparse settlement has kept both human and property losses to a minimum. However, the risk will increase with population growth and urban development.

In recent years, damaging earthquakes occurred in the Kokopo area of East New Britain (1967); on the southern coast of New Britain Island and in Sepik Province of the mainland (1968); at Madang (1970) with a loss of 15 lives; in the Gazelle Peninsula (1971) with two deaths from a tsunami; in southwest Bougainville (1975) followed by a two meter tsunami; in southeast Papua (1979) causing some damage in Port Moresby; and in the northeast near Madang (1977, 1978, and 1979). An earthquake registering 7.4 on the Richter scale (centered at Biialla) caused extensive damage to buildings and infrastructure in West New Britain on May 11, 1985. Another earthquake on July 3, 1985, with its epicenter in New Ireland, triggered minor landslides and a 1.3 meter high tsunami but caused little property or structural damage.

The country has been divided into four zones according to earthquake risk:

<u>Hazard</u>	<u>Area</u>
Extremely High	Bougainville, East New Britain, and southern New Ireland
Moderately High	Northern coast of the mainland, West New Britain, mid New Ireland
Moderate	The central region of the mainland, Northern Province, D'Entrecasteaux and Trobriand Islands, northern New Ireland
Very Low	Southern coast of the mainland, Louisiade Archipelago

Source: UNDRO. Disaster Management in Papua New Guinea, 1982.
 [Quoting Beca, Carter, Hollings, and Fenner Ltd. Seismic Zone Development and Lateral Load Evaluation for Building Design in PNG, 1980]

2.4 Landslides

A large portion of the population resides in mountainous areas where the landslide hazard is significant. Earthquakes frequently precipitate landslides in mountain regions. According to PNG records, an average of 10 to 15 people die in landslides during a three to four year period. Twenty-five people died in landslides during the construction of a road to the mining town of Paguna in the Solomon Islands (Bougainville Copper, Ltd.). Ten people died and 80 were left homeless as the result of a landslide in the Menyamy area of central eastern PNG in May 1976. A landslide in the Highlands Highway at Kasam Pass in 1977 temporarily cut off access to areas served by the highway and caused two deaths. In November 1979, a landslide in a remote area of Chimbu Province created a dam in a narrow valley, which later burst. Floodwaters took 13 lives. Landslide problems are being aggravated in some urban areas as squatters move to marginal hillsides, build settlements, and gradually destroy vegetation that is needed to prevent erosion.

2.5 Tsunamis

Most tsunamis affecting Papua New Guinea occur along the coastline of the Solomon Sea and are generated by local shallow earthquakes. Wave heights up to two meters are fairly frequent but do little damage. Destructive tsunamis have been recorded, however. The most devastating in the past century was triggered by the collapse of the Ritter Island caldera in March 1888. The 12-15 meter wave killed hundreds of people on the coasts of the neighboring islands. Tsunamis at Buna Bay in Northern Province (1895) and at Ninigo and Awin Islands (1930) also took several lives. More recently, an earthquake-generated tsunami killed two people in Rabaul town in 1971, and another washed over the village of Torokina (Bougainville Island) in 1975.

2.6 Tropical Cyclones and Strong Winds

Cyclones occur at the rate of one a year in the Solomon or Coral Seas but rarely pass over land. Only the southeast part of Papua New Guinea is likely to be affected by such storms which occur seasonally from November to May. The occasional cyclone may be very destructive however, in a limited area. Cyclone Annie in 1967 damaged homes and coconut plantations and killed 14 people in the Misima Islands and Conflict Groups. The township of Tufi in Northern Province was devastated by Cyclone Hannah in 1972 which also affected the southern coast of New Britain Island. Misima Island was again ravaged by a cyclonic storm in 1977. Strong winds in the non-cyclonic part of the country destroy approximately 200 homes built of indigenous materials each year.

2.7 Floods

Flooding occurs in rain-swollen rivers and along coastal areas subject to storm surges. Loss of life and damage to crops and property were minimal in the past, since land was plentiful, and people could avoid living in vulnerable areas. The situation is changing, however, with increased urbanization and the growth of settlements in flood plains near cities. Floods have affected populations in Popondetta and Lae in recent years. Some 16,000 people required relief assistance as a result of flooding in Lae in 1983.

2.8 Frost

Between May and October, areas above 1,200 meters may experience severe frosts. Food shortages occurred in the Highlands Provinces in 1941, 1972, and 1981 as a result of frost damage to the sweet potato, maize, and pandanus crops. In 1972, an estimated 143,000 people received food assistance. The 1981 frost, compounded by drought in the Central Province, is reported to have affected 40,000 people.

2.9 Other

Other possible disaster types include drought, fires, and accidents. In addition, an influx of several thousand Indonesians from the Irian Jaya Province into Papua New Guinea has created a refugee situation requiring international assistance.

The areas most likely to be affected by drought are the Highlands, Western, Central, and Milne Bay provinces. The drought season is the normal dry period between May and October.

Fire is a constant hazard throughout the country. Losses are extensive each year in both the government and private sectors. Fire damaged the central government office building at Waigani on January 19, 1979.

Aviation accidents are not uncommon due to the large number of light aircraft in the country and the often difficult flying conditions encountered in the highlands. Maritime accidents also occur in the country's vast territorial waters. The placement of bulk fuel storage tanks close to heavily populated areas has created another potentially hazardous situation.

The flow of migrants from Irian Jaya since February 1984 has significantly exceeded the normal border crossings between the two countries. An estimated 10,000 Irian Jayans were living in temporary camps in Papua New Guinea at the end of the first quarter of 1985. The PNG government has agreed not to force the repatriation of those who qualify for asylum. The Office of the United Nations High Commissioner for Refugees (UNHCR) and other organizations have contributed to the support of the migrants.

2.10 Disaster History

<u>Disaster</u>	<u>Location</u>	<u>Date</u>	<u>Number Killed</u>	<u>Number Affected</u>	<u>Damage (\$000)</u>
Tsunami	Minigo/Awin Is.	00/00/30	11	n.a.	n.a.
Volcano	Rabaul; Vulcan and Tarvurur	05/29/37	506	7,500	n.a.
Volcano	Mt. Lamington	01/05/51	3,000	n.a.	n.a.
Volcano	Manam	00/12/57	0	3,200	n.a.
Earthquake/ Landslides	Madang	10/31/70	15	n.a.	1,750
Cyclone	New Britain/ Northern Prov.	05/00/72	n.a.	n.a.	n.a.
Frost/ Famine	Highlands	00/00/72	n.a.	143,000	n.a.
Drought Frost	Central Prov./ Highlands	03/00/81	n.a.	40,000	n.a.
Flood	Lae	03/09/83	11	16,000	11,900
Volcanic Alert	Rabaul	10/15/83	0	25,000	0
Earthquake	Northwest	12/22/83	10	n.a.	n.a.
Earthquake	West New Britain	05/11/85	0	n.a.	n.a.

Source: OFDA Disaster History on file in Washington, D.C.

2.11 Vulnerability of Infrastructure

As the population of Papua New Guinea grows and the country develops, natural disasters pose an increasing threat to infrastructure. A list of some of the damages sustained in recent events illustrates the growing danger.

Two wharves and a number of water storage tanks were damaged beyond repair in the 1968 New Britain earthquake. The SEACOM cable was broken during several of the country's recent earthquakes, and the Torokina Post and Telegraph Microwave Station was damaged in the 1975 earthquake and tsunami in southwest Bougainville. Roads were reportedly closed telephone and telex communications disrupted, and several buildings and water tanks damaged in the May 1985 earthquake in West New Britain.

Damage to infrastructure from volcanic eruptions has been extensive in localized areas. Entire villages were buried in the 1937 eruption in Rabaul which covered an area of 4-5 sq. km. The Mt. Lamington eruption in 1951 devastated an area 230 km radially around the crater. Mudflows closed roads and hindered communications in outlying areas. The airport in Port Moresby, 140 miles away, was closed because of the heavy ashfall. The Manam eruption of 1958 destroyed forests and gardens as well as part of an evacuated village. Because Rabaul has today become an important center for industry and international trade, renewed volcanic activity in that area would have a major economic impact on the country.

Cyclone damage is infrequent but may be severe in affected areas. Cyclone Annie destroyed boats, houses, and coconut plantations in the Misima Islands and other island groups in 1967. The township of Tufi in Northern Province was devastated by a cyclone in 1972. Virtually the entire town had to be reconstructed.

The flood danger is increasing as development proceeds and populations move into flood prone areas. Extensive damage to property and dwellings occurred in the city of Lae as a result of flooding in 1978 and 1983. The only road to the Highlands provinces was cut off for nearly a month while reconstruction work was underway following the 1978 flood. A landslide in 1977 also cut off road access to the Highlands for about a week.

2.12 Vulnerability of Agriculture

Although agriculture contributes only about one-third of the country's GDP and approximately 40-50% of its exports, an estimated 85% of the population lives in rural areas and is dependent on agriculture for a livelihood. The issue of vulnerability of agriculture to natural disasters is therefore an important one. The main problems can be briefly summarized.

Volcanic eruption is potentially a threat to production in localized areas due to the concentration of agricultural activity in the volcanic islands. The fertility of the soil in these regions encourages settlement despite the risk.

Frost in areas above 1,200 meters has seriously affected crops in the Highlands. The sweet potato, which is the main staple in the Highlands, grows well at higher altitudes but is easily damaged by freezing.

Reports of damage to crops from flash floods are increasing. Again, the fertility of the soil in flood plains makes those areas attractive but risky locations for settlement. Landslides, accompanying flooding or earthquakes, may damage hillside gardens and reduce future production through soil loss.

The strong winds and torrential rains of tropical cyclones are damaging to coconut stands and food crop gardens in the regions affected by such storms.

Rainfall is abundant in most areas, but drought occasionally causes regional food scarcity. The areas affected are the same as those affected by frosts - the Highlands, Western, Central, and Milne Bay provinces.

Soils are not of uniform fertility in Papua New Guinea, and cultivation is difficult or impossible in many areas. Dense jungles (rainforests) cover a large part of the country from sea level to 980 meters. Vast swamplands and limestone outcroppings are equally inhospitable environments. The fertile alluvial deposits in some of the drier regions cannot be farmed intensively for want of adequate rainfall. On the other hand, excessive rainfall may cause crop damage or failure in poorly drained areas.

The Agriculture Sector

Despite the limitations on production imposed by the natural phenomena mentioned above, the country has considerable agricultural potential which has been only partly exploited. Production derives from three sources: some 900 plantations originally owned and managed by expatriates but now largely in the hands of Papua New Guinea nationals; smallholder cash cropping; and subsistence farming (40-50% of the total). Some 700,000 ha are under cash crops or pasture and another 250,000 ha are under subsistence production.

The issue of land ownership and the use of available land has become important in policy-making. A land system regulated by native customs accounts for most PNG land. In addition, the government passed legislation to transfer expatriate-owned plantations to New Guineans. The resulting uncertainty regarding land ownership is seen by some as a serious disincentive to foreign reinvestment and as a factor in the stagnation of production in the estate sector.

Smallholder cash cropping, on the other hand, has generally flourished but has been accompanied by a decline in garden productivity. Food imports are therefore growing. About 100,000 tons of rice are imported annually, along with such other items as sugar, fruit, vegetables, wheat, and flour.

Subsistence farming in the highlands employs a fairly sophisticated technology. The intensive gardening of the area, carried out in carefully arranged plots, gives way to shifting cultivation in the foothills. In traditional agriculture most cultivation tasks, except for the initial land clearing, are performed by women. Rural people in less developed regions still depend on hunting and gathering to supplement their diets.

The varied topography in Papua New Guinea has resulted in the formation of numerous micro-climates with a corresponding multiplicity of plant types. The principal cash crops, mostly for export, are copra, coffee, cocoa, palm oil, and rubber. Others include tea, pyrethrum, cardamom, and chillies. The main food crops are sweet potatoes, taro, yams, bananas, sugar cane, and coconuts. In some of the swampy lowland areas, the subsistence sector is based on sago.

Cash Crops

Cocoa is cultivated in most coastal provinces, but especially in East New Britain, Bougainville, New Ireland, and Madang. An estimated 75,000 smallholders grow cocoa, and some 8,000 people are employed on plantations. Production in 1982 totaled about 31,000 MT.

Coffee is the country's largest agricultural export earner, grown both on plantations and by some 200,000 smallholders. Arabica, comprising about 90% of the crop, is cultivated in the Eastern and Western Highlands and Chimbu provinces and in the highest elevations of Morobe. Small amounts of robusta are grown in Central, Milne Bay, and Northern provinces. The unofficial production figure for 1982 was 54,000 MT of green coffee.

Coconuts are grown on plantations and smallholdings in all coastal areas. The largest concentrations are in East and West New Britain, New Ireland, Manus, the northeast coast of Bougainville, the Madang coast, and the Milne Bay, Central, and Morobe provinces. Copra production in 1982 was estimated to be 135,000 MT.

Rubber production is limited to the Port Moresby side of Papua New Guinea. Plantations and smallholdings are found in Western, Gulf, and Central provinces. An estimated 5,000 MT were produced in 1982.

Palm oil is produced on three major holdings and several smallholdings in West New Britain and Northern provinces. Palm oil production was estimated at 39,700 MT in 1981.

Tea is grown almost entirely on estates in the Highlands provinces (principally Western and, to a lesser degree, Southern). The estimated total production in 1982 was 8,000 MT.

Food crops

The estimated production in 1982 was as follows: sweet potatoes, 455,000 MT; cassava, 98,000 MT; other roots and tubers, 580,000 MT; bananas, 949,000 MT.

Livestock

The government's long-range plan is to make the country self-sufficient in meat. Though cattle, poultry, and pigs are all farmed commercially, progress toward achieving the national goal has been slow. Morobe Province is the most important cattle area, followed by Central, Madang, and Western Highlands. Cattle on ranches and smallholdings numbered 133,000 head in 1982. Both pigs and poultry were important in traditional village life but contributed little to the diet. Pigs were primarily an indication of an individual's or a community's wealth and were consumed only on ceremonial occasions. In recent years, several large-scale commercial pig and poultry industries have been established near the main towns, and the numbers of pigs and chickens in 1982 were estimated at 1.4 million and 1.2 million, respectively.

Forestry

Forests cover about 87% of PNG (40 million ha), but much of this is not suited to commercial exploitation. With the vast resources available, forestry products could eventually become one of the main export earners. Large-scale forest production, however, would require extensive reforestation programs. Several large forestry projects are located in Madang, East New Britain, and Central provinces.

Fishing

With an 8,300 km coastline, over 300 islands, and several large river systems, PNG's marine resources are significant. Tuna and other ocean fish, as well as prawns, lobsters, and barramundi are caught for export. The industry, however, has considerable scope for expansion. Coastal species are important in the diets of some 500,000 people who live close to the sea.

3. Disaster Preparedness and Assistance3.1 Host Government Disaster PreparednessDisaster Organization

Prior to January 1982, the responsibility for emergency services in PNG came under the Department of Public Utilities. The National Emergency Service (NES) was the coordinating organization for planning and preparedness as well as for relief activities. The NES was abolished at the beginning of 1982 and its former functions transferred to the Defense Force.

The National Disaster Management Act of 1984 provides for a National Disaster Committee to supervise and coordinate activities relating to the management of emergencies and disasters. The Secretary to the Department of the Prime Minister heads the Committee which also includes the Commissioner of Police, and the Secretaries of several other departments, such as Finance, Defense, Works, Health, and Foreign Affairs.

A National Disaster Plan is being drafted to cover all aspects of disaster management: prevention, mitigation, preparedness, and relief. The long-term project, which is being assisted by outside consultants, will stress community self-reliance, public education, and training. In concept, the Plan ensures that mitigation and preparedness responsibilities will be shared by all government agencies and departments, and that implementing strategies will be incorporated in development. It will be the responsibility of the National Disaster Committee to declare a state of national disaster.

The National Disaster Management Act also provides for a National Disaster Center and for Provincial Disaster Committees. A National Emergency and Surveillance Coordination Center at the Papua New Guinea Defense Force Maritime Base, Port Moresby, carries out the functions of a national center at the present time.

Although primary responsibility for disaster management rests at the provincial level, information is unavailable, on the contingency planning of most PNG provinces. The province of East New Britain does have an updated and detailed disaster plan, however. This plan, revised in 1983, applies to all types of disasters except airport emergencies (covered by plans prepared under the Department of Transportation). The major portion of the plan outlines evacuation procedures for Rabaul and surrounding villages in the event of a volcanic eruption. (See Appendix A.)

A Provincial Disaster Control Committee is chaired by the Head of the Department of the Province. The committee is responsible for preparing emergency plans for the province, coordinating the stockpiling of relief supplies, and encouraging mitigation activities at the local

level. The duties and responsibilities of provincial government agencies and the local Red Cross are spelled out in detail for the various states of alert. (See section 3.2, Warning Systems.) The Provincial Disaster Center is located in Rabaul. In the event the Rabaul Center becomes endangered or inoperable, an alternate center will be established at Vunadidir.

Departmental Responsibilities

Various PNG government departments carry out tasks related to the prevention and management of disasters. The Department of Minerals and Energy through its Geological Survey and Weather Services Divisions monitors seismological and meteorological phenomena and issues warnings on potentially hazardous events.

Several departments are involved in search and rescue activities, and every airport has its own S and R procedure within the national framework. The Department of Transport and Civil Aviation is a member of the National Search and Rescue Committee and is responsible for vehicles, aircraft, etc. required to evacuate endangered populations and transport food and other relief supplies to disaster victims. An UNDRO (Office of U.N. Disaster Relief Coordinator) Technical Advisory Mission to PNG in 1982 pointed out the need for a more effective sea rescue service and also recommended a general updating of the Interdepartmental Search and Rescue Agreement.

The Department of Public Health is involved in all areas of crisis management in which medical care is required. The Department of Works and Supply is charged with responsibility for providing emergency food and relief supplies and for reconstructing and rehabilitating damaged infrastructure. The Telecommunications Division of the Department of Public Utilities is responsible for overseeing emergency communications. Fire service, which also comes under the Department of Public Utilities, was described by the UNDRO Mission in 1982 as generally inadequate.

Evacuation Procedures

Because the evacuation of threatened populations is the only possible response when a destructive volcanic eruption appears to be imminent, drawing up plans for such exercises is an important part of disaster preparedness in Papua New Guinea.

On seven occasions, inhabitants of areas near volcanoes have had to be evacuated: three times spontaneously in response to an unpredicted and devastating eruption (Rabaul 1937, Lamington 1951, and Ulawun 1980); three times as a precautionary measure when an expected eruption did not, in fact, occur (Bam 1954, Esa'ala 1969, and Kadovar 1976); and once in anticipation of dangerous activity which did eventuate (Manam 1957).

Hazard maps to facilitate emergency planning are known to exist for three PNG volcanoes - Manam, Karkar Island, and Rabaul. (Copies of these maps are found in Problems of Volcanic Hazards in Papua New Guinea.) Evacuation plans have been prepared for those three volcanoes as well as for Esa'ala and Mt. Lamington. The evacuation plan for Rabaul was updated in 1982 and is included in the East New Britain Provincial Disaster Plan. (See also Appendix A.) The evacuation plan for Karkar Island was also due for revision in 1982.

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3.2 Warning Systems

Volcanic Eruption

Although the exact timing and magnitude of volcanic eruptions can not be predicted, an eruption can be anticipated with a fair degree of accuracy if the volcano is properly monitored. Papua New Guinea has an extensive volcano surveillance network, consisting of ten manned observatories which monitor 13 volcanoes - eight active and five dormant. (See section 2.2, Volcanoes.) Several other volcanoes with a high hazard rating are expected to be included in an eventual expanded surveillance program.

Regular monitoring of volcanoes in PNG began in 1937 following the disastrous eruptions at Vulcan and Tavurvur within the Rabaul caldera. The Rabaul Volcanological Observatory, established at that site, is the country's largest and main observatory.

Advance signs, not requiring instruments, such as swarms of felt earthquakes and the visible upheaval of land near eruptive centers may be evident in some instances and correctly recognized as precursors to activity. In other cases, however, such as Mt. Lamington in 1951 and Rabaul in 1937, the obvious warning signs were misinterpreted, with tragic consequences. The use of sophisticated equipment to monitor dangerous volcanoes is therefore a necessary adjunct to visual observation. Instruments now employed in the surveillance program include seismographic equipment (with a telemetry system for some volcanoes) to record earthquakes; tiltmeters and other techniques to measure ground deformation; and instruments to measure thermal activity and magnetic field. In addition, volcanologists periodically inspect the country's most dangerous volcanoes, and at least one volcanologist is on duty at all times to receive reports of any unusual activity.

Radio reports of volcanic and seismic activity and tiltmeter readings are received daily in Rabaul from most of the outstations observatories. The actual seismic records, however, which are the best indicators of a possible eruption, were still being mailed or sent weekly to Rabaul via domestic airlines as recently as 1982. This serious deficiency was expected to be at least partially corrected by one of the three major projects being considered by the PNG Planning Office in the early 1980s to improve the quality of volcano surveillance. The proposed project, submitted to the government for funding in 1982, would permit seismic data to be telemetered by VHF radio from four of the most potentially dangerous volcanoes (Karkar Island, Mt. Lamington, Manam, and Uluwun) to the nearest Posts and Telegraphs telephone exchanges for onward transmission to the Rabaul Observatory. Seismic records would thus be available for real-time inspection by volcanologists, greatly enhancing warning time.

A second project proposed for funding that year would upgrade the computer processing system at the Rabaul Observatory for more efficient handling of the surveillance data and also establish a computer link-up between Rabaul and the National Computer Center in Port Moresby. The third project, already being implemented in 1982, provided for the installation of a remote controlled slow-scan video surveillance system at Karkar Island. This would eliminate the need for station observers at the crater and the possibility of another accident of the kind which took the lives of two volcanologists in 1979.

Earthquakes

The Geological Survey collects seismic data, but no precise techniques exist for predicting earthquakes at the present time.

Tsunamis

Papua New Guinea is a member of the International Coordination Group for the Pacific Tsunami Warning System (ICG/ITSU), with headquarters located in Honolulu. Like other member countries, PNG relays information on earthquakes to the ICG/ITSU to assist the network in determining the location of an earthquake and its potential for generating a tsunami. Bougainville Copper Ltd. maintains a tsunami warning tide gauge station at Anewa Bay, near Kieta, and the PNG Department of Transportation has tide gauge stations at Rabaul, Port Moresby, and Vanimo. The Geophysical Observatory issues warnings of possible tsunamis.

Tropical Cyclones

The National Weather Service provides forecasts, storm and tropical cyclone warnings, and other meteorological information to aviation and shipping authorities and to the general public. The Tropical Cyclone Warning Center at Port Moresby remains in contact with storm tracking centers in Australia. Storm warnings are broadcast by national and local radio stations.

Frost

The National Weather Service also issues frost warnings over national radio which are general for the whole Highlands area. Villagers are often aware of weather patterns which may be leading up to frost conditions in their particular area.

Stages of Alert

The East New Britain Provincial Disaster Plan describes the four stages of alert applicable in all forms of disasters.

Stage 1 - There is a risk but no immediate cause for alarm and normally no public announcements. Government departments are informed to allow time to review and update plans.

Stage 2 - The risk has increased but there is still no cause for alarm or public action. Preliminary deployment measures are taken.

Stage 3 - The risk is serious and precautionary action by the public as well as the government is necessary. Extensive government preparations are required. A public ORANGE ALERT is issued with appropriate advice.

Stage 4 - The situation is critical and the event may be imminent. Full scale government deployment is required. A public RED ALERT is issued.

3.3 Mitigation Efforts

Volcanic Eruption

The Geological Survey has gathered a considerable amount of information on the country's volcanoes through a study of the historical and geological records and the volcano monitoring program. Much remains to be done, however, in pre-emergency planning. The government's role in preparedness needs to be better understood through improved communications between volcanologists and PNG authorities. Government authorities have the final responsibility for ordering an evacuation.

Earthquakes/Floods/Fires

Accelerograms collected by the Geophysical Observatory are available for use by engineers in determining safe-building procedures for structures and foundations. A revised building code prepared by the Department of Works and Supply divides the country into two zones based on an earthquake risk analysis. Earthquake-resistant design specifications must be followed in Zone A, which includes Kerema in the Gulf Province, Popengetta in the Northern Province, Milne Bay Province, and all of the previous territory of New Guinea. Building specifications differ but also apply to Zone B which covers Central and Western Provinces. No building over eight storeys will be permitted in Port Moresby and none over five in Rabaul. The new building code also includes fire prevention clauses. Policies are also reportedly being formulated for land-use to minimize damage from floods and earthquakes. Enforcement of the new regulations is likely to be difficult.

Frost

The traditional method of cultivation in the Highlands offers some protection against the hazards of frost and famine. Gardens supplying Highlands villages are usually maintained in two different locations, sometimes as much as a two day walk apart. Migration to frost-free areas to plant temporary gardens is the traditional response when frost wipes out existing crops.

Public Awareness

Mitigation efforts in Papua New Guinea also include programs to educate the public on potential hazards. Radio is the primary medium for the dissemination of information. Pamphlets and posters in simple pictorial form are also distributed on the subject of earthquakes, strong winds, cyclones, tsunamis, volcanic eruptions, and floods. The National Red Cross issues handbooks through the schools describing precautions to be taken for various disasters.

3.4 Diet Summary and Host Country Food Resources

Except in coastal areas where there is access to fish, the subsistence diet is likely to be protein deficient. Roots and tubers are the staple foods, accounting for 45% of calories (compared with 5% in developed countries). Cereals supply only about 14% of calories (compared with 30% in developed countries), though rice and wheat imports are increasing.

Staple Foods

- Grains and starches: wheat and wheat products (all imported), rice, maize, sorghum, sweet potatoes (Highlands staple), yams, taro, wild and cultivated sago (staple in Sepik and Fly River areas).
- Meat and fish: pork, poultry (traditionally limited to ceremonial occasions), beef, lamb, many varieties of fish, canned mackerel, wild game (in rural areas), eggs.
- Fruits and vegetables: coconuts, bananas, pineapples, melons, pawpaws, mangoes, oranges, passionfruit, sugar cane, raw peanuts, cucumbers, turnips, tomatoes, bamboo, pumpkins.

Emergency Food

The PNG government does not maintain food stockpiles since shortages can generally be anticipated and provided for in advance. Food relief was provided by the national government to the victims of frost and drought in 1972 and 1981 with the help of external donors. The wisdom of providing such assistance for a prolonged period has been questioned, however. There is some indication that the vulnerability of the people may actually be increased because of the tendency under these conditions to abandon traditional methods of coping. (See Case Study: 1972-73 Famine. Disaster Preparedness and Disaster Experience in the South Pacific. PIDP.)

3.5 Housing

Settlement patterns vary in the rural areas: homesteads may be scattered or clustered in villages. The tendency in the Highlands to build villages in easily defensible sites is changing gradually. Proximity to roads is becoming a more important consideration.

Building materials in traditional housing are derived from the forests or grasslands, with the design differing from highlands to lowlands. Because of the cool night temperatures in the highlands, homes are generally built close to the ground and with little provision for ventilation. Timber is used if available, the wooden planks being fitted over a framework of saplings or bamboo poles. Houses in the lowlands are frequently raised above ground and are more open and spacious. Flattened bamboo or cane are used to construct walls. Roofs in both areas are made of thatch. Because of the rapid deterioration of such materials in a tropical climate, houses usually have to be rebuilt after a few years.

Western style housing is found in urban areas, and shortages have developed with the growing population drift to the cities. Emergency housing has been required in some disaster situations. After the flooding in Lae in 1983, for example, a "tent city" was erected to temporarily house some 1,000 people whose homes had been destroyed.

3.6 Health Resources

Malaria is a major health problem in Papua New Guinea, endemic in coastal regions and epidemic in the Highlands. Because of the debilitating effects of malaria and malnutrition on much of the population, secondary infections take a severe toll. Pneumonia is the leading cause of death in PNG hospitals. Diarrhea contributes significantly to the high mortality rate in young children and infants. Measles, respiratory disease, tuberculosis, and leprosy are also common, although cases of the two latter diseases are reportedly declining.

Papua New Guinea has a fairly well-developed health infrastructure under the direction of the Department of Health. Four base hospitals providing specialist services are located in Port Moresby, Lae, Rabaul, and Goroka. Each province lacking a base hospital has a district hospital. In addition, there were 184 health centers, 236 sub-centers, and 2,201 aid posts in the country as of January 1983. Each aid post serves approximately 1,000 people. A hospital at Arawa is maintained by Bougainville Copper, Ltd., and a number of Christian churches with missions in PNG also operate hospitals and other health facilities.

Despite the well-established health structure, medical outreach is described as ineffective in many areas, with a large segment of the population at highest risk still not receiving primary care. This is partly due to the lack of adequate training of the aid post orderlies

(APOs). Social customs are also a barrier. For example, there is a high mortality rate associated with childbirth, yet APOs are not trained to provide MCH services since most of them are men and it is not socially acceptable for them to attend women during pregnancy.

Emergency Health Care

Because of the relatively large number of health facilities in the country, medical assistance from outside the affected area should be available in the event of a localized disaster. Stocks held in the government area medical stores are also expected to be sufficient in most emergency situations.

The Rabaul evacuation plan assumes that it will be necessary to evacuate Nonga Base Hospital if volcanic eruption in Rabaul is predicted. The plan states that mobile first aid units will be deployed outside the danger area. Primary health care services through existing health centers/clinics and aid posts will be upgraded to care for evacuees in a safe area. A referral hospital providing specialist medical services will be established at Vunapope.

3.7 Host Country Transportation Resources

Road Network

The PNG road network is about 19,000 km in total length. Only about 5% of the roads are paved; the rest are gravel or earth roads. Because of the difficult terrain and harsh climatic conditions, the road system is fragmented, serving mainly the areas around provincial capitals, coastal communities, and the Highlands region. The 600 km Highlands Highway is PNG's major transport artery, extending from the port of Lae through Mt. Hagen to Mendi. The Enga Highway is a continuation of the Highlands road from Togoba to Webag. The government intends to continue improving this road over the next decade.

Many communities in PNG are inaccessible by road. Others can be reached only with difficulty, especially during the rainy season. Road, bridge, and culvert washouts are common. Inadequate road maintenance and overloaded vehicles also contribute to the generally poor condition of existing roads.

Vehicles

About 38% of the estimated 55,000 vehicles in use in 1983 were cars or station wagons. Another 32% were light trucks, 15% heavier trucks, 5% buses, 6% motorcycles, and 4% tractors. The 1980 census showed vehicle ownership averaged only 16.5 per 1,000 inhabitants with wide variations at the provincial level. Approximately one third of the vehicles were in

the Central Province (includes National Capital District). A high rate of vehicle depreciation is attributed to poor road conditions, a lack of vehicle maintenance, and frequent traffic accidents.

Ports

Being an archipelagic nation, PNG relies heavily on water transport. The port of Lae in the northwest Huon Gulf is the largest of the country's 18 major sea and river ports. Nearly all coffee and tea exports and about 60% of all timber products pass through the port of Lae. The other main ports of call for cargo ships are Port Moresby and Rabaul. In addition, some 4,000 small ports serve the coastal trade.

A project to rehabilitate and improve existing port facilities at Lae was undertaken in the early 1980s. The project components included the construction of a tanker berth to accommodate vessels up to 40,000 deadweight tons (dwt), the reconstruction of Berth No. 2 to handle vessels up to 20,000 dwt, and the improvement of the back-up area including the construction of a container yard and a container freight station. Storage space at the port of Lae consists of 14,285 sq. m in transit sheds and 37,000 sq. m in an open area. An airport is located 4 km from the port.

Kavieng (lat. 2°34'S; long. 150°48'E), located at the northernmost tip of the island of New Ireland, can berth a vessel of 8,543 gross registered tonnage (grt) and 129.5 m in length. Anchorage is good in ample depths of water (14.6 to 27.5 m). The port has one 750 sq. m transit shed and 3,000 sq. m of open storage. The nearest airport is 2.4 km away.

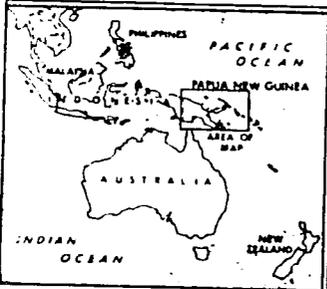
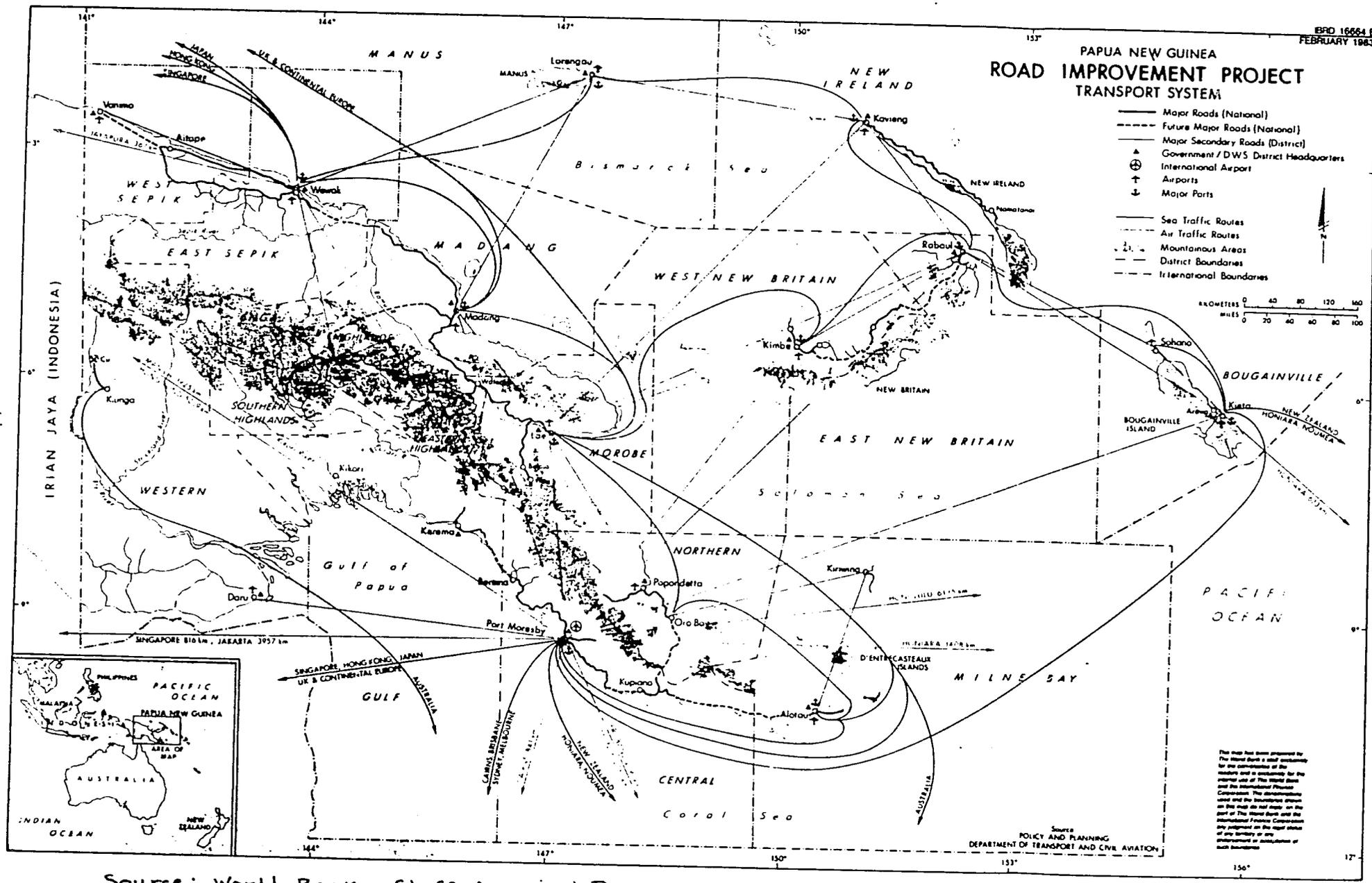
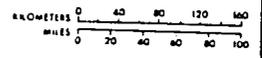
Kieta (lat. 6°13'37"S; long. 155°38'25"E) is the major port on Bougainville Island, but there are no recommended anchorages for large vessels (12,000 grt maximum). Some 2,230 sq. m of covered storage space is available and 14,172 sq. m of open space. The airport at Aropa, 16 km south, has daily flights to Rabaul and Port Moresby.

Approaches to the harbor entrance and to the wharf at Madang (lat. 5°12'S; long. 145°49'E), on the northeast coast of the mainland, are clear and unrestricted in depth. The wharf is 137.1 m long with 10.1 m minimum depth alongside. Two Arbilifts are available for container movement. Storage space adjacent to the wharf consists of 2,500 sq. m undercover and 5,575 sq. m in an open area. An airport located 6 km from the port provides daily service to Port Moresby.

Port Moresby (lat. 9°29'S; long. 147°8'E) can accommodate a vessel with a maximum draft of 30 meters. The outer entrance to the harbor lies through a gap in the barrier reef which has a navigable width of 600 m and depths varying from 11 to 31 m. The port has a new heavy duty multi-purpose berth and a new container terminal which will accommodate RO/ROs. Total covered storage is 7,875 sq. m and total open storage is 38,590 sq. m. Jackson's Airport is located 13 km from the port.

PAPUA NEW GUINEA ROAD IMPROVEMENT PROJECT TRANSPORT SYSTEM

- Major Roads (National)
- - - Future Major Roads (National)
- - - Major Secondary Roads (District)
- ▲ Government / DWS District Headquarters
- ⊕ International Airport
- ⊕ Airports
- ⬇ Major Ports
- Sea Traffic Routes
- Air Traffic Routes
- ⬄ Mountainous Areas
- - - District Boundaries
- - - International Boundaries



This map has been prepared by the World Bank as a staff appraisal for the convenience of the readers and is available for the general use of the World Bank and the International Finance Corporation. The information used in the preparation of this map is based on the best available information at the time of preparation and the International Finance Corporation does not assume any responsibility for any errors or omissions or for any consequences of its use.

Source: DEPARTMENT OF POLICY AND PLANNING
DEPARTMENT OF TRANSPORT AND CIVIL AVIATION

Source: World Bank. Staff Appraisal Report. Papua New Guinea Road Improvement Project, March 1983. (Used with permission)

Rabaul harbor (lat. 4°13'S; long. 152°12'E) is located at the eastern end of New Britain Island. Depth at entrance to the harbor is 110 m, and the port has two overseas berths. Storage consists of 9,640 sq. m covered and 18,600 sq. m in an open area. The nearest airport is 3.2 km away.

(Consult Lloyd's of London, Ports of the World, for more detailed information on Papua New Guinea's ports.)

Some 15 companies provide overseas shipping from the main ports, the most frequent services being those between PNG and Australia. The government-owned PNG Shipping Corporation maintains a fleet of 61 vessels and operates both overseas and coastal services.

Airports

Air transport is an important mode of travel in Papua New Guinea, providing the only link with many interior communities. Of the country's 425 airports and airstrips, seven are equipped for international operations.

Jackson's Airport in Port Moresby, the country's main terminus for air services, has a runway approximately 2,800 meters in length and can accommodate wide bodied aircraft. Other important airports are located at Wewak, Madang, Mt. Hagen, Garoka, Rabaul, Kieta, and Daru. As part of the preparedness efforts for a possible volcanic eruption in Rabaul, an emergency airstrip was constructed at Tokua which is capable of accepting C-130 aircraft.

The national airline, Air Niugini, operates a 707 service several times a week between Sydney, Brisbane, and Port Moresby as well as other international flights to several cities and domestic flights to 20 destinations. The fleet consists of two Boeing 707-338C, four Fokker F-27, four Fokker F-28, and three de Havilland DHC-7. Regular domestic services are also provided by Douglas Airways Pty. Ltd. and Talair Pty. Ltd. Qantas provides twice weekly 747 flights between Sydney and Port Moresby.

3.8 Communications Resources

The SEACOM coaxial international cable links Papua New Guinea to Guam, Sabah (Malaysia), Hong Kong, and Singapore in the northern hemisphere and with Australia in the southern hemisphere. Telephones operate on a microrelay system with cross switch capability. Subscriber trunk dialing is possible in most areas, and PNG subscribers connected to all automatic exchanges can generally dial direct to subscribers in Australia.

The Coastal Radio Service with a station at Rabaul providing 24-hour service and another at Port Moresby operating 12 hours a day maintains communications with ships at sea. Frequencies are 2182, 4125, and 6215 kHz. Three radio telegraph frequencies are also available.

A system of internal radio communications connects several zone centers to over 1,000 government or privately operated HF outstations. These are generally isolated missions, timber or mineral survey camps, plantations, or government posts.

The Central Observatory in Rabaul operates a volcanological network. Each of the stations on the network is equipped with 6815 kHz and all sets are single side band (SSB).

Police in all provinces also have SSB transceivers fitted with two daylight and two night frequencies, and their cars are equipped with 2-way radios and loudspeakers.

The National Broadcasting Company (NBC) operates 19 provincial radio stations and three networks: the Kundu (provincial), the Karai (national), and the Kalang (commercial). All national programs originate in the capital.

NBC medium and short wave stations are located in Port Moresby, Rabaul, and Wewak (also Madang and Goroka for medium wave). Provincial short wave stations serve several areas throughout the country.

3.9 Power Resources

The New Guinea Electricity Commission (ELCOM) provides the bulk of the public power supply which amounts to about 177.1 MW. The private sector, mainly Bougainville Copper Ltd., supplies another 150.5 MW.

ELCOM's operations are spread over 22 load centers, the largest of which are the Port Moresby System serving the National Capital District and surrounding towns in the Central Province; the Ramu System serving Lae, Madang, and the Highlands region; and the Rabaul-Keravat System serving the Gazelle Peninsula in East New Britain Province.

The Port Moresby and Ramu systems account for about 75% of power generated by ELCOM. By 1990, the projected installed capacity for the Port Moresby system will be 112 MW (62 MW hydro and 50 MW thermal) and for the Ramu system 119 MW (87 MW hydro and 32 MW thermal). A proposed Asian Development Bank project would construct a high voltage transmission interconnection between the Port Moresby and Ramu systems making it possible to exchange energy and power between the two systems and share reserve plant capacity.

3.10 Host Country Voluntary Agencies

The Papua New Guinea Red Cross Society has its headquarters in Port Moresby and branches in ten provinces (as of 1982). The PNG Red Cross also maintains 14 blood banks. The East New Britain Disaster Plan assigns specific disaster responsibilities to the Red Cross branch serving its province. These include the provision of first aid teams; the distribution of clothing, if necessary; tracing service; and the coordination of all voluntary agencies involved in the relief operation, if desired by the Disaster Controller.

St. John Ambulance, with divisions in all major urban centers, is chiefly responsible for providing first aid in civil emergencies.

3.11 U.S. Mission Disaster Plan

There is no U.S. Mission Disaster Relief Plan. The Chief of Mission makes a disaster determination in accordance with A.I.D.'s Handbook 8 and monitors activity throughout the emergency. The Mission Disaster Relief Officer is responsible for coordinating U.S. relief efforts with Papua New Guinea officials and other donor governments.

U.S. Contacts

Donald Cleveland
Political/Economic Officer
Tel: 21-1455 (office)
21-3624 (home)
Tour ends: 9/86

Mission Disaster
Relief Officer

James Williard
Administrative Officer
Tel: 21-1455 (office)
21-3781 (home)
Tour ends: 8/86

Alternate Mission
Disaster Relief Officer

3.12 Other U.S. Resources and Disaster Assistance

American development aid is modest and largely disbursed through voluntary organizations. Forty U.S. Peace Corps volunteers were working in the country as of June 1984.

At the time of the Rabaul volcano alert in 1983, A.I.D.'s Office of U.S. Foreign Disaster Assistance (OFDA) procured an electronic distance measuring (EDM) device for the Rabaul Volcanological Observatory and funded visits by USGS technicians to Papua New Guinea. The EDM equipment was later purchased by the PNG government. (See Appendix B.)

OFDA is also supporting efforts to strengthen the country's disaster management capability. A grant was provided to the Circum-Pacific Council on Energy and Mineral Resources in 1984 to assist its sponsorship of an international workshop on volcanology forecasting in which Papua New Guinea participated.

Papua New Guinea will be one of the countries to benefit from the establishment of a Regional Disaster Preparedness Training Program sponsored by the Asian Institute of Technology. The program, which received initial funding from OFDA in 1985, is expected to provide increased awareness, institution building, technology transfer, and information dissemination in the participating countries.

3.13 Voluntary Agencies and International Organizations

International Organizations

Several governments and international organizations provide development assistance to Papua New Guinea, and they are likely to be active in disaster relief operations. Australia is by far the largest external aid donor. Other countries making significant contributions include New Zealand and Japan.

The United Nations Development Program (UNDP) resident representative acts as coordinator of the U.N. disaster assistance program. The UNDP office in Port Moresby represents all U.N. organizations in PNG except the World Health Organization (WHO) which has separate headquarters.

U.S. Voluntary Agencies

A number of U.S. based voluntary agencies and churches are involved in development and social programs in Papua New Guinea. Some 2,000 missionaries are working in churches, hospitals, and schools throughout the country.

The following agencies are among those known to have active programs:

Society of the Divine Word
P.O. Box 109
Goroka, Papua New Guinea
Tel: 721405

Program: communications (air service and radio communications to areas of limited accessibility); education (1,065 elementary schools and several high schools and professional schools); food production and agriculture; industrial development; medicine and public health (21 hospitals, 20 clinics, three maternity hospitals, and approximately 70 dispensaries).

Foundation for the People of the South Pacific
P.O. Box 1261
Boroko, Papua New Guinea

Program (in Manus, Bougainville, New Ireland, Gulf, Enga, Simba, and Milne Bay Provinces, and in Port Moresby): community development; economic and development planning; education (technical and vocational education for youth and women); food production and agriculture; industrial and development planning; medicine and public health (nutrition program in cooperation with the government's Department of Health, including mobile nutrition clinics providing health treatment and nutrition education).

Missionary Sisters, Servants of the Holy Spirit
Holy Spirit Convent
P.O. Alexishafen
Madang Province
Papua New Guinea

Program (in Eastern Highlands, Madang, Western Highlands, Enga, and Wewak Provinces): communications (radio programs in both English and Pidgin, audio visuals, and translations); community development; education (schools and non-formal education in literacy and skills training); equipment and aid; medicine and public health (health care centers and a training school for aid post orderlies); population and family services; and social welfare.

The following agencies also had programs in Papua New Guinea in 1983:

The American Lutheran Church
Evangelical Lutheran Church of Papua New Guinea
P.O. Box 80
Lae, Papua New Guinea

Capuchin Fathers (O.F.M. CAP.)
P.O. Box 69
Mendi, Southern Highlands
Papua New Guinea

Church of the Nazarene
Nazarene Mission
P.O. Box 416
Mt. Hagen, Papua New Guinea

Missionary Sisters of the Most Sacred
Heart of Jesus of Hilstrup (M.S.C.)
Vunapope
Post Office Kokopo, New Britain
Papua New Guinea

The Salvation Army
The Salvation Army Headquarters
P.O. Box 1323
Boroko
Moyon Street, Koko
Port Moresby, Papua New Guinea
Tel: 25-5507

Wheat Ridge Foundation
Immanuel Hospital
P.O. Box 181
Wapenamanda, Enga Province
Papua New Guinea
Tel: 274033, 574010

Adventist Development and Relief Agency

Catholic Relief Services

Church World Service

World Concern

World Relief Corporation

World Vision Relief Organization

[See TAICH Directory 1983 for a complete listing of agencies
providing development assistance in Papua New Guinea.]

3.14 Disaster Mitigation and Development

Given its relatively early stage of development, Papua New Guinea has a unique opportunity to consider disaster mitigation in the development process. The cost-effectiveness of such planning has been amply demonstrated world-wide. Failure to incorporate disaster mitigation and preparedness into development may actually increase the vulnerability of the population. The potential for long-term social and economic transformation and disruption is inherent in the process of development.

The growing emphasis on cash cropping, for example, has been accompanied by a decline in garden productivity. While there is no clear evidence that this has had a negative effect on the nutritional status of the indigenous population, the question has been raised. Similarly, population shifts from rural to urban areas may pose new risks as marginal areas are settled and new styles of housing adopted. Technological advances in other areas may create a host of new hazards such as environmental pollution and industrial accidents.

The PNG government appears to be aware of some of the risks as well as the opportunities that go with development. This is evidenced in the introduction of land use policies and building codes as well as in the expansion of services by the various government departments responsible for surveillance and early warning. (See also section 3.3, Mitigation Efforts.) It is incumbent upon development planners to anticipate the many changes that industrialization will produce in order that the dangers to society can be minimized and the quality of life truly enhanced.

APPENDIX A

Rabaul Volcano

Attention was focused on the Rabaul volcanoes in the fall of 1983 and 1984 when increased seismic activity and ground deformation appeared to be precursors to an impending eruption. Even before that, however, the updating of the hazard map and evacuation plan had been given high priority because of the large population involved (approximately 25,000 living in Rabaul town and 70,000 within 15 km of the center of the caldera) and the probability of another eruption by the end of the century. Surveillance since 1971 had revealed a phase of uplift and increasing seismicity.

At least two major prehistorical eruptions contributed to the development of Rabaul volcano. A massive eruption 3,500 years ago is believed to have initiated caldera development. Another major eruption, though possibly of lesser magnitude, occurred about 1,400 years ago. The most notable eruption in historical times (records date back to 1767) was in 1937 when more than 500 people perished. Although scientists expect that the next event will be a small-to-moderate eruption similar to the 1937 eruption, there is a 4% probability that a massive eruption with caldera subsidence will occur. Because there are several potentially active vents within the caldera the site or sites of future eruptions can not be precisely predicted. The strongest concentrations of seismicity, however, have been in the Vulcan Island/Vulcan area and in an area extending southwards about 3 km from Tavurvur.

Plans are in progress to permanently relocate Rabaul town, but pending that eventual move, a hazard map was produced in 1981 to enable the Rabaul emergency plan to be updated (See below). The map takes into account two kinds of hazards associated with volcanoes - flowage hazards (lava flows, pyroclastic flows, and mud flows) and tephra hazards (airfall tephra and gases). Maps have also been prepared for two magnitudes of eruption, guided by the known distribution of two Rabaul eruptions - namely, the small-to-moderate 1937 Vulcan eruption and the moderate-to-large eruption of 1,400 years ago.

The four hazard zones (A, A_S, B_S and C_S) established for small-to moderate eruptions signify a transition from greater (A) to lesser (C_S) hazard. Winds are not expected to have a significant effect on tephra fall in zone A where the accumulation would be devastating. The dispersal effect of prevailing seasonal winds is,

however, taken into account in determining the boundaries of the surrounding zones and is an important consideration in establishing evacuation routes and refuge points.

Three zones of flowage hazard have also been mapped for small-to-moderate eruptions. Zone F₃I is subject to pyroclastic flows, surges, and mudflows. The surrounding zones may be affected by mudflows as a result of the accumulation of airfall tephra.

Areas of airfall hazard for moderate-to-large eruptions are considered to be mainly west of Rabaul and extend some 200 km as the outer limit of the low hazard zone. Pyroclastic flows formed during such an eruption would probably be extensive, perhaps ranging 35 to 40 km from the center of the caldera.

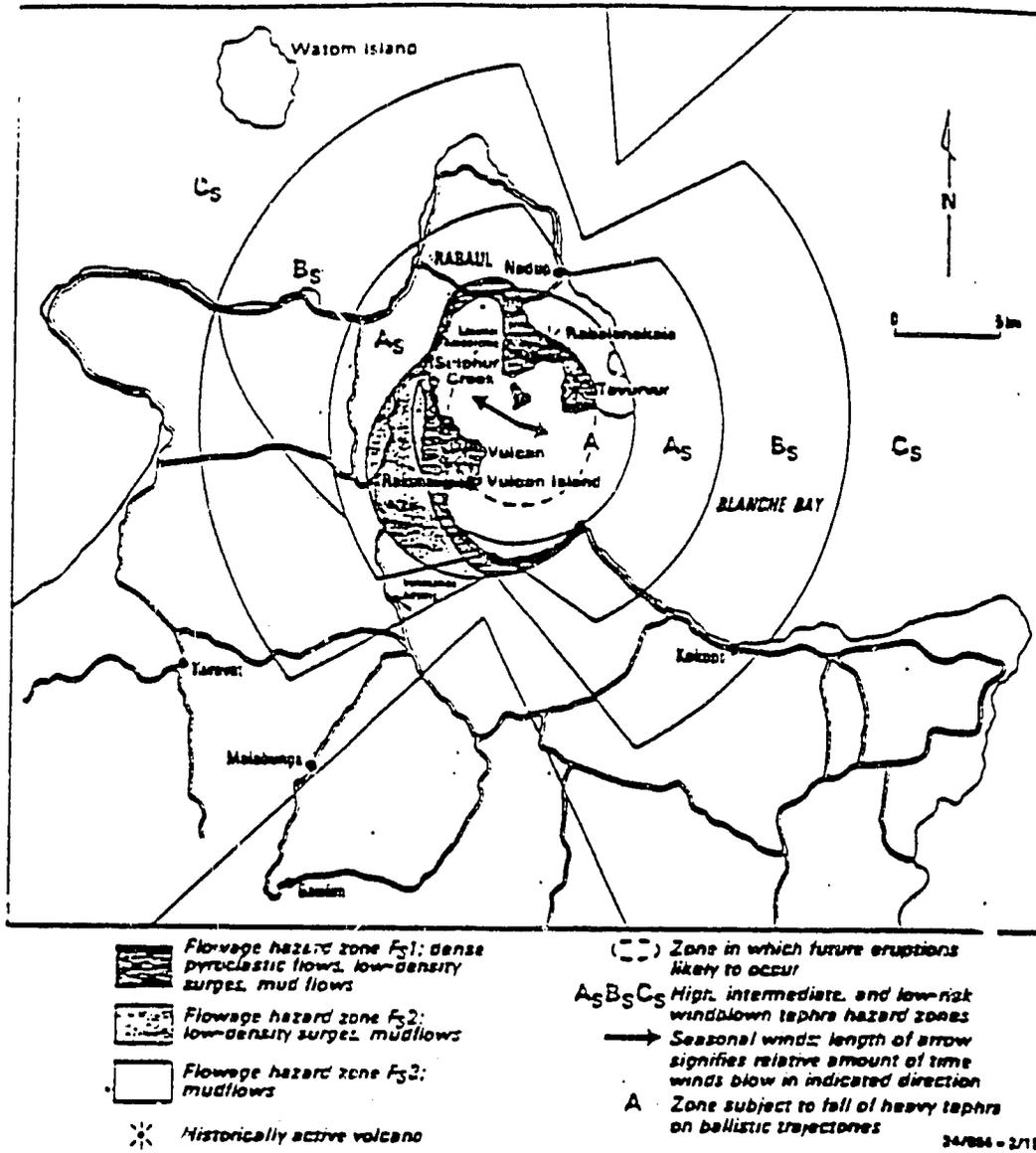
The tsunami hazard zone in Rabaul, for small-to-moderate eruptions, includes areas from the sea shore to a height of 10 m above sea level.

Based on the new hazard map, the Rabaul evacuation plan was updated in 1982. The plan assumes that the probable scale of activity will be similar to that of the 1937 Vulcan eruption. Under the plan, the vicinity of the caldera is divided into four areas, each with a distinguishing color. Red and blue areas will be automatically evacuated upon the declaration of a RED ALERT. (See Section 3.2 Warning Systems.) The Provincial Disaster Committee will decide at the time whether to evacuate the green or yellow areas, depending on the prevailing winds.

Land-route evacuation to the Keravat and Kokopo areas will be the method of first choice. This presupposes accurate and sufficient warning, as the only roads from the town could soon become impassable. The sea route is considered hazardous because of the possibility of a new volcanic cone emerging in the Bay, although a sea evacuation of 4,000-6,000 people was accomplished in the 1937 event. Ships already in harbor will be ordered to sea immediately upon RED ALERT where they will stand by and assist in a seaborne evacuation if that should be necessary.

The plan designates pick-up points and evacuation routes as well as the location of places where evacuees can be accommodated in the safe areas. Vehicles will be requisitioned to move those people from the danger zone who are unable to make their own transportation arrangements.

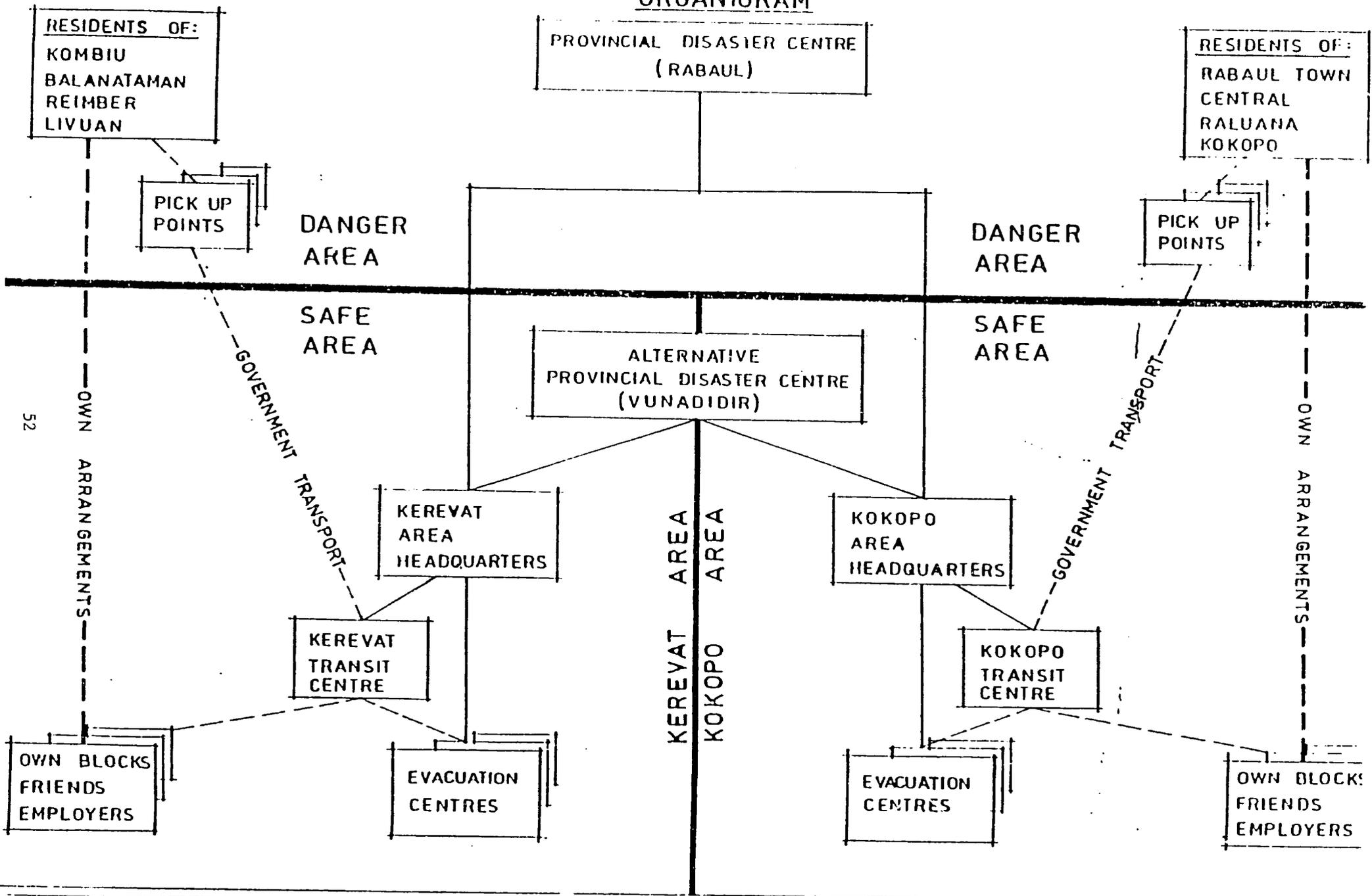
A possible alternative to evacuation is suggested in the report issued by the PNG Geological Survey entitled Rabaul Caldera, Papua New Guinea: Volcanic Hazards and Eruption Contingency Planning. This source mentions an existing network of tunnels in the Rabaul area dug during the Japanese occupation of the island and suggests investigating their potential as a place of shelter during a small-to-moderate eruption.



Hazard Zones for Small-Moderate Eruptions at Rabaul.

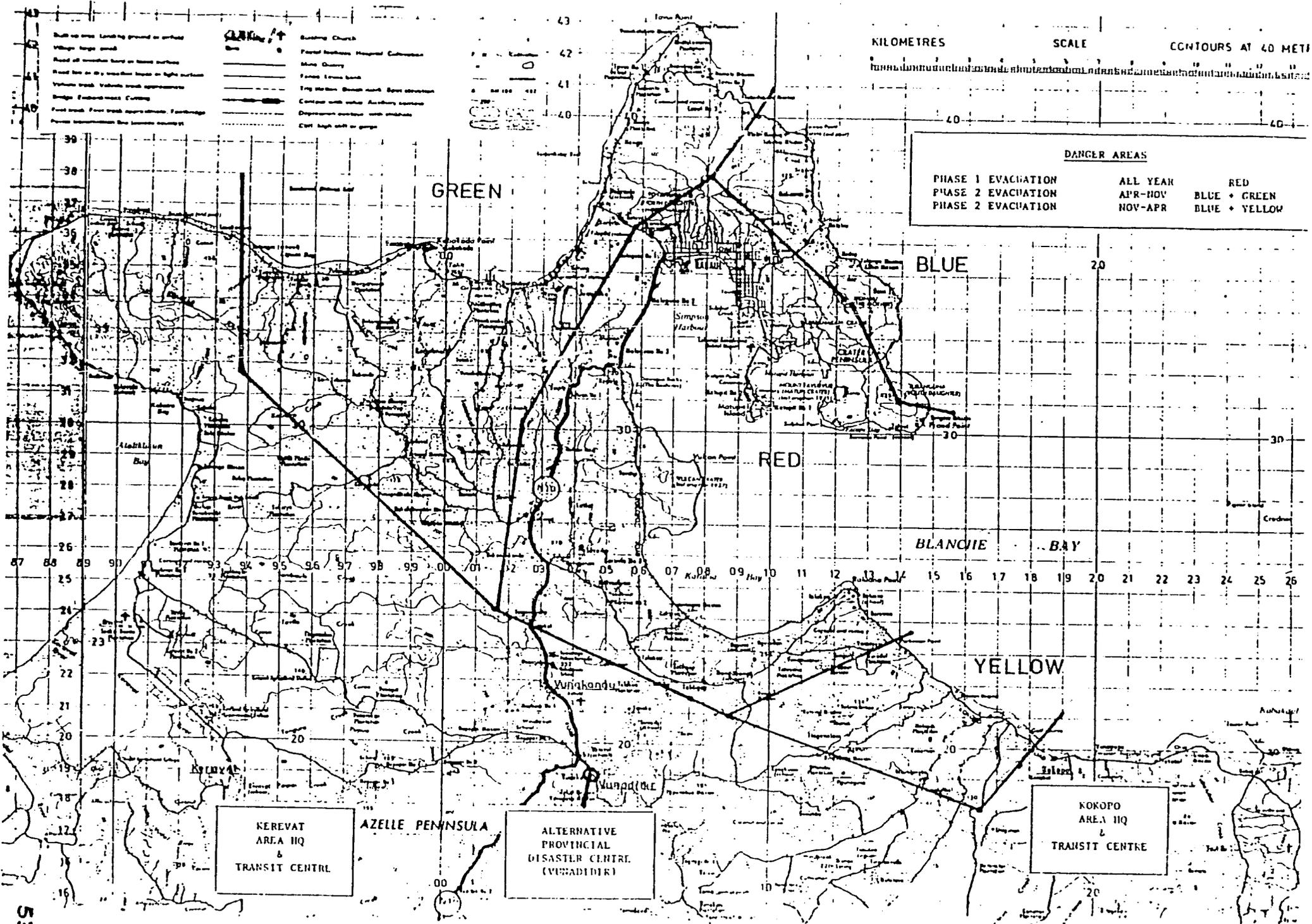
Source: Rabaul Caldera, Papua New Guinea: Volcanic Hazards and Eruption Contingency Planning. Report 83/17. Geological Survey of Papua New Guinea. Department of Minerals and Energy, November 1983.

RABAU EVACUATION PLAN ORGANIGRAM



52

Source: East New Britain Provincial Disaster Plan. 1983 Edition.



Source: East New Britain Provincial Disaster Plan, 1983 Edition.

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APPENDIX B

PAPUA NEW GUINEA - Volcanic Activity

Date: November 1983-November 1984

Location: Rabaul Volcano on East New Britain Island

No. Dead: None reported

No. Affected: 25,000

Damage: Tremors and ground deformation caused only slight structural damage.

The Disaster

The town of Rabaul sits within an active caldera on the Gazelle Peninsula, at the northeastern tip of East New Britain Island. Rabaul serves as the administrative capital of East New Britain Province and has approximately 25,000 residents. On October 15, 1983, the town began experiencing a series of rolling earthquakes and ground swelling, normally precursors to a volcanic eruption. The second stage of a four-stage alert was declared, indicating that an eruption was possible within a few months. Residents feared that a future eruption would be of the same scale as the last explosion in 1937, when 500 people were killed and the entire population had to be evacuated. For the most part, the residents continued their daily routines, although some banks reported large transfers of money and airlines received heavy bookings out of Rabaul.

In January, it was estimated that there was a 96% probability that the Rabaul volcano would erupt within 18 months, but only a 4% probability there would be a cataclysmic caldera collapse. An increase in ground deformation and seismic activity was reported in January and March and preparations were made for a Stage 3 alert, which entails mobilizing the population to evacuate. However, the Stage 2 alert remained in effect as seismic activity and ground swelling gradually subsided and the probability of an eruption before the end of the year dropped to 50%. By November 1984, the volcanic alert was officially downgraded to Stage 1, signifying that an eruption could take place within twelve months or several years.

Action Taken by the Government of Papua New Guinea (GPNG)

The East New Britain Provincial Disaster Control Committee began preparing for an eruption at Rabaul several months before the declaration of a Stage 2 volcanic alert. In June 1984, the Committee approved a Provincial Disaster Plan detailing mass evacuation procedures for leaving Rabaul in case of a major eruption. The plan also specified high risk zones around Rabaul and recommended establishing an emergency operation center and airfield in safe areas beyond the range of the volcano. The GPNG provided \$2,040,000 to upgrade evacuation routes, construct an emergency control center at Vunadidir, and resurface two emergency airstrips at Vunakanau and Tokau. The GPNG defense forces were put on standby for a possible evacuation and an additional police force was moved to Rabaul in February. Food, water, and medical supplies were stockpiled at an evacuation site near Kopoko, approximately 20 km southeast of Rabaul. Fear that an eruption would totally destroy the Rabaul Volcanic Observatory prompted the GPNG to approve funds to construct a temporary observatory at Tomavatur, a safe distance from Rabaul. The GPNG also purchased electronic distance measurement equipment (EDM) from the United States Government, to monitor ground swelling around the caldera. On March 2, 1984, the GPNG Parliament passed the Disaster Management Act of 1984, specifying the membership and responsibilities of national and provincial disaster committees. Fortunately, Rabaul did not erupt in 1984 as the experts had predicted, but the renewed threat did result in making the population better prepared for an eventual eruption.

Assistance Provided by the United States Government

On November 11, 1983, the U.S. Ambassador determined that the possible volcanic eruption at Rabaul had reached life-threatening proportions and warranted USG assistance. The chief volcanologist at the Rabaul Volcanic Observatory contacted the USGS and the U.S. Embassy at Port Moresby and requested that the USG provide electronic distance measurement (EDM) equipment to monitor ground deformation around the caldera. OFDA, in cooperation with the USGS, agreed to loan the EDM equipment to the Rabaul Volcanic Observatory. This equipment proved so valuable in monitoring the volcanic activity that the GPNG asked to purchase the EDM instrumentation directly from the USG. In April, the EDM equipment malfunctioned and OFDA sent a manufacturer's service kit and 50 replacement reflectors to Rabaul. OFDA also funded two visits by a USGS geophysicist and an electronics technician to provide technical assistance.

Summary of USG Assistance

Cost of EDM monitoring equipment.....	\$22,692
Reimbursement for above equipment by GPNG.....	(\$21,782)

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