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by

R. Feachem

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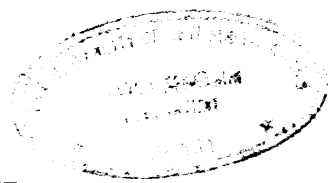
THE UNIVERSITY OF NEW SOUTH WALES
SCHOOL OF CIVIL ENGINEERING



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PREFACE

This report contains information collected during a four year research project into the environmental influences on morbidity in a community in New Guinea's Western Highlands. The special focus of this research is the extent to which the use of faecally contaminated water for domestic purposes is a significant influence on morbidity. A later report in this series will describe some bacteriological properties of the Highlands' streams, and data on morbidity patterns will be published elsewhere. It is hoped that this report of a single aspect of the overall study will be of practical value to sanitary engineers in Papua New Guinea and possibly elsewhere in the developing tropics.

B.W. GOULD
Associate Professor of Public Health.

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Abstract

As part of a research programme on environmental influences on morbidity in the New Guinea Highlands, a study was made of traditional patterns of domestic water use. Data is reported on the water use of a Raiapu Enga clan in the Saka valley near Wapenamanda in the Western Highlands District. The environment and culture of this region are briefly discussed.

Raiapu attitudes to water are discussed and the importance of the fear of poison, and of female contamination in the water sources is emphasised. The Raiapu collect their water from natural streams, rivers and springs. Rainwater is also collected but only in the wetter season is this common. The pollution status of the water used ranges from relatively clean to highly contaminated with faecal material deriving from pigs and humans.

Water is collected in gourds, bamboos, tins and cooking pots and it is mostly collected during the late afternoon. The average water collection journey takes 12.5 minutes from dwelling to source and back. Each "domestic group" collects a mean of 2.46 litres per day and 79% of this is drunk. The remainder is used for cooking food (for humans and pigs); for pigs, chickens and dogs to drink; for washing utensils; or is thrown away. Total per capita usage is 0.68 litres daily. On average, 0.54 litres of water per capita are drunk daily and, including the water contained in food and water produced by the oxidation of food, 2.4 litres per capita per day are available to the body.

Per capita use tends to decrease with increasing size of domestic group but travel time to source has no association with water use patterns. Major non-domestic uses of water include coffee washing and the growing of the reed-like plant kuta from which women's aprons are made.

Acknowledgments and Conventions

The help and encouragement of many people have made this research possible and space does not permit a full acknowledgment here. While in New Guinea I was given invaluable assistance and much hospitality by the staff of the New Guinea Lutheran Mission and of the Lutheran Hospital at Mambisanda. Professor David Lea of the University of Papua New Guinea was constantly helpful. I am indebted to Zuzana Feachem for her continual support in the field and to the Tombeakini clansmen for their patience and cooperation. I am particularly grateful to my assistants on the water use survey-Nyio Upasa and Ose- and to Tetepe who acted as my interpreter and companion throughout.

My post-graduate researches in Australia are supported by the Commonwealth Scholarship and Fellowship Plan. Funds for my work in New Guinea have been provided by generous donations from the Nuffield Foundation, the Wenner-Gren Foundation (grant no. 2731) and the Frederick Soddy Trust. I am especially indebted to these organisations.

I have endeavoured to follow the Enga orthography adopted by the New Guinea Lutheran Mission who are responsible for most of the linguistic studies on Enga. However, I have rendered the prenasalized consonants b, d and g as mb, nd and ng and not simply b, d and g. To convert litres to U.S. gallons and imperial gallons, divide by 3.79 and 4.55 respectively.

1. INTRODUCTION

A large proportion of the world's population lives in the rural areas of what are generally described as developing countries or the countries of the "third world". Typically these rural farmers live in conditions which are far from healthy and enjoy very low standards of sanitation and environmental health protection. Of central importance is the inadequate nature of water supplies - in terms of both the quality, and the availability, of the water which is used. Wagner and Lanoix (1959:10) claim that "in most small towns and villages in rural areas, more health benefits can be gained from money spent on a water-supply programme than in any other way". While this assertion is not substantiated, and may well be untrue in many areas, it is certainly correct that water supplies are among the crucial factors which determine the health status of rural communities.

In order to plan, design and implement water-supply programmes for rural areas the public health engineer needs a variety of data which are not readily available. He needs data on the likely benefits which may be anticipated to accrue from a particular scheme and he needs data on existing water-use patterns and the way in which these may change in response to improved water supplies. He also needs information on a wide range of cultural aspects of the community concerned in order that the water-improvement programme may blend, and not be in conflict, with local custom so that the scheme may enjoy maximum local participation and support.

This type of data is in very short supply and, in some parts of the world, it is non-existent. Even data on current water-use patterns, which is probably the easiest to collect and accurately quantify, is often unavailable. White et al (1972:109) have discussed this problem in the East African context and conclude that "only a handful of accurate data is available about actual domestic use within municipal water systems. Even less is known about the water carried from sources outside the household". White et al (1972) also review

existing data on water usage and, for unconnected dwellings in rural areas, they quote only 5 reference sources from throughout the world (see Table 1).

TABLE 1: WATER USAGE IN RURAL AREAS WITHOUT HOUSE CONNECTIONS: FROM WHITE ET AL (1972:APPENDIX D)

COUNTRY	PLACE	ESTIMATED DAILY PER CAPITA USE. LITRES	ORIGINAL SOURCE
Bolivia	Seven villages	10	Teller (1969)
Kenya	Zaina	7	Fenwick
Nigeria	Anchau district	23 - 27	Nash (1948)
Sudan	Kordofan	9 - 16	F.A.O. (1967:238)
Tanzania	26 villages in 10 districts	5 - 26	Warner (1969)

Probably the most detailed data on water usage is provided by White et al's own study in East Africa. They report water usage for rural households, without piped supplies, at 12 sites in Kenya, Uganda and Tanzania. Mean per capita daily use ranges from 4.4 to 17.6 litres, and this use is related to size of household, size of container, cost of water and material wealth (1972:109-149). Of particular interest is White's data for Mwisi - a settlement in south-western Uganda occupied by the Chiga people. The Chiga are subsistence farmers, they draw water from springs, wells and rivers and they have a population density of approximately 250 per sq. km. Mwisi is set in hilly country at about 1,800 m. altitude. It resembles the New Guinea Highlands' situation more closely than other sites in White's sample and data from Mwisi will

be quoted in the following pages for comparative interest.[1]

White et al (1972:113) also survey the water use figures which are adopted by engineers as a design basis for domestic supplies. For piped connections in rural developing areas, the estimates range from 100-125 litres per capita per day for Venezuelan villages to 60 litres per capita per day for Guatemalan rural communities. For village stand pipes, design figures range from 40 litres per capita per day in Latin America to 10 litres per capita per day in Tanzania. Wagner and Lanoix (1959:43) comment that "few reliable data are available regarding water consumption when the source of supply is a hand— or motor— pumped well or a public tap". They quote a design figure from Venezuela of 15 litres per capita per day for supply to small towns through public taps.

Data for Oceania is extremely scarce and, so far as I am aware, there is no previous data on rural water usage in Papua New Guinea. Dirkis (1968:30) quotes figures of 682 litres per capita per day for expatriate households in urban areas; 400 litres per capita per day for indigenous households in Port Moresby and an overall Port Moresby figure of 468 litres per capita per day.

Most existing information on rural supplies in Papua New Guinea is contained in a series of reports by the Bureau of Mineral Resources of the Australian government. The fullest reports are on the Milne Bay District (MacGregor, 1966) and the East and West Sepik Districts (Read, 1967) and these are summarised in MacGregor and Reed (1967). These reports contain a brief description of existing supplies at 267 sites with recommendations for appropriate improvements. Data was collected on the concentrations of disolved salts in the existing supplies but

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1. Much information on rural water supplies in Tanzania is contained in a series of reports by the Economic Research Bureau and the Bureau of Resource Assessment and Land Use Planning of the University of Dar es Salaam. Readers with an East African interest are referred to this source.

not on their bacteriological quality. An estimate is made of the future water demand at each site and this appears to be based upon an assumed demand of 45 litres per capita per day. Groundwater investigations in the Central and Gulf districts are reported by Brouxhon (1965a, 1965b) and MacGregor (1967) describes proposals for the water supply of Daru town. Dirkis (1968:99-103) gives brief notes on the rural water supply situation in the Gulf District, the Madang District and the Markham Valley. The literature reviewed in this paragraph provides no reliable information on existing water-usage patterns and gives no details of actual demand.

The purpose of this report is to provide detailed information on water usage in a New Guinea Highlands' community. This will be of direct benefit to anyone engaged on water-supply works in the area and will facilitate the formulation of realistic design criteria. It should also be of interest to those responsible for other Highlands' regions in that it indicates inter-relationships and qualitative insights which may well have general validity. In addition, I hope that there will be much of interest to anthropologists and human geographers who are concerned with man-environment interactions. Much has been written on man-land relationships and agricultural systems in the Highlands (see Brookfield and Brown, 1963; Clarke, 1971; Rappaport, 1968; and Waddell, 1972b) but none of these describe the utilisation of the fundamental resource of water.

2. THE RAIAPU ENGA

The setting for the study reported here is the New Guinea Highlands. The Western Highlands District (centred on Mount Hagen), the Southern Highlands District (centred on Mendi), the Chimbu District (centred on Kundiawa) and the Eastern Highlands District (centred on Goroka and Kainantu) will be collectively referred to as the Highlands and contain approximately 900,000 people. Map 1 indicates the location of these Districts within Papua New Guinea.

The Raiapu Enga inhabit the valleys of the rivers Lai, Tare and Minyampu in the Western Highlands District[1] (see Map 2). They number approximately 30,000 and are administered from Wapenamanda. Together with the Mae Enga of the Wabag region, they make up the Central Enga, with a population of about 80,000. To their north, round Kompiam, live the Saui Enga; to the north-east, at Baiyer River, live the Kyaka Enga (see Bulmer 1960a, 1060b); to the south-east, in the Tambul region of the Upper Kaugel valley, live the Kakoli (see Bowers 1965, 1968); and to the south-west live the Kandepe Enga. In the east, on the far side of the Mount Hagen Range, live the Melpa (see Strathern 1971, 1972 and Vicedom and Tischner 1943-8).

In many aspects of their culture, social organisation and agriculture, the Raiapu are similar to the Mae who have been described in the extensive writings of M.J. Meggitt, (see particularly 1964 and 1965). Raiapu social institutions are recorded in Westermann (1968) and their agricultural system has been outstandingly researched by Waddell (1969, 1972a, 1972b). This paper is based on field work in the Saka valley (the valley of the river Tare) during 1971 when I resided with the Tombeakini clan of the south-eastern Saka[2].

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1. The administration is considering the creation of a new Enga District.

2. The Saka Valley is also known as the Tsak, Sark, Tchak, etc. The people of the Saka are sometimes referred to as Syaka Enga but this is not a meaningful ethnographic distinction and I shall treat them as Raiapu.

The Raiapu form patrilineal, segmentary, descent hierarchies comprising phratries, clans, sub-clans and patrilineages. All are named after their putative founders and, in any hierarchy, the founders are agnatically related so that the sons of the phratry founder are usually themselves clan founders. The clan is ideally exogamous (in practice also except in the case of large clans of perhaps 800 people) and clan members reside in a continuous stretch of territory which is deemed to be a clan possession.

Population densities often exceed 80 per sq. km. and in some areas rise to over 300 per sq. km. Neighbouring clans frequently experience hostile relations (despite the high probability that they belong to the same phratry) and borders are often contested in the courts and ultimately in fierce warfare. The Raiapu value privacy and scatter their houses about the clan's territory. The men traditionally lived in clubhouses with older male children, while their wives lived apart with infants, female children and pigs. Today this separation is breaking down and, in 1971, 33% of houses in Tombeakini territory were inhabited by nuclear families and their pigs, and contained 48% of the clan population.

The Raiapu staple food is sweet potato grown in large mulched mounds. They also cultivate a range of vegetables, sugar cane and bananas which provide them with a fairly varied diet (see Waddell 1972b). Pigs are kept primarily for exchange and ceremonial purposes and pork is not a regular item of Raiapu diet. Feachem (in press b) gives an account of Raiapu pig husbandry and the size of pig herds. In recent years they have turned enthusiastically to the cash cropping of coffee and introduced vegetables, as described by Waddell (1972b) and by Meggitt (1971) for the Mae. Feachem (in press a and in press c) describes Raiapu religious belief and ritual and the changes in belief which have resulted from missionary activity.

3. TOMBEAKINI AND THEIR ENVIRONMENT

Map 3 shows the territory of Tombeakini at Lyokote. Lyokote is one of 14 named localities within the territory but, since it includes both the tee-ground (an area for ceremonial activity especially for the tee and other pig exchanges) and the cluster of houses round the church, it is often used to refer to the whole clan territory. A vehicular road runs through Lyokote and joins the main Saka road which, in turn, joins the Highlands' Highway near Wapenamanda. Various land use categories are indicated on Map 3 by capital letters and these are identified in Table 2. Tombeakini has a population of 211 with a density, on the land they claim to be theirs, of 377 persons per sq. km.

Map 3 also indicates the location of various house types. I have classified houses as either "men's", "women's" or "mixed" and their typological features are given in Table 3. The nai anda, of which Tombeakini has only 2, are grouped with mixed houses and are not separately marked. Table 4 shows the distribution of clansmen in the three house types and it will be noted that 48 per cent now live in mixed houses. Traditionally, men and women would not cohabit but this restriction is breaking down and it is likely that families will increasingly live together. Meggitt (1964) describes the male-female antagonisms which underlie the sexual segregation of living quarters.

This description of housing is relevant to the survey of water use. The normal approach to a water-usage survey (for instance White et al, 1972) is to deal with households and household consumption.[1] This is only applicable, however, if the household is a domestic unit with a shared behaviour pattern with respect to water collection, washing, cooking etc. For the Tombeakini mixed household this is the case. The family is a domestic unit whose members cook and eat together and who share the water which one of them collects. In the case of

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1. A household is defined as the residents of a house and, similarly, a "men's household" is the residents of a men's house.

TABLE 2: LAND USE CLASSIFICATION OF TOMBEAKINI TERRITORY (SEE MAP 3)

CATEGORY	AREA sq. km.	% OF CLAN AREA	DESCRIPTION	UTILISATION
Sweet Potato Fields	0.21	38	Extensive open fields in which Ipomoea batatas is cultivated in large mulched mounds	Produces dietary staple and supports pig herds.
B	0.09	16	Swampy river flats with casuarina stands and ponds for kuta cultivation	Casuarina oligodon for timber. Kuta (Eleocharis sphacelata and E. dulcis) for women's aprons. Pig foraging.
C	0.04	7	Grassy swamps	Some taro (Colocasia esculenta). Pig foraging.
D	0.07	13	Steep hillside with grass, shrubs and limestone out-crops.	Miscanthus floridus and Imperata cylindrica for house construction. A little honey. Caves used as retreats in times of war.
E	0.08	14	Mixed gardens and coffee gardens.	Wide range of traditional and introduced vegetables and coffee. Often sold to provide main source of cash income
F	0.03	5	Sweet potato garden lying fallow or with disputed ownership.	Pig grazing
G	0.04	7	Steep hillside with cover of trees and scrub. Also limestone outcrops.	Pig foraging and timber. A little honey.

TABLE 3: A TYPOLOGY OF RAIAPU HOUSES

TYPE	ENGA NAME	DIMENSIONS	USUAL OCCUPANTS	COMMENTS
Men's	Akaryanda	Circular: - 5m diameter + 3.5m high or rectangular:- 6.5m long + 3.4 m wide + 2.5 m high.	Adult males with their male children over 8 years old.	Mostly circular type in Tombeakini. Traditional.
Women's	Endanda	Rectangular with one bay-end. 11m long + 3.8m wide + 2.7m high.	An adult women with female, and young male, children + pigs.	Traditional
Mixed	Kitisenanda*	Identical to women's house	A nuclear family + pigs	Recent
NAI ANDA	Nai anda or Kitisenanda*	Square, high roof and woven Miscanthus walls Copy of Administration rest-house or school classroom.	A nuclear family	Pigs usually kept in separate outhouse. Recent.

*Literally "christian house" (anda = house).

TABLE 4: RESIDENCE PATTERN OF TOMBEAKINI BY HOUSE TYPE

TYPE OF HOUSE	NUMBER OF HOUSES	PERCENTAGE OF TOTAL NUMBER OF HOUSES	NUMBER OF RESIDENTS	PERCENTAGE OF CLAN POPULATION	AVERAGE NUMBER OF RESIDENTS PER HOUSE
MEN'S	26	37	56	27	2.1
WOMEN'S	21	30	54	25	2.5
MIXED	23	33	101	48	4.3
ALL HOUSES	70	100	211	100	3.0

men's and women's households the situation is more complex and flexible. A woman living with her children in a women's house will cook and eat in that house and may be joined for evening and morning meals by her husband. However, her husband may eat in his men's house or he may join another of his wives (if he is a polygynist) for his meals. An old woman living alone may eat with her daughter-in-law or may join another similar woman. It is also common for old women to be visited by their unmarried, adult sons for meals.

This complex situation leads me to define a "domestic group" for the purposes of the water-usage survey. A domestic group is comprised of people who habitually eat their evening (and perhaps their morning) meal together and who share water which has been brought to the house where they gather. They may, or may not, cohabit and they are usually closely related. The size of a domestic group is measured in consumption units which are, somewhat arbitrarily, defined on the basis of children under 10 years equalling ½a unit and all others equalling 1 unit. All domestic group sizes are expressed as the mean number of consumption units who belonged to the group during the period of the survey.

Tombeakini have access to two major rivers - the Punate and the Tobaka. The Punate rises inside clan territory from a pair of springs at the foot of a limestone outcrop. It is soon joined by the Tipini stream. The Tobaka forms the eastern border of Tombeakini territory and rises at approximately 3,500 m. many miles to the south on Sugarloaf Mountain. Reference will also be made to a stream called Tsimbunai which rises at "12" (Map 3) and flows into the Tipini near "11". It is ephemeral and is dry for at least 4 months of the year.

4. THE SURVEY METHOD

The survey took place during two separate periods. In August 1971, 15 domestic groups were surveyed for an average of 14 days each. In December 1971 another 23 domestic groups were surveyed for 17 days each. The 38 groups contained 79.6% of the clan population. They were selected non-randomly, partly on the basis of ensuring that groups in all parts of the clan territory were surveyed, and partly due to prohibitions enforced by my assistants.

The survey was conducted by daily house-to-house visits during which a standardised questionnaire was administered. Most of this interviewing was conducted by two secondary school students who were living with Tombeakini. These students felt unable to survey a few domestic groups due to internal clan politics, and family feuds, which made them unwelcome in certain houses. However, nearly 80% of the clan was surveyed and no bias is evident in the resulting sample. A total of 665 water collection journeys were recorded.

The students visited the selected houses each morning between 6.00 a.m. and 8.00 a.m. They asked questions about activities over the previous 24 hours:- who collected water? what in? when? from where? and for what purpose? Volumes were calculated by measuring the capacity of each group's water containers. These early morning visits coincided with a period between rising and leaving for the day's work in the gardens. It was a time when the interviewees were prepared to sit and talk and were not particularly busy. Most questions referred to the collection of water the previous afternoon or evening (the times when most water is collected) and these events were still fresh in the minds of the interviewees.

After the morning interviews, the students reported to my house for their schedules to be checked. Queries were discussed and dubious responses were spotted and could be immediately investigated. The survey procedure proved most satisfactory and provided

data of good reliability. The data on choice of source, time of collection, containers used, identity of collector and the total volumes collected can be treated with confidence. Data on the volumes used for different purposes was harder to obtain and is probably only accurate to ±20%.

Table 5 shows the characteristics of the survey sample. The mean domestic group size of 3.6 consumption units is considerably larger than the mean household size of 3.0 people (Table 4) which illustrates the need to consider water use in terms of domestic groups. Figures 1 and 2 show the distribution of domestic group sizes, and travel times to water source, for the sample of domestic groups surveyed. Figure 3 shows the rainfall for the two periods of the water usage survey.

TABLE 5: DETAILS OF THE 38 DOMESTIC GROUPS SURVEYED

MEASURE	UNITS	MEAN	MAX.	MIN.	COMMENTS
Length of survey period	Days	15.8	21	14	15 domestic groups surveyed in August and 23 in December.
No. of collection journeys per domestic group per day.		1.1	1.9	0.7	
Domestic group composition	Consumption units. (Adults = 1; children under 10 yrs=½)	3.6	6.6	1.8	All "per capita" or "per head" water usage data quoted here is in fact "per consumption unit".
Time for round trip to nearest major source (Punate or Tobaka)	Minutes	12.5	23	4	Timed by walking the distance at the speed of an Enga woman carrying water (a brisk pace).

FIG. 1: THE DISTRIBUTION OF DOMESTIC GROUP SIZES IN THE SAMPLE OF DOMESTIC GROUPS SURVEYED

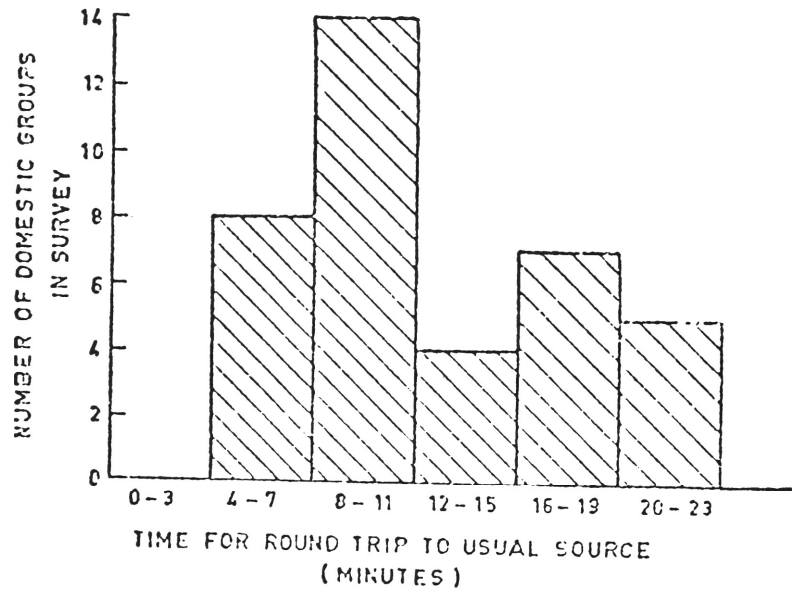

FIG. 2: THE DISTRIBUTION OF TRAVEL TIMES TO THE USUAL MAJOR SOURCE (TOBAKA OR PUNATE) FOR THE SAMPLE OF DOMESTIC GROUPS SURVEYED

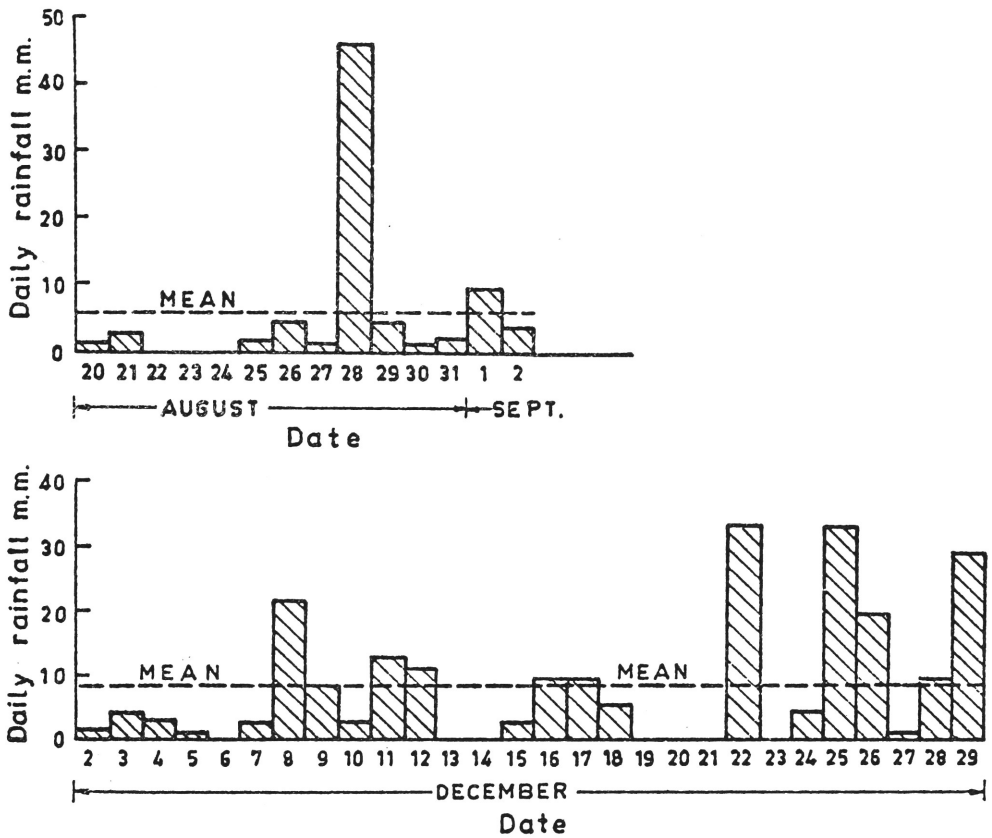

FIG. 3: DAILY RAINFALL DURING THE TWO PERIODS OF THE WATER USE SURVEY - 1971

5. ATTITUDES TO WATER

In any attempt to upgrade the water supply of a rural community, it is of crucial importance that the attitudes and beliefs of the people should be fully understood. If this is the case it is possible to assess the local demand (or "felt need") for improved water, to design a scheme which is approved of by the users, to enlist the community's co-operation in construction and maintenance and to ensure that the new supply is used to the best advantage and that maximum benefits are derived from it. An understanding of Raiapu attitudes to water will also help the reader to appreciate the data on water use in its cultural, as well as its environmental, context.

The Raiapu view of water is generally prosaic. The rivers

have never been known to dry up and they are very much taken for granted. Droughts occur (for instance in 1972) but it is the frosts which accompany the droughts that the Raiapu really fear since they kill the sweet potatoes. No religious ritual or magic is undertaken to promote rain and people are more concerned with flooding than droughts. It is appreciated that heavy rain in the hills will cause rivers (like the Tobaka) to flood causing damage to kuta ponds, casuarina stands and the swampy flats which are much used for pig grazing (see Table 2, category B). Floods also bring down earth which makes the rivers unpleasantly turbid and occasionally people and pigs are drowned in swollen rivers.

The Raiapu perceive the fundamentals of hydrology and are generally uncurious about more complex aspects. They know that rainfall drains into rivers and that heavy rain will lead to floods. They appreciate the power of water to erode and the way in which rivers change their course and eat away their banks. It is now known that the rivers flow down to the sea but traditionally it was not known where they went. The source of rain is the yalyakali or "sky people" who live in a world above the earth and are the creative beings. It is said that rain is caused by sky women (yalya enda) swimming in a lake which then spills over the edge and falls to earth. Some say that rain is caused by the sky women urinating. Other meteorological and natural phenomena (earthquakes, lightening, stars and strong winds) are also associated with the yalyakali, but no attempt is made to influence nature by appeals to the sky world. If heavy rain comes it is treated fatalistically and the yalyakali are not blamed or appealed to.

Since water is generally plentiful, its ownership is not a source of dispute or litigation. Rivers frequently form the boundary between two clans and, in these cases, the river is said to belong to both. If a river flows through a clan's territory it will belong to the clan in that stretch but others would not be prevented from using it. Ownership is more assertively claimed in the case of a spring rising inside a clan's territory - as with Tombeakini and the River Punate. A spring produces water which is clear and cold (the

properties most valued) and it is not subject to fouling in floods or poisoning by up-stream enemies. A clan possessing a major spring (of which I knew of only 2 in the Saka) will be proud of this resource and will even boast about it publicly.

Tombeakini, for instance, see the Punate as one of their major assets but they would not prohibit its use by others unless they were enemies. They also claim no rights to the Punate after it has left their territory and flown into Yanuni. The Punate has become a feature of the stories which support Tombeakini's claim to their territory. It is told that two descendants of Tombeakini (the clan founder who lived in the Kaugel Valley above Tambul) came, after various hardships, to the Saka where one settled to the west of the Punate spring while the other built his house on the eastern side. Several old casuarina trees, which are used to record the date of historical events ("we fought a great battle with Tashikini when that tree was small"), are also standing near the Punate springs.

Generally, the Raiapu do not undertake any improvement or protection works for their water sources. The only source protection I saw was an impressive dry stone wall which surrounds the other major spring in the Saka. This wall was designed to keep pigs and cattle away from the spring but it also served to advertise the pride with which the spring was regarded by the clan who owned it.

The qualities of water most appreciated by the Raiapu are clearness and coldness and they prefer to drink water of this type. Warm and turbid water will be drunk if that is all which is available, and it is not generally felt that any sickness or other bad outcome will result. Some say that drinking very turbid water will lead to a blockage of the small intestine, but most Raiapu do not worry about this. If turbid water is collected it is often left to settle before drinking. On a hot day water will be collected in a gourd or bamboo because it is thought (quite correctly) that it stays cooler than in a metal pot or bottle. Water is almost never stored inside a house lest it becomes

unpalatably warm.

Rainwater is considered good water but it will not be caught off the roof of a house. Roofs are made of thatched Imperata cylindrica and water that has run off them contains a heavy load of dust and small grass particles. Rainwater is collected from dripping trees during heavy rain.

Water is not used directly in religious rituals (compare, for instance, Maring practice - Rappaport, 1968:205) but there are inter-relationships between water and religion. Perhaps the most important of these is the fear of sorcery. The Raiapu are continually apprehensive about the possibility that enemies will introduce menstrual blood, faeces or parts of a corpse into their food or water. To consume these items would mean serious illness or death. The ownership of a spring precludes such a danger but many Raiapu use water which has travelled through the territories of other clans, some of which may well be hostile. This gives rise to accusations and litigations concerning the poisoning of water supplies and may well lead to warfare. Such disputes are not common however, when compared with other sources of inter-clan strife. Feachem (in press c) should be consulted for a full account of Raiapu religious belief, ritual and sorcery.

The Raiapu also believe in sacred pools (yaka pete or yalya pete) which are inhabited either by ghosts of the recent dead (timongo) or by demons (pututuli). They avoid these places and one such pool in Yanuni territory (see Map 3) was drained when a boy drowned in it a few years ago. It was said that a timongo held him under and a ritual specialist (topoli) was employed by Yanuni to exorcise the area.

The only other magical associations of water which I have encountered are in rituals designed to cure sick dogs and promote healthy growth of a young man's hair. In the veterinary ritual the dog is held near a large river (like the Tobaka) and a tree fern (tambu ita) branch is held near it. Spells are recited and the branch is cast into the river thus symbolically removing the poison from the dog's body.

In the second ritual a specialist (topoli) will pour bespelled water over a young man's head to promote a luxuriant growth of hair and beard.

Two prohibitions concerned with drinking water should be mentioned. Firstly, the Raiapu fear that the "juice" of a corpse may contaminate a river and so people are usually buried far from rivers. A few years ago the River Tame (see Map 3) changed course and cut into an old grave. This caused Yanuni to stop using the Tame as a water source for approximately six months in order that all the "juice" could be washed away. Secondly, males are constantly aware of the contaminating nature of women which can cause them to become prematurely old and loose their vigour and potency. Meggitt (1964) gives an account of male-female antagonisms amongst the Mae and the Raiapu case is very similar. Due to this, males will never drink immediately down-stream of a place where women are standing or have recently waded. A woman, who notices that a man is about to inadvertently drink down-stream of a place where she has been standing, will often call out to warn the man of his danger. If she does not do this, and is observed by other men, she will be severely chastised for not drawing attention to the hazard.

Women are not permitted to bathe in the Punate, or the Tipini because it runs into the Punate, lest this excellent water source should be contaminated. It is said that female bathing in the Tobaka is permissible because the greater flow will cause any polluting substances to be swiftly washed away. It is indicative of how dangerous female contamination is regarded to be that, while women may not bathe in the Punate, the intestines of pigs are commonly taken by women and children to be cleaned out and washed in the Punate. Tombeakini appreciate that the contents of the pigs' intestine are foul and potentially harmful but it is thought that, if the cleaning is carried out in mid-stream, the danger will be quickly washed away.

Generally speaking, larger rivers are regarded as safe from all types of pollution since any contaminants will be quickly carried down-stream. Small rivers, like the Punate, need to be protected from major

pollution (e.g. women) but are acceptable as washing places for pigs' intestines. The smallest rivers, like the Tipini, are not considered capable of cleansing themselves atall and so they are not used for any washing activities. Standing water, such as in the kuta pete (see Section 10), are also unable to receive any pollution and it is said that, if pigs intestines were washed in a kuta pete, the kuta would soon die.

Finally, it can be noted that the Enga use rivers as a means of geographical reference. River names are surprisingly standardised so that people from a wide area will all agree on a particular river's name. These names are then used to describe locations. Most people of the Wabag area have never heard of Tombeakini but they know of the river Tobaka and the other major Saka rivers - the Tare and the Wakema (see Map 2) - and use these as points of reference when discussing the Saka.

6. THE CHOICE OF WATER SOURCE

Decisions regarding the choice of water source are not made with respect to the situation as a sanitary engineer would define it but rather with respect to the situation as it is perceived by the water user. The choice is made, not between all available sources, but between all perceived sources and it is made according to Raiapu concepts of suitability. A useful model for the analysis of this choice "views the water user as a person who perceives the choices open to her with varying degrees of accuracy and who judges according to her own perception of the quality of the source, the technical means available to her in drawing on the source, the expected returns and costs, and the interaction with other people which such use involves" (White et al 1972:227). These four criteria will be labelled "quality", "technology", "efficiency" and "human interaction".

Tombeakini perceive 6 alternative sources within their territory and these are listed in Table 6 with an assessment of the consensus of opinion towards them under the four criteria stipulated.

TABLE 6: CRITERIA AFFECTING CHOICE BETWEEN SIX ALTERNATIVE WATER SOURCES

NAME OF SOURCE	QUALITY	TECHNOLOGY	EFFICIENCY	HUMAN INTERACTION
Punate	Excellent	Readily available at all times	In all cases this depends upon the distance, and length of travel time, between source and dwelling.	All these sources are reached without going outside Tombeakini territory or encountering hostile groups. Also water collection points are not social meeting places. Human interaction, therefore, is not an operative criterion.
Tobaka	Good			
Tipini	Bad			
Tsimbunai	Satisfactory	Only in times of heavy rain		
Rain Water	Excellent			
Ponds or Puddles	Bad			

Table 6 shows that there are three permanently available sources, the choice between which rests solely on two criteria - quality and efficiency. Human interaction is not an operative criterion in the choice between the six sources within Tombeakini territory, but it is operative in the exclusion of nearby sources. For instance, people living at 14 (Map 3) might well consider the Tame as a possible source except that this would involve a journey into Yanuni territory which would be unacceptable on a regular basis. The quality judgements follow from the attitudes to water which were discussed in the previous section. The Punate is cold and clear and therefore perfect. The Tobaka is cold but sometimes turbid and the Tipini is warm and turbid. Table 7 presents data on these same rivers and it is clear that Tombeakini perception corresponds closely to scientific perception and leads them to prefer a source which has an appreciably lower load of faecal material than other available sources.

TABLE 7: MEAN FAECAL BACTERIAL CONCENTRATIONS, TEMPERATURES AND TURBIDITIES IN FOUR SAKA RIVERS DURING JUNE - DECEMBER, 1971.

RIVER NAME	MEAN TEMP. AT TIME OF COLLECTION ^{o}C	MEAN TURBIDITY	FAECAL COLIFORMS. COLONIES PER 100 ml.	FAECAL STREPTOCOCCI. COLONIES PER 100 ml.
Punate (Near spring)	15.1	11	8	40
Tipini	20.5	56	1,563	1,405
Tobaka	14.4	53	220	270
Tame	21.2	29	669	559

Table 8 shows the utilisation of the six sources already mentioned plus collection, by travellers returning home, from external sources and collection from my water tank which was only available during 1971. A total of 665 water collection journeys were surveyed and, of these, 85% were from the Punate or the Tobaka. The Tsimbunai was used by two domestic groups who lived adjacent to it. Rain-water is collected in times of heavy rain by placing an open container underneath a tree where there is a natural spout. Reliance on rain-water varies with the weather and, overall, 8% of collection journeys were for rain-water. During August, only 1.1% of journeys were for rain-water and 87% of groups used no rain-water. During December, 13.5% of journeys were for rain-water and only 22% of groups used no rain-water. A strong seasonal variation in rain-water usage exists although the difference in mean rainfall during the August and December survey periods is not particularly great (see Fig. 3). Rain-water can only be collected during periods of heavy precipitation. During December, 25% of days had a precipitation of > 10 mm, whereas August had only 7% of similar days. It is this seasonal difference in the frequency of high rainfall days which explains the greatly increased usage of rainwater during December.

As has been mentioned, the choice between the permanently available sources (Punate, Tobaka and Tipini) rests upon assessments of quality and efficiency. The Tipini is clearly rejected (only 1% of journeys) because of its bad quality (Tables 6 and 7). This leaves the Punate and Tobaka between which Tombeakini have to choose and from which they collect most of their water. It is instructive to inquire whether this choice is primarily influenced by quality judgements or by efficiency. Efficiency in this case means proximity to the water source and the relevant measure of this is the round-trip travel time from dwelling to source and back. A measurement of distance would not be meaningful since some journeys involve the descent and ascent of steep muddy slopes whereas other journeys, which may be of equal distance, are over relatively flat terrain.

TABLE 8: UTILISATION OF EIGHT ALTERNATIVE WATER SOURCES BY SURVEY SAMPLE

NAME OF SOURCE	NUMBER OF JOURNEYS MADE TO GIVEN SOURCE	PERCENTAGE OF TOTAL NUMBER OF JOURNEYS
PUNATE RIVER	337	50
TOBAKA RIVER	232	35
TIPINI RIVER	6	1
TSIMBUNAL STREAM	25	3½
RAIN WATER	52	8
PONDS OR PUDDLES	6	1
RIVERS OUTSIDE TOMBEAKINI TERRITORY	2	½
TANK ON AUTHOR's HOUSE	5	1
ALL SOURCES	665	100

Although eight sources were utilised by the sample of domestic groups, 85% of journeys were made to the Punate or Tobaka and all groups made some use of one or both of these sources. Table 9 shows that 87% of groups used between 1 and 3 sources during the survey. All domestic groups have been classified according to their usage of the two major sources. Groups are either Punate-users, Tobaka-users or Punate-and-Tobaka-users. Since utilisation of other sources is so low, this is a reasonable division and, in fact, Tombeakini often characterise themselves in this way. A man who lives near the Punate but who also uses some rain-water, will say he is a Punate-user and will not refer to rain-water unless closely questioned. Table 10 shows the whole clan divided (by

household) according to their usage of the two major sources. Map 4 shows the geographical location of these houses and it can be seen that the choice between Punate and Tobaka is closely related to the household's relative position between the two sources.

TABLE 9: MULTIPLE WATER SOURCE USAGE AMONGST SURVEY SAMPLE

NUMBER OF SOURCES USED	NUMBER OF DOMESTIC GROUPS USING GIVEN NUMBER OF SOURCES	PERCENTAGE OF NUMBER (38) OF DOMESTIC GROUPS SURVEYED
1	9	24
2	16	42
3	8	21
4	3	8
5	2	5

TABLE 10: TOMBEAKINI'S CHOICE OF WATER SOURCE

USUAL SOURCE OF WATER	NUMBER OF HOUSES	PERCENTAGE OF TOTAL NUMBER OF HOUSES	NUMBER OF RESIDENTS	PERCENTAGE OF CLAN POPULATION
PUNATE	30	43	83	39
TOBAKA	28	40	80	38
PUNATE AND TOBAKA	12	17	48	23

Is the decision between Punate and Tobaka made purely on the basis of efficiency (as Map 4 might suggest) or do domestic groups display a preference for the Punate which they all agree is a source of superior quality? Figure 4 displays this problem. If efficiency (travel time from source) were the only criterion then quadrants B and D would be empty and all groups would be symmetrically placed in A and C. We find, however, that 4 groups are in B and 3 are in D and that those in B are more centrally

placed within that quadrant. This indicates a slight preference for the Punate. Of the groups in A, 79% never use the Tobaka (P/(P+T) = 1.0) whereas only 42% of those in C never use the Punate. A further indication of preference is that 100%, of the 24% of domestic groups who use only one source (Table 9), are Punate-users.

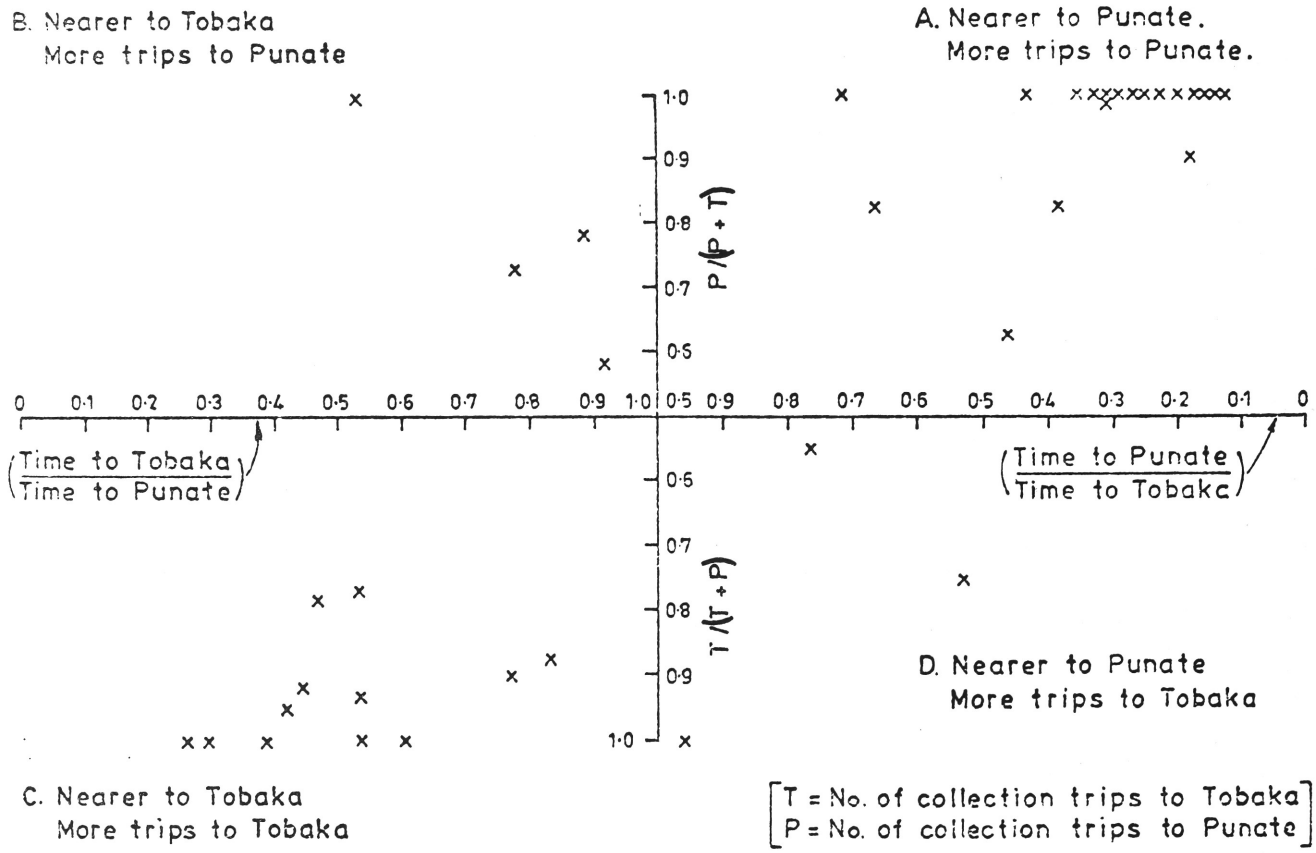

FIG. 4: THE DISTRIBUTION OF DOMESTIC GROUPS SURVEYED ACCORDING TO THEIR PROXIMITY TO THE MAJOR WATER SOURCES AND THEIR RELATIVE UTILISATION OF THOSE SOURCES

This evidence indicates a slight preference for the Punate - attributable to its clearness, coolness and its lack of exposure to poisoning or flooding. However, Map 4 and Figure 4 show that it is a preference affecting only a few houses which are located in a marginal position between the two sources. For most domestic groups the choice is simply dependent upon which source is the nearer.

7. THE COLLECTION OF WATER

When is water collected; by whom; and in what? Tables 11, 12 and 13 answer these questions. Water is collected at all times except at night and mainly in the late afternoon. Slightly more is collected by females and people of all ages participate. 47% of journeys are made by children or teenagers. It is collected most commonly in gourds or glass bottles but pots, bamboos and tins are often used.

TABLE 11: TIMES AT WHICH WATER COLLECTION JOURNEYS ARE MADE

TIME	NUMBER OF JOURNEYS MADE AT GIVEN TIME	PERCENTAGE OF TOTAL NUMBER OF JOURNEYS
06.00 - 11.59 MORNING	64	10
12.00 - 15.59 EARLY AFTERNOON	197	29
16.00 - 18.59 LATE AFTERNOON	378	57
19.00 - 20.59 EVENING	26	4
21.00 - 05.59 NIGHT	0	0

TABLE 12: COMPARISON OF THE NUMBER OF WATER COLLECTION JOURNEYS MADE BY INDIVIDUALS IN DIFFERENT AGE-SEX COHORTS

AGE	NUMBERS AND PERCENTAGES OF JOURNEYS					
	MALES		FEMALES		TOTAL	
	No.	%	No.	%	No.	%
0 - 9	59	9	65	10	124	19
10 - 19	67	10	121	18	188	28
20 - 29	35	5	105	16	140	21
30 - 39	48	8	37	5	85	13
40 - 69	68	10	60	9	128	19
ALL AGES	277	42	388	58	665	100

TABLE 13: THE FREQUENCY OF USAGE OF FIVE TYPES OF WATER CONTAINER

TYPE OF CONTAINER	VOLUME OF CONTAINER LITRES			NUMBER OF CONTAINER - JOURNEYS MADE	% OF TOTAL NUMBER OF CONTAINER - JOURNEYS MADE
	MEAN	MIN	MAX		
GOURD	1.3	0.3	2.8	264	29
GLASS BOTTLE	0.4	0.3	0.8	237	26
COOKING POT	3.0	1.3	5.6	193	21
BAMBOO	1.7	0.4	3.0	107	12
TIN	2.6	0.8	3.0	104	12
ALL TYPES	1.8	0.3	5.6	905	100

Traditionally all water would be collected in gourds or bamboos and 41% of journeys are still made with these containers. The gourd (Lagenaria sp.) is an object of beauty and it is a slow and skillful task to make one. Gourds are items of traditional value and are kept as family heirlooms or exchanged in minor prestations. Larger gourds (> 2 litres) are fragile and are not often used for water collection. On hot days, gourds and bamboos are the preferred containers since water remains cooler in them.

In assessing the benefits which may accrue from a new water supply scheme, it is necessary to know the cost of water in the existing water use system in order that this may be compared to the cost from the proposed new supply. Where an urban authority charges for water piped to the house, this charge will usually represent the whole direct cost to the consumer, even if the charge is merely a nominal percentage of the real cost of supply. For unpiped supplies, costs may include the

charge made at the standpipe or by the water carrier and the energy expended in carrying the water home.

The Raiapu clearly have to make no direct payment for their water. The cost therefore is simply the energy cost of water collection added to the cost of the time spent in water collection which could be otherwise employed. The estimation of these costs in a subsistence, or partly subsistence, economy presents real problems. The procedure adopted here is that proposed by White et al (1972:93 - 98) and apperas appropriate to the Raiapu situation. The energy cost is calculated by costing the quantity of staple food required to provide the amount of energy used in water collection. It is not possible to produce a realistic estimate of the opportunity cost of the time spent in water collection. I assume however, that the time is worth at least the cost of food consumed in that time which is calculated by distributing the total caloric intake uniformly over a 24 hour period. The energy cost and the time cost are added to give a value for the total cost of water collection.

The average domestic group collects 2.46 litres of water per day, in 1.1 journeys, each of 12.5 minutes duration (Tables 5 and 14). Considering the weight of the load (2.46 kg + container), the hilly terrain and the age of the carriers (Table 12) a figure of 5.0 calories per minute is estimated (from the data of Hipsley and Kirk, 1965:43) for Tombeakini energy expenditure during water collection. Therefore 5.0 x 12.5 x 1.1 = 68.75 calories per domestic group per day are spent on water collection. A mean of 12.5 x 1.1/60 = 0.23 hours are spent collecting water per day which, assuming a total caloric intake of 2,400 calories per day (Waddell, 1972b : 126), is equivalent to 2,400 x 0.23/24 = 23 calories per domestic group per day.

Adding the energy cost to the time cost gives 91.75 calories per domestic group per day. This is converted into monetary units by assuming a cost of sweet potato of 1 cent (Australian currency) per pound (the price paid by Waso Ltd. of Wapenamanda during 1971) and a

caloric content of 150 calories per 100 g of sweet potato (Hipsley and Kirk, 1965:39). Applying these data, costs of 0.134 cents per domestic group daily, 0.037 cents per capita daily and 0.054 cents per litre are obtained.

These costs are negligible but they are similar to those for Mwisi where White et al (1972:103) report a cost of 0.028 U.S. cents per litre and 0.126 U.S. cents per capita daily. The costs for the entire Tombeakini clan are only 7.81 cents per day and $28.5 per annum.

8. WATER USAGE

The pattern of domestic water usage is tabulated in Table 14. It should be stressed that figures refer only to water which is brought to the dwelling and do not include any extra-domiciliary water usage. 79% of water collected is drunk. Of the remaining 21%; 47% is used for cooking, 36% for pigs, 4% for washing, 2% for dogs and chickens and 11% is thrown away. 29% of domestic groups surveyed used water only for drinking. Per capita usage is shown in Table 15.

TABLE 14: WATER USAGE PER DOMESTIC GROUP

USAGE CATEGORY	VOLUME USED - LITRES PER DOMESTIC GROUP PER DAY			% OF TOTAL USED (MEAN)	COMMENTS
	MEAN	MIN.	MAX.		
Drinking	1.93	0.60	4.37	79	Mainly drunk with the morning and evening meals.
Cooking	0.25	0	2.08	10	Cooking purchased rice, pumpkin leaves and vegetable soup. 45% of d.g.s.* used no water for cooking.
Washing (plates etc)	0.02	0	0.15	1	84% of d.g.s. used no water for washing.
Pigs (for drinking or cooking pig's food)	0.19	0	1.94	7	Pigs are fed small tubers and leaves normally boiled in water. 55% of d.g.s. used no water for pigs.
Dogs and/or Chickens. (for drinking)	0.01	0	0.13	½	86% of d.g.s. used no water for dogs or chickens.
Thrown Away	0.06	0	0.58	2½	63% of d.g.s. threw none away.
Total Collected	2.46	0.60	4.99	100	

*d.g.s. = domestic groups surveyed.

TABLE 15: PER CAPITA WATER USAGE

USAGE CATEGORY	VOLUME USED - LITRES PER CAPITA PER DAY		
	MEAN	MIN.	MAX.
Total Collected	0.68	0.19	1.27
Drinking	0.54	0.19	1.16

The most striking feature of the data in Tables 14 and 15 is the extremely low level of water use. Data for Mwisi (White et al, 1972:119) shows a mean per capita daily use of 4.4 litres and a minimum per capita daily use of 1.4 litres. Water use at Mwisi was appreciably lower than at any other East African site studied by White. The Raiapu use little water for purposes other than drinking and drink little water. This results in low per capita total usage.

The only comparable data from the New Guinea Highlands is provided by Hipsley and Kirk (1965:79) from their data on the Chimbu settlement of Pari (near Kundiawa - see Map 1) and by Oomen and Corden (1969:16) from their study on the Kyaka Enga at Baiyer River. Hipsley and Kirk report extremely low daily fluid intakes of 0.07 and 0.01 litres per capita for men and women respectively. It appears (1965:143) that they obtained these figures by questionnaire and observation and, in the absence of further details, one must view the validity of this data with suspicion. Hipsley and Kirk add to these consumption figures water from food and water from food oxidation to obtain total volumes of available water. These are again low when compared with the clinical norm of 2.5 litres for "resting conditions in a moderate climate" (1965:144). The authors discuss this low intake and conclude that it is possibly related to the low-protein and low-sodium dietary characteristics which lead to a reduced demand for water as a "vehicle for waste nitrogenous products and other solutes" (1965:146).

TABLE 16: FLUID CONSUMPTIONS OF CHIMBUS AT PARI
AFTER HIPSLEY AND KIRK (1965:79)
LITRES PER CAPITA PER DAY

TYPE OF FLUID	MALES	FEMALES
Water	0.036	0
Water (as tea)	0	0.007
Cooking water	0.035	0.006
Total Fluid	0.071	0.013
Water in food	1.234	0.963
Total consumed	1.305	0.976
Water of Oxidation*	0.355	0.243
Total available	1.660	1.219

*Calculated as 150 ml./1000 calories of food oxidized.

Oomen and Corden (1969) provide fluid intake data in their study of dietary intakes and nitrogen metabolism among 24 subjects at Baiyer River (see Map 2). They report that between 0.23 and 0.43 litres per capita per day were drunk although these figures may be high because the experimental subjects had water close to hand at all times. Allowing for water in food, but not for food oxidation, Oomen and Corden compute a total daily per capita intake of 1.56 litres for adult males and 1.95 for adult females. The authors suggest that these low fluid intake figures may relate to the low-sodium nature of the diet caused partially be extremely limited salt use and the apparent absence of salt hunger. They

note that traditional salt is used mainly on ceremonial occasions (see Meggitt, 1958) and that, in any case, this type of salt is primarily potassium based. Oomen and Corden do not comment on the recent development of purchasing packaged salt from native-owned stores and this practice is certainly common in the Saka. It may be that the taste for salt will grow and with it the Enga thirst.

Tombeakini data (Table 15) shows a considerably higher level of fluid intake amongst the Raiapu than the Chimbu. Also, 0.54 litres per capita daily excludes any water that is drunk away from home and also excludes water drunk in the form of soup (the Raiapu do not typically drink tea or coffee). My impression is that, during days of light work and moderate weather, the Raiapu will drink little or nothing away from home. However, during heavy tasks (clearing new gardens, house-building, etc.) or hot weather, they will drink heavily while at work. I therefore suggest a mean figure of 0.7 litres per capita daily for water consumed throughout the day. Waddell (1972b:121) provides dietary data for a Raiapu clan at the entrance to the Saka valley. Using this I calculate that the Raiapu consume approximately 1.38 litres per capita daily of water in food[1] and 0.36 litres of water of oxidation (assuming 150 ml of

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1. Enga men relish sugar-cane (Saccharum officinarum) and will eat large quantities when it is available. It is considered to be extremely thirst-quenching and the Raiapu say that it is their substitute for water. It contains 82% water by weight (Hipsley and Kirk, 1965:40) and its consumption may dramatically increase the figure of 1.38 litres given here. However, women eat little or no sugar-cane and men who are old, or who are not prosperous, will eat little because they have none and are unlikely to receive any from other men. Sugar-cane water cannot therefore be included in any generalisations concerning Raiapu water intake.

water per 1000 calories of food oxidized). This gives a total daily water availability of 0.7 + 1.38 + 0.36 = 2.44 litres which corresponds closely to the clinical norm of 2.5 litres.

If Hipsley's explanation of the low Chimbu water consumption is correct we should expect the Raiapu to have a diet richer in protein than the Chimbu. This appears to be the case. Waddell (1972b:126) reports 29.5 g and 34.7 g of protein daily during his two survey periods while the mean Chimbu figure is only 21 g of daily protein (Hipsley and Kirk, 1965:146). It is likely that other Enga groups have a diet which is lower in protein than the Raiapu and indeed Sinnett (1972) reports a protein intake of 25 g per day for an Enga clan near Laiagam (see Map 2). It may be anticipated therefore that these Enga will require less water than the Raiapu.

A notable feature of Table 14 is that, with the exception of the 1% of water used for washing utensils, water is not utilised for hygienic purposes within the home. Most Raiapu households own a few metallic eating and cooking utensils but only 16% of domestic groups surveyed carried any water to the house for the purpose of washing these. Tombeakini clansmen never wash their bodies at their houses, and this is probably true throughout the Enga region and indeed for most of the New Guinea Highlands. The Enga pay little attention to personal hygiene of any sort but do occasionally bathe all or parts of their bodies in rivers. This river bathing only occurs on hot days and is practised very rarely by adults of either sex. Some Enga, perhaps even many Enga, live their whole lives without ever thoroughly washing themselves. This situation clearly has medical significance and its influence on morbidity patterns will be briefly discussed in Section 12.

9. FACTORS AFFECTING WATER USAGE

In this section I shall briefly consider the two major factors which are likely to influence patterns of Tombeakini water use. White et al (1972:109-149) found East African usage to be associated with size of household, cost of water, size of container and material wealth. Since their is little variation in material wealth between Tombeakini families, and since all families have a similar selection of containers, it is only household size and cost which are likely to influence Tombeakini usage.

(a) Size of Domestic Group: Figure 5 shows that usage per domestic group increases with the size of the domestic group. Figure 6 indicates a tendency for per capita usage to decrease as group size increases, for groups of at least two consumption units. The low per capita usage in the smallest groups is due to these small groups being almost exclusively composed of elderly people who are not very active and have a diminished need. The elevated demand displayed by the 6-7 units domestic group is probably atypical and results from there being only one group of this size in the sample. Had there been more groups of > 6 units, their mean usage would almost certainly have been < 0.6 litres per day. White et al (1972:123) also found a decreasing per capita demand with increasing household size.

Figure 7 shows the influence of domestic group size on the amount of water used for purposes other than drinking. The 6-7 units group should be ignored for the reason mentioned above. The remaining data shows maximum general usage by the middle sized (3-4 units) groups. The old people in the smallest groups use little water except for drinking because they do not keep pigs, dogs or chickens and they do not often cook soups.

(b) Travel Time to Source: As has been discussed in Sections 6 and 7, the relevant measure of the cost, or efficiency, of water collection is the round-trip travel time from dwelling to source. Figures 8, 9, 10 and 11 show that this travel time is not correlated with per capita usage, per capita consumption, the percentage not drunk or the frequency of

FIG. 5: DOMESTIC GROUP SIZE VERSUS THE VOLUME OF WATER USED PER GROUP PER DAY

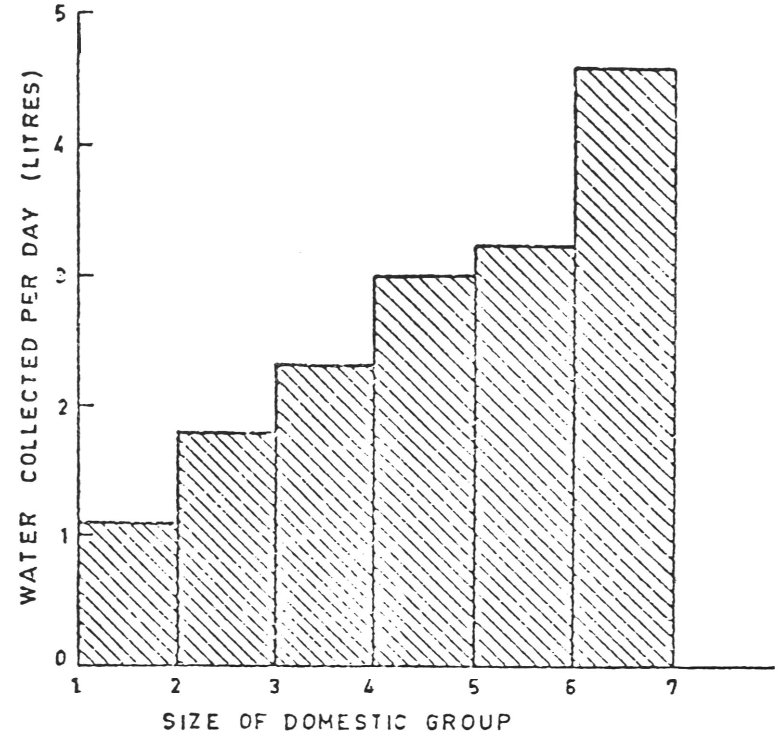
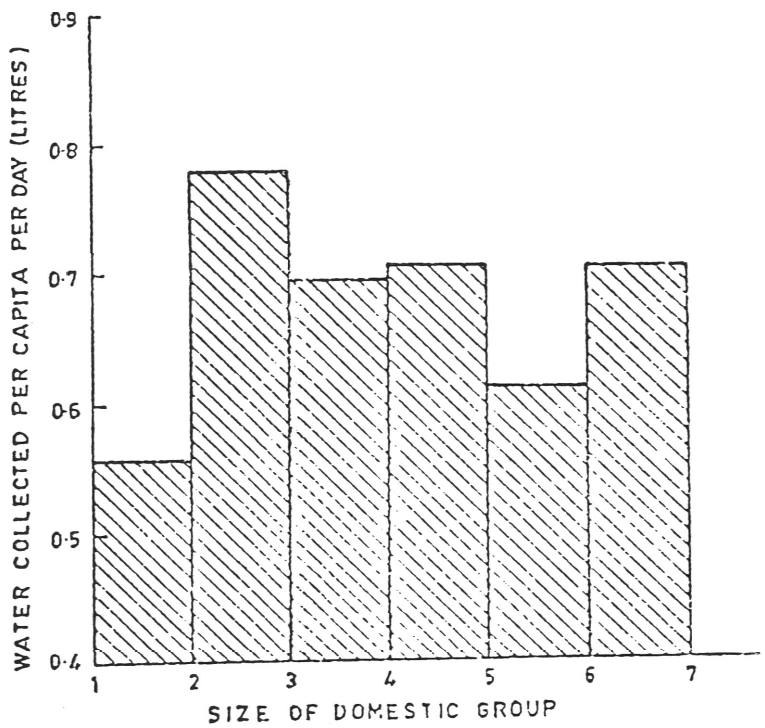


FIG. 6: DOMESTIC GROUP SIZE VERSUS THE VOLUME OF WATER USED PER CAPITA PER DAY



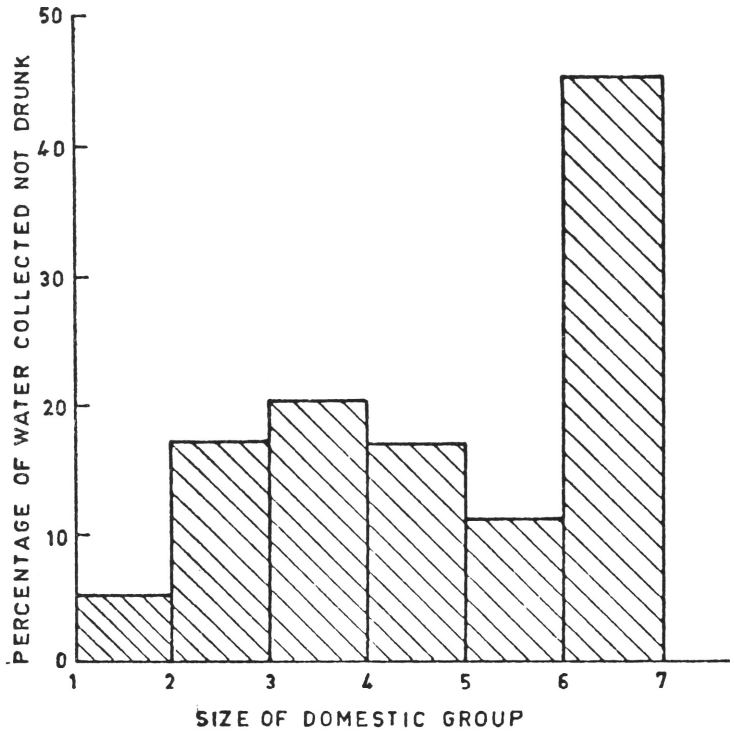


FIG. 7: DOMESTIC GROUP SIZE VERSUS THE PERCENTAGE OF WATER USED FOR PURPOSES OTHER THAN DRINKING

rain-water collection. This lack of association stems from the proximity of all Tombeakini dwellings to either the Punate or Tobaka (see Map 3 and Fig. 2). The range of times is only 4 minutes to 23 minutes (Table 5) and it appears that this range is not great enough for travel time to become a significant influence on water usage.

White et al (1972:127-130) also found that travel time and distance did not play the role that might have been expected. They report:

> At the outset we thought it reasonable that the longer the distance carried the less water would be consumed. Observations soon showed this to be doubtful . . . . . Up to some critical distance - in most sites it appears to be about one mile - there is a tendency to use the same range of water per capita, but beyond that point the tendency is to reduce the range toward whatever is a minimum for the area. . . . . If distance is influential only for the near

> and far distances it may be asked whether time, energy and other expenditures show any different association. Distance, time, energy expenditures and terrain gradient are highly intercorrelated, and no major variations are found.

Since no Tombeakini dwelling is more than 300 m from either the Punate or Tobaka, it is not surprising that travel time does not affect water usage patterns. In some other parts of the New Guinea Highlands, where ridge-top villages cause much greater travel times, a contrasting situation may exist.

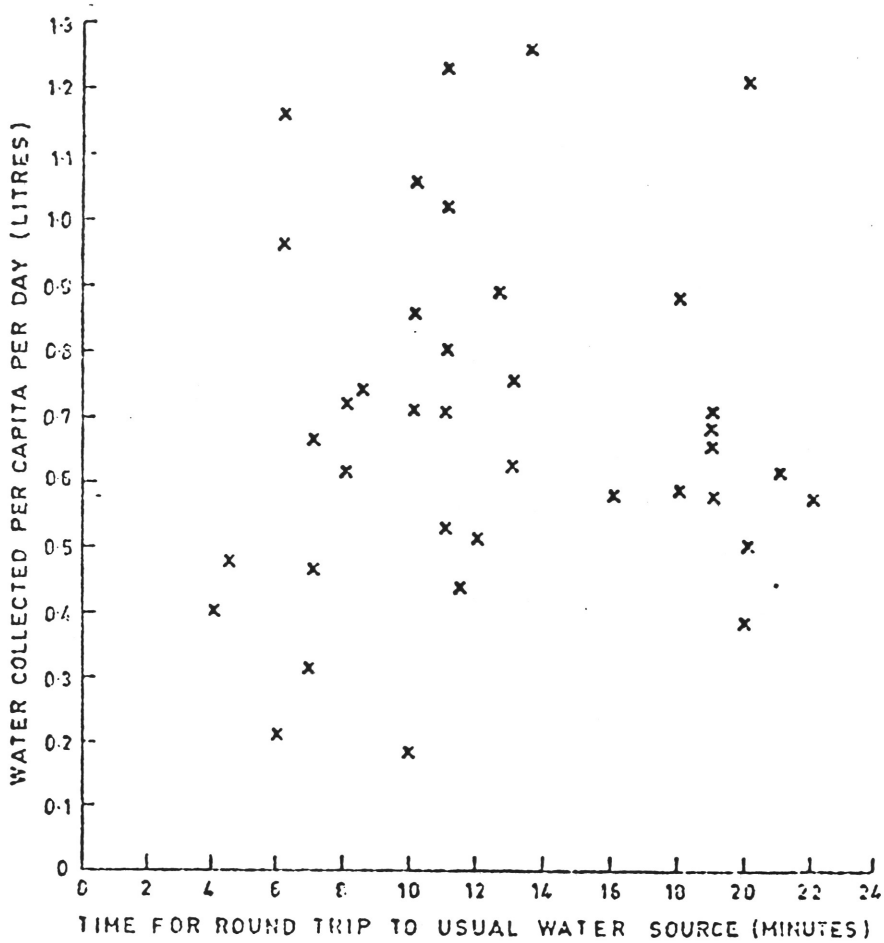


FIG. 8; TRAVEL TIME TO USUAL SOURCE VERSUS PER CAPITA USAGE

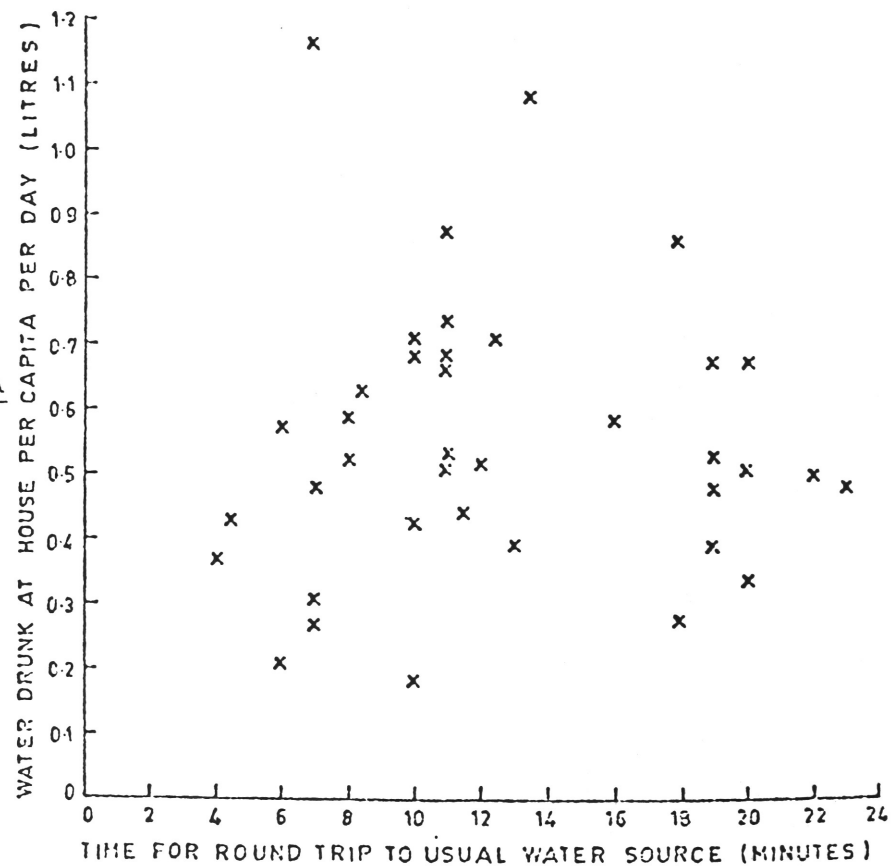


FIG. 9: TRAVEL TIME TO USUAL SOURCE VERSUS PER CAPITA CONSUMP-TION.

FIG. 10: TRAVEL TIME TO USUAL SOURCE VERSUS PERCENTAGE OF WATER USED FOR PURPOSES OTHER THAN DRINKING

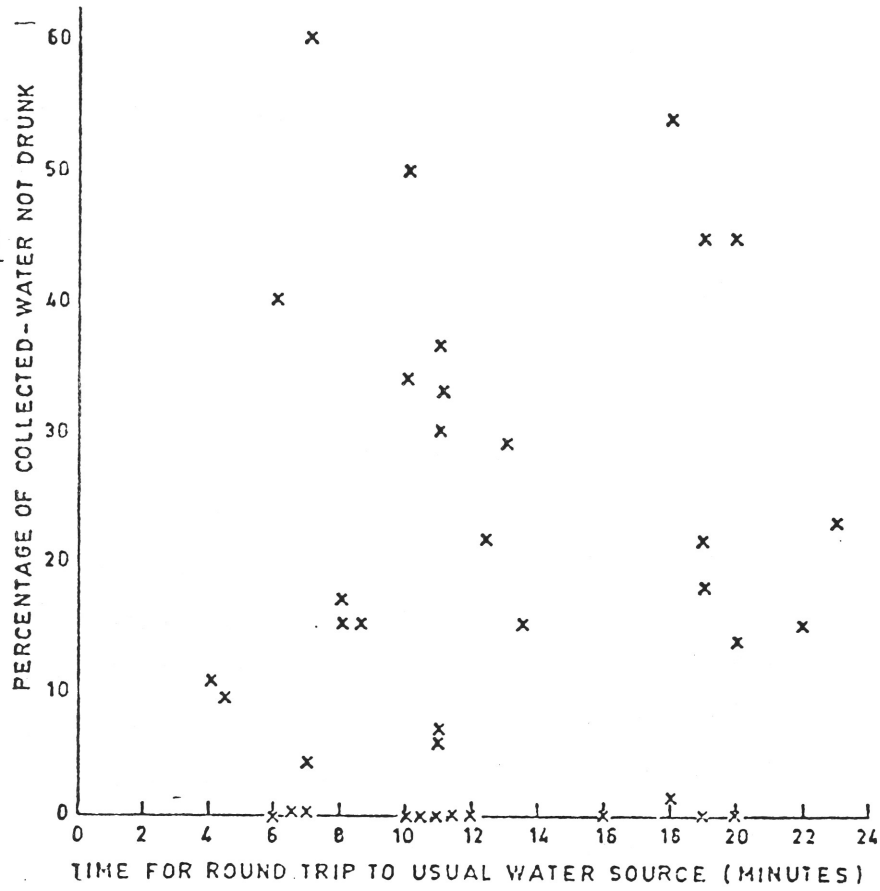
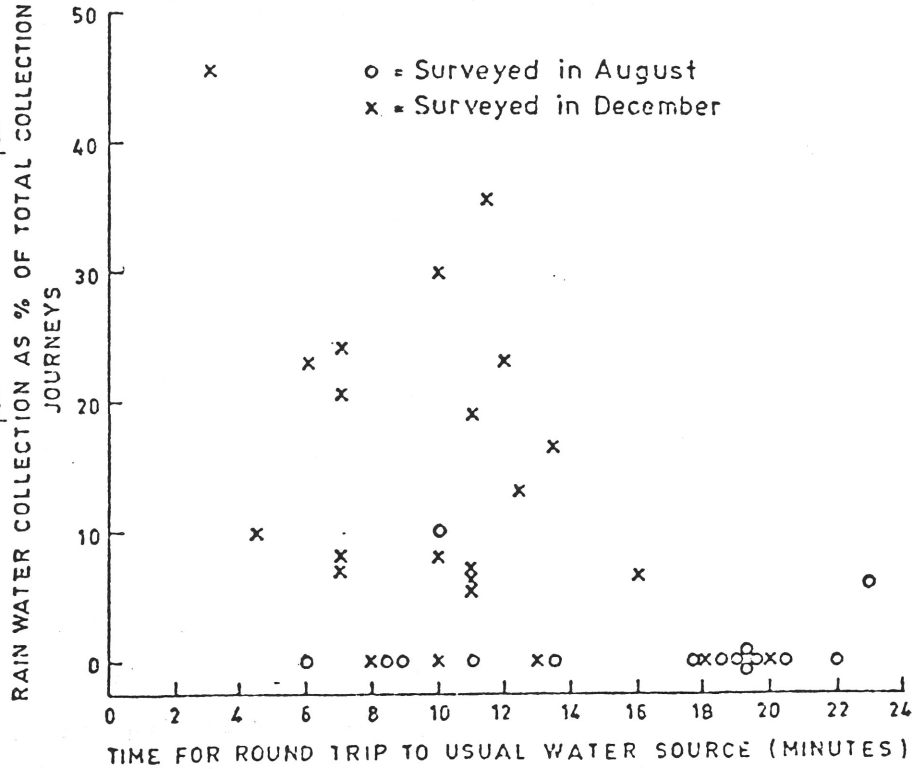


FIG. 11: TRAVEL TIME TO USUAL SOURCE VERSUS PERCENTAGE OF JOURNEYS MADE FOR RAIN-WATER



10. NON-DOMESTIC WATER USAGE

In order to complete the picture painted in the previous sections, I will briefly describe the principal non-domestic uses of water amongst the Raiapu.

(a) Coffee: Since 1959 (Waddell, 1972b:59) the Raiapu have been enthusiastically growing coffee for sale to Waso Limited and other coffee buying enterprises. Tombeakini are no exception and, despite their critical shortage of land, they devote 0.009 ha per capita to the cultivation of coffee (Coffea arabica) and pyrethrum (Pyrethrum cinerarifolium) and of this area about 90% is under coffee. Most Raiapu clans probably assign more land to cash-cropping and Waddell's sample had 0.02 ha per capita under coffee and pyrethrum (1972b:116). The processing of this coffee involves the use of considerable volumes of water. Waddell (1972b:60) writes that the cherries are picked,

> split between thumb and forefinger or between the teeth, and the bean placed in a cooking pot. The pot is then filled with water, the beans soaked, "washed", and then laid out to dry.

A family often has a special container reserved for coffee washing and the process usually occurs at a public place (such as the tee-ground or near the church) where men will gossip while they prepare their coffee. Others will wash coffee outside their houses, but water collected for this purpose is excluded from the data previously presented. Any water will be used and it is not considered important that it be clean.

(b) Kuta: Raiapu women make aprons and skirts out of a reed-like plant called kuta (Eleocharis sphacelata and E. dulcis). This is cultivated in large man-made ponds and ditches (all called kuta pete) and grows with its roots well submerged. Tombeakini women grow a great deal of kuta, some of which is sold to other clans (approximately $2 for a completed apron). Kuta pete are mostly constructed by digging into the swampy flats (category B-Map 3) near the rivers Tobaka and Punate. These naturally fill with water and are surrounded by banks or fences to exclude pigs

and children. A kuta pete is normally round, about 3 m in diameter and will have up to 1 m of water in it.

Some kuta pete are made by daming the Tipini and creating a series of small ponds, one below the other. Water flows down through the ponds and the heights of the "spillways" are adjusted to allow for differing rainfall conditions. These ponds remain comparatively clean and are also used for breeding fish.

(c) Taro: The Raiapu cultivate taro (Colocasia esculenta) either in swampy depressions or in a system of man-made ditches. These ditches are not fed by water from a stream and rely on rainfall, and seepage from nearby swamps, for their supply of water.

(d) Sweet Potato: Sweet potato (Ipomoea batatas) is harvested daily by women. On their way home they will stop by a convenient stream to wash the tubers. The streams most commonly used are the artificial ones which run in ditches beside the vehicular road. However these are dry for several months each year and, on these occasions, the nearest natural stream will be utilised.

(e) Drainage: Apart from kuta and taro, the Raiapu do not irrigate crops but they do provide drainage in their mixed gardens. This drainage takes the form of irregular ditch systems which lead water away from the swampy garden areas or break surface run-off down steeper slopes. Large ditches encountered round the perimeter of mixed gardens are, in fact, part of pig exclusion works and are not primarily for drainage.

(f) Fish: Encouraged by officers of the Department of Agriculture, Stock and Fisheries, some Enga breed carp in large ponds for their own consumption or for sale to fellow clansmen. A few men use kuta pete for this purpose but mostly the carp are kept in special and larger ponds. Westermann (1968:157) reports that these fish are "highly prized" but in the Saka this is not the case. The fish are considered inferior to purchased tinned mackerel because they lack the oil which is greatly appreciated. There is little fish breeding in the Saka and people display scant enthusiasm for it.

11. IMPLICATIONS FOR DESIGN

In order to demonstrate how studies such as this one can be utilised to formulate realistic design criteria, there follows a brief list of design guides for an improved Tombeakini water supply.

(a) Tombeakini do not have a strong "felt need" for improved water supply. The Punate is regarded as an excellent source and the Punate and Tobaka together are believed to meet all water needs.

(b) If a new supply were built (perhaps for medical reasons) it would be welcomed if it provided cold and clear water and it would be used by those who lived closer to it than to their original source. It is unlikely that people would utilise the new source if it entailed a more time consuming collection journey than that to their old source. Outlets would therefore need to be sited so that most dwellings were nearer to a tap than to either the Punate or the Tobaka.

(c) At least initially, there would be enthusiasm for a new supply because it would give cold clear water, it would be safe from poisoning and fouling in floods and it would give great prestige to Tombeakini. A high degree of local cooperation could be anticipated in the construction of the supply but long-term maintanence could prove to be a problem.

(d) The new supply would need to serve Tombeakini and only Tombeakini. Any attempt to supply two or more clans with one supply would be completely unacceptable. Accusations of poisoning would abound and, in the event of a major dispute or warfare, the clan upstream on the supply would sabotage the pipes. This latter problem has occurred frequently in the multi-village supplies of the Kainantu region of the Eastern Highlands District.

(e) Present daily demand for water is 0.68 litres per capita. Volumes used for drinking may increase slightly over the next few years and volumes used for cooking will probably increase considerably. At present, very little water is used for washing or other hygienic purposes and it is likely that the level of this type of water use will remain fairly low. The washing of clothes, blankets, utensils and bodies will become more

common but it will probably take place at the rivers and not affect the demand at the house. A demand of approximately 1 litre per capita daily could be assumed if washing water were not to be drawn from the new supply. If however facilities for washing and bathing are provided at the outlet, the demand will be greater and will rise as the popularity of hygiene increases.

The whole question of whether a water supply should be installed in a community like Tombeakini, and if so what type of supply, cannot be discussed here. The justification for new supply rests largely on the possibility of health improvements which may be anticipated to follow. However, I hope to show in later publications that the health benefits, resulting from the mere installation of a new water supply, may be negligible and that a new supply may be justified only if it is accompanied by comprehensive public health, and health education, programmes.

12. SUMMARY AND CONCLUSIONS

Clarke (1971:165) writes of water usage amongst the Bomagai-Angoiang of the Ndwimba Basin:

> No houses are located beside streams or springs, because the advantage of having water just outside the door is outweighed by the disadvantages of noise, valley fogs night and morning, and the lack of view and of freshening winds. Besides even the ridgetop houses are nowhere more than fifteen minutes from water, and the need for water at the houses is small because people neither wash there nor use more than a few pints in preparing the evening meal. The energy cost of walking to fetch water is often incorporated into trips to and from gardens: the bamboo tubes used to carry water are left by the source of water on passing in the morning and filled and carried home in the afternoon.

The Raiapu also say that one reason for not locating houses near rivers is that the noise prevents communication by yodelling from one house to the next. Tombeakini also expend little energy in water collection although they usually make separate journeys for water because their afternoon return trip from garden to house does not typically take them across the Punate or Tobaka.

In order to summarise the main points of the preceeding sections, there follows a story episode in which the "typical domestic group" in Tombeakini makes a typical water collection journey. A typical domestic group comprises 3-4 consumption units and will collect water once a day. In the late afternoon, a member of the group takes a gourd and a glass bottle and walks for about 6 minutes to either the Punate or the Tobaka. The choice between these two will probably depend on which is more quickly reached but, if they are almost equidistant from the dwelling, a preference will be shown for the superior quality of the Punate. The containers are filled with 2.2 litres of water and carried home. 79% of the water is drunk with the evening meal or stored outside the house (to keep cool) and drunk with the meal next morning. The remaining 21% may be used for cooking soups or cooking potatoes for pigs but will not be used for washing (except 1% for cleaning plates) or

other hygienic purposes.

Generally speaking, the Enga do not wash utensils, they do not wash clothes or blankets[1] and they do not wash themselves. This situation may well apply over large areas of the New Guinea Highlands and any marked hygienic tendency that does exist is almost certainly a recent innovation. Thus the Highland situation is in sharp contrast to coastal New Guinea and Papua (where river bathing is often frequent) and also to East Africa where White et al (1972:124) show a large percentage of house-hold water use being devoted to bathing, cleaning and dishwashing.

In order to investigate the Tombeakini attitude to washing I stocked the local stores (see Map 3) with soap which was offered for sale at the current retail price. The Raiapu appreciate the purpose and qualities of soap and all Tombeakini families have sufficient cash to purchase soap regularly if they want to. The only reason why I had to stock the stores with soap was that the particular store owners concerned (both Tombeakini clansmen) were not sufficiently organised to maintain stocks of anything but the two most demanded items - tinned fish and rice. During a period of 21 weeks, Tombeakini bought 41 small bars of soap which gives a usage of 1.4 g per capita per week. It was noticable that the buyers were mostly from amongst the most "westernised" clansmen - those who had had some schooling, those who had travelled to seek employment outside the Saka, those who spoke pidgin english, or those who sometimes dressed in shorts, shirts or dresses. Demand for soap, and the use of water for hygienic purposes, are therefore likely to increase steadily over the next few years.

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1. Traditional dress (see Feachem, 1972) is a string apron in front, and leaves behind, for males and a kuta apron for females. Shorts, shirts and cotton dresses are now fairly common but the majority of Enga will not wash these. Some households have blankets which are also seldom, if ever, washed.

This lack of domestic and personal hygiene must clearly influence Raiapu morbidity patterns. In particular it will affect the prevalence of "water-washed diseases" (White et al, 1972:162) which are those infections which become less common as the volume of water usage is increased, irrespective of the quality of such water. Some of the diseases, which are commonly found in the New Guinea Highlands and which are primarily "water-washed", are skin sepsis, skin ulcers, eye infections, scabies, tinea, leprosy, ascariasis and infected wounds. Other diseases which are "water-borne" as well as "water-washed" are dysentery (bacillary and amoebic), infectious hepatitis, enterovirus infections and gastroenteritis. Some of these diseases are extremely susceptable to improvement by increasing the volume of water used for domestic and personal hygience and infected scabies could be almost completely eliminated by this means.

I will publish later detailed material on Tombeakini morbidity and the effect which increased water usage and improved water quality might have upon this. Data will also be published on the levels of faecal pollution in the rivers which Tombeakini use as water sources. In order to give a general picture of the magnitude of the morbidity problem and its relationship to water usage and water quality, Table 17 is presented. Table 7 should also be consulted for a summary of faecal bacterial pollution.

In conclusion it is necessary to discuss the range of applicability of the data presented in this report. Clearly, the precise figures given in the various tables only apply to Tombeakini. However, the water use picture throughout the Saka (pop. = 11,000) is likely to be very similar. The Central Enga (Mae and Raiapu, pop = 80,000) will also have a water use pattern which closely resembles that described here. Considering the Highlands, one must make a fundamental distinction between the scattered or dispersed settlement pattern which is common in the Western Highlands, Southern Highlands and Chimbu Districts and the nucleated, village-type, settlement of the Eastern Highlands

TABLE 17: WEEKLY PERIOD PREVALENCES PER 1000 OF 8 SYMPTOMS AMONGST TOMBEAKINI WITH ESTIMATES OF THE IMPACT CAUSED BY IMPROVED WATER AVAILABILITY AND QUALITY

DESCRIPTION OF SYMPTOM	AVERAGE WEEKLY PERIOD PREVALENCE PER 1000	IMPROVEMENT EFFECT OF NEW WATER SUPPLY	
		VOLUME INCREASE	PURITY INCREASE
Eye infections, and injuries	74	++	
Skin infections, ulcers, infected scabies, infected wounds, etc.	271	+++	
Fevers	40	+	+
Abdominal pains	45	+	+
Diarrhoea	35	+++	++
Diarrhoea with blood in stools	3	++	+
Diarrhoea with vomiting	2	++	+
Cough	142	+	

Note: The connection between coughing and water is due to the probability that a sizable proportion of coughs in the Highlands are attributable to ascariasis. The data reported here is part of an extensive symptomological morbidity survey of Tombeakini which will be reported elsewhere.

District. Villages in the Eastern Highlands will tend to utilise fewer sources and make much longer collection journeys than the Raiapu. There may be great similarity between Raiapu water use and that of other dispersed groups and the reader will need to compare the relevant environmental and cultural characteristics in order to decide whether this report is applicable to his area of interest.

This report indicates the types of relationships, and of water usage patterns, which may well be found elsewhere in the Highlands. I hope that I have demonstrated the relevance of this type of study to anyone engaged in public health improvement, or sanitary engineering, in a rural community in the developing tropics. I trust that others will study, and report on, water usage in communities with differing environmental and cultural settings.

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MAP 1

PAPUA AND NEW GUINEA

ENGA REGION

LEGEND

POPULATED PLACES
- Capital of Territories
- Principal Centre
- Inspection Centre
- Patrol Post
- Village
- Rural Developmental Centre

ROADS
- Major
- Secondary
- Minor
- Track

CONTOURS (Approximate)
- Hypsometric in feet
- Bathymetric in metres
- District Headquarters

HYDROGRAPHY
- River
- Unsurveyed River
- Lake
- Swamp
- Reef and Rock
- Shoal
- Spot Elevation in feet (approx.)
- Pass

BOUNDARIES
- International
- Territorial
- Limits of Sovereignty over Included Islands
- District Boundaries

Statute Miles 50 0 50 100 150 Statute Miles

Kilometres 50 0 50 100 150 Kilometres

Simple Conic (Modified) Projection with Standard Parallels 5° S and 8° S

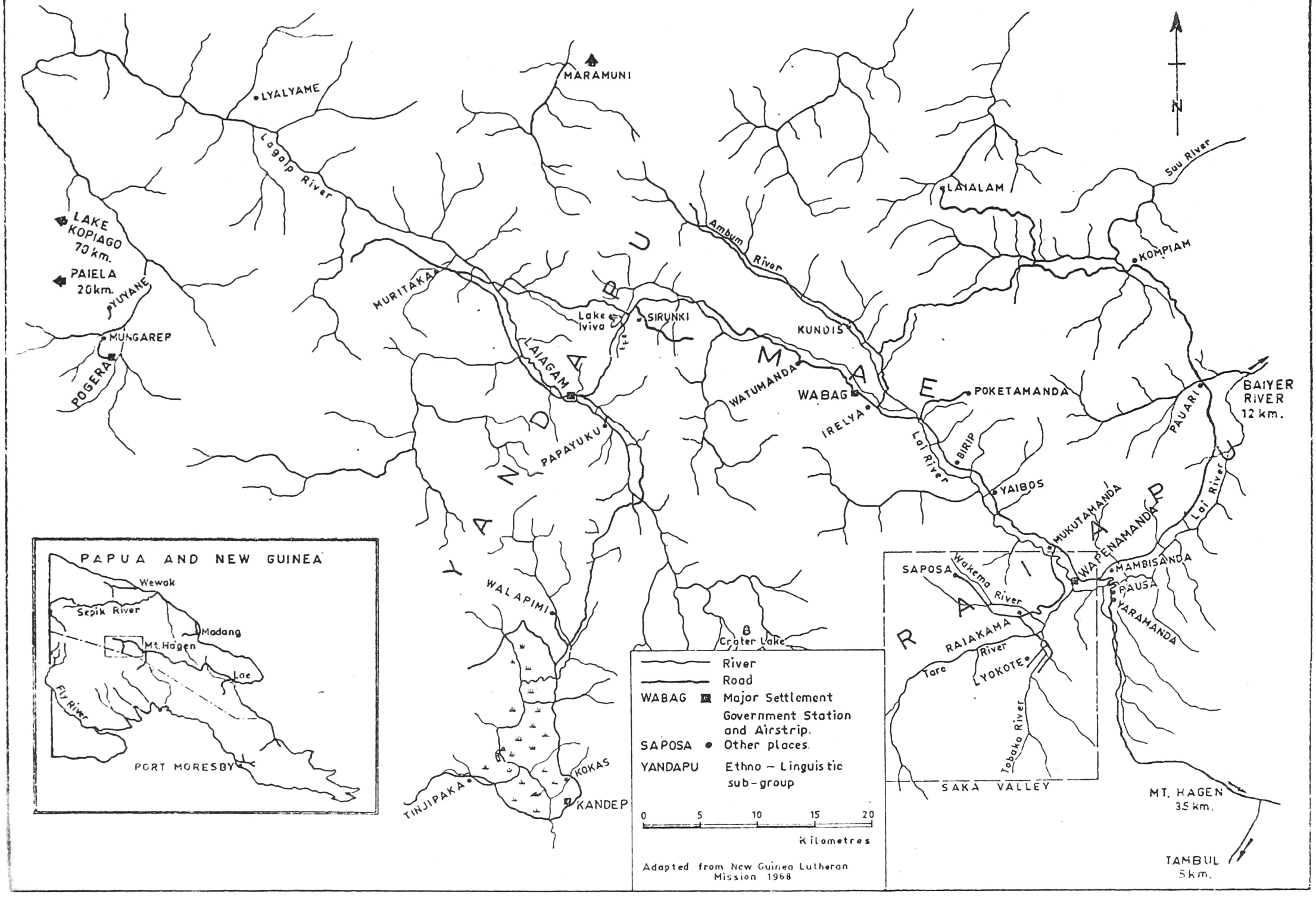
BRITISH SOLOMON ISLANDS PROTECTORATE (U.K.)
TERRITORY OF PAPUA (AUST.)
TRUST TERRITORY OF NEW GUINEA (AUST.)
TERRITORY OF PAPUA (AUST.)

Map 2.

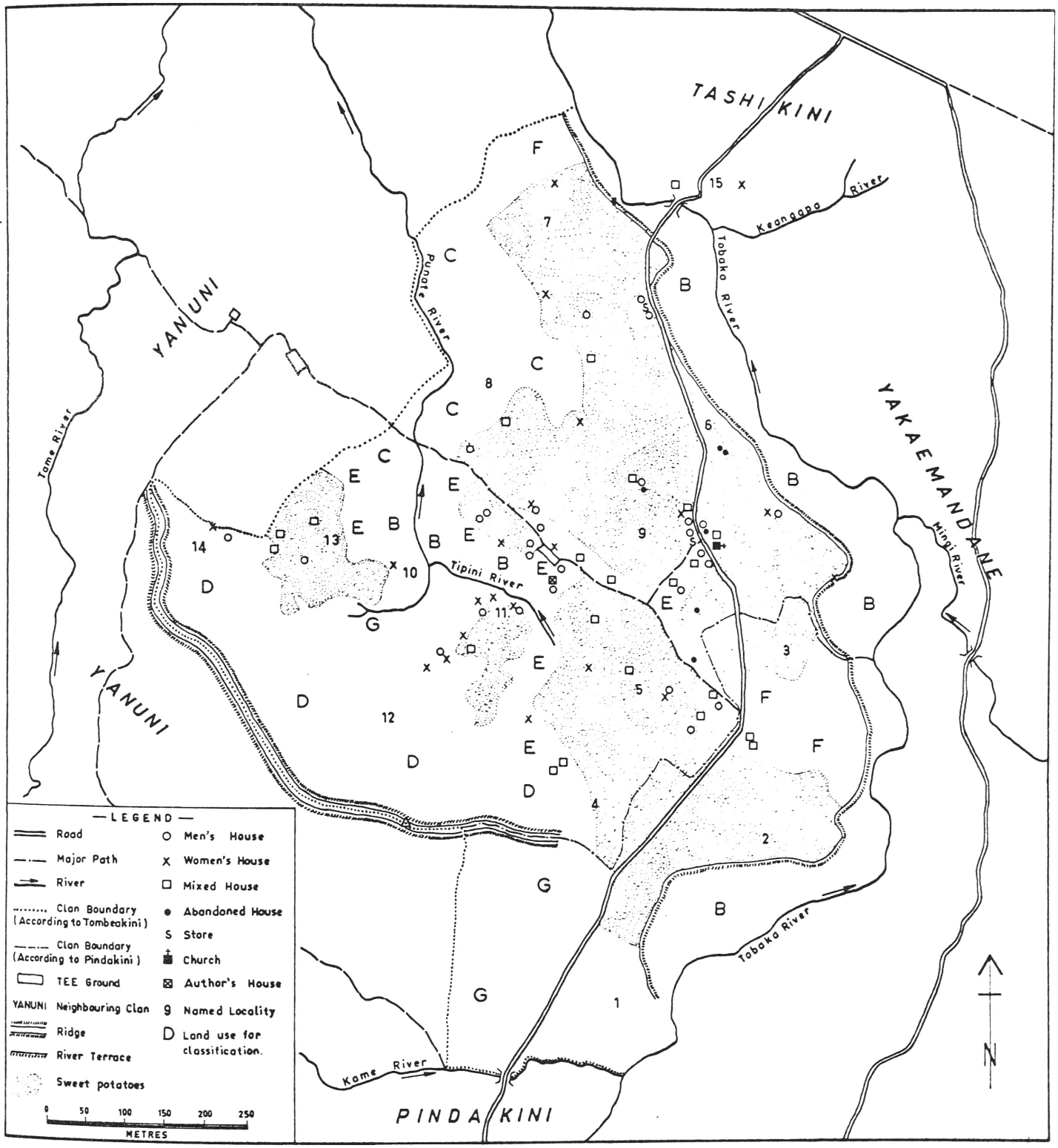
The Enga Speaking Region
of the New Guinea Highlands.

MAP 2.

THE ENGA SPEAKING REGION OF THE NEW GUINEA HIGHLANDS



MAP 3 — TOMBEAKINI CLAN TERRITORY —



MAP 4 — TOMBEAKINI CLAN TERRITORY —