Mountain Research and Development, Vol. 3, No. 4, 1983, pp. 422-428

FIREWOOD CROPPING, FOOD CULTIVATION, AND CONSERVATION PLANTING
A THREE-DIMENSIONAL STRATEGY FOR DISPLACED RURAL COMMUNITIES— THE CASE OF THE ATZERA HILLS, LAE, PAPUA NEW GUINEA

V.N. DUBE

Lae City Interim Authority
Lae, Papua New Guinea

ABSTRACT The ecological management of the Atzera Hills which surround the City of Lae, Papua New Guinea is an example of the integration of agriculture and forestry. The severe erosion of the hills, caused by heavy rainfall and by destruction of forests due to the extensive cutting of trees for firewood and clearing of the hillsides for food gardening, is destroying the human use potential of the Atzera Hills. The present paper describes how agro-forestry techniques are being used, not only to rehabilitate and conserve this valuable hill resource but also to supply food and fuelwood on a sustained basis to the neighbouring community which consists mainly of displaced people.

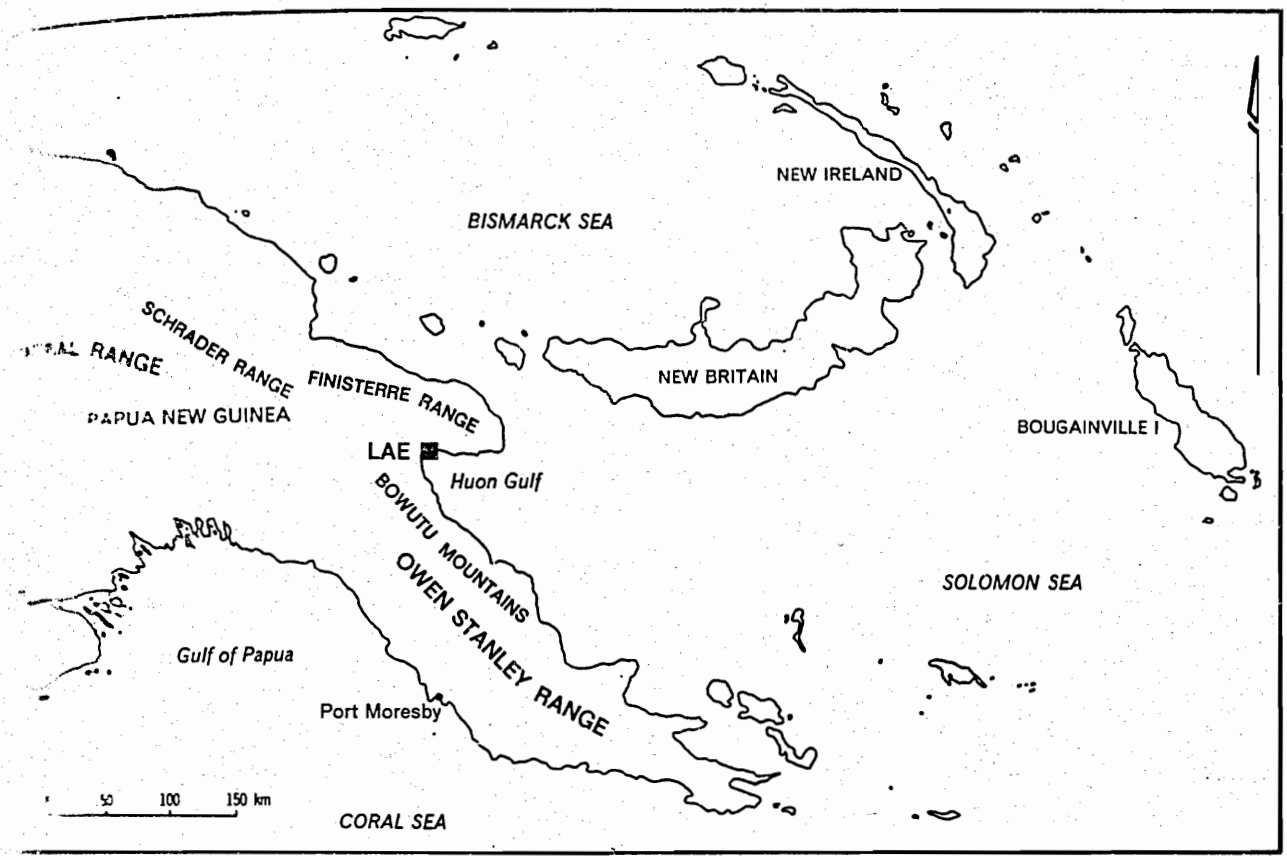
RÉSUMÉ *Production de bois de chauffage, agriculture, et conservation : Une stratégie à trois dimensions pour les communautés rurales de personnes déplacées—Cas des Monts Atzera (Lae, Papouasie-Nouvelle-Guinée)* La gestion écologique des Monts Atzera qui entourent la ville de Lae en Papouasie-Nouvelle-Guinée est un exemple d'intégration de l'agriculture et de la sylviculture. La forte érosion causée par les précipitations abondantes et la destruction des forêts (abattage abusif pour le bois de chauffage et défrichage des versants pour la culture) est en passe de détruire les possibilités d'exploitation des Monts Atzera. Cette étude décrit la manière dont les techniques agro-forestières sont utilisées, non seulement pour restaurer et conserver ces ressources naturelles incomparables, mais aussi pour produire en permanence des denrées alimentaires et du bois de chauffage pour la communauté avoisinante composée en grande partie de personnes déplacées.

ZUSAMMENFASSUNG *Feuerholzgewinnung, Nahrungsmittelanbau und Bepflanzung zur Bodenerhaltung: Eine drei-dimensionale Strategie für entwurzelte Landgemeinden am Beispiel der Atzera Berge (Lae, Papua Neuguinea)* Das ökologische Management der Atzera Berge, die die Stadt Lae, Papua Neuguinea, umgeben, ist ein Beispiel für die Integration von Land- und Forstwirtschaft. Das menschliche Nutzungspotential der Atzera Berge wird durch die fortgeschrittene Erosion der Berghänge zerstört. Die Ursache dieser Erosion sind schwere Regenfälle und die Vernichtung von Waldflächen durch Abholzung zur Brennholzgewinnung und die Rodung der Hänge für Nutzgärten. Die vorliegende Veröffentlichung beschreibt nicht nur, welche agro-forstwirtschaftlichen Methoden angewendet werden, um diese wertvolle Naturressource zu rehabilitieren und zu konservieren, sondern auch wie für die umliegenden Anwohner, die vorwiegend Heimatvertriebene sind, die Nahrungsmittel- und Brennholzversorgung sichergestellet wird.

The growing of trees for timber and of field crops for food have, in the past, developed as independent systems confined within their own rigid limits. But lately, because of the pressures brought about not only by modern technology but also by the need of greater productivity for a growing population, this artificial barrier between agriculture and forestry is breaking down. Fortunately, some degree of merger and integration is developing and there are prospects of a viable symbiotic existence. Thus, monoculture is now being replaced by multiple use practices for valuable, limited resources.

The need to translate this new ideology into active practice is nowhere more appropriate nor more expedient than in the city of Lae, Papua New Guinea. Papua New Guinea covers the eastern half of New Guinea, the world's second largest island, and the islands of New Britain, New Ireland, and Bougainville. It is situated about 5° south of the equator, 150 km north of the northern tip of Australia. Lae with a population of 50,000, is the second largest urban centre and foremost industrial town. The city is situated on the Huon Gulf, at latitude 7° South (Figure 1).

In the late 1970s the city of Lae experienced a population growth rate of more than 5 percent per annum. This is mostly due to the migration of people from the Highlands where the population density is too high to sustain a reasonable living standard with existing agronomic methods. Thus, to seek employment, which often proves elusive, the Highlanders come by the Highlands Highway (the longest all-weather road in the country) to the city of Lae. These new arrivals face the same problems which displaced groups face anywhere in the world. After moving to the self-help settlement areas on the outskirts of the city, they face the problem of high unemployment and the consequent struggle for survival



: The location of Lae, Papua New Guinea.

to survive, these migrant settlers look for land for . Because most land suitable for cultivation is under al ownership, it is not available. They have no t to grow food crops, to gather firewood, and even timber to build their makeshift houses, in the adja- – the Atzera Hills (Figure 2).

Atzera Hills are a long, steeply sloping, and dis- . 13 km in length, northwest of the city of Lae. is flanked by two major rivers, the Markham on and Bumbu on the north. Numerous tributaries number of creeks traverse these hills and flow Huon Gulf just southwest of Lae. The highest point is 500 m above sea level, but there are numerous to this height (Figure 3).

aggregate and cumulative activity of the migrant had disastrous results on the stability of the Hills. To prepare for cultivation, the land has to to obtain timber for housing and firewood, trees felled. Thus the vegetative cover of the hills is re- and its surface exposed to high intensity rainfall (the rainfall at Lae is 5,000 mm).

surface soil is alluvial silt or fine-to-coarse gravel, real binding ability, and it is very loose and lacks This unstable surface, combined with the steep- hills and the removal of the vegetative cover, disturbed by the rains. The rains wash the sur- down from the higher areas of the catchment to the middle slopes where the eroded material occasionally forms miniature dams and lakes. These burst at some stage and the mighty force of the gushing water builds up an even mightier force for further erosion, with disastrous results:

1. The streams, creeks, and rivers are silted and polluted and the river banks are cut, causing widespread flooding which even extends to the residential areas of the city (Figure 4).
2. Road bridges are damaged by horizontal and vertical erosion.
3. Roads are washed away.
4. Silt and gravel are deposited on roads making them temporarily impassable.
5. Drains in the residential areas are silted up and culverts are blocked, causing localized floods and unsanitary conditions (Figure 5).
6. As a result of loss of fertile top soil, a large section of the hill slopes is regressing to infertile kunai (*Imperata cylindrica*) grassland and this results in loss of its human use potential.

Thus, not only are roads in the city of Lae and its environs constantly in need of repair, sanitation impaired, and the health of its residents adversely affected, but there is an even more important consequence: the future of the productive resources of the Atzera Range and its neighbourhood are endangered. This deterioration of the ecosystem

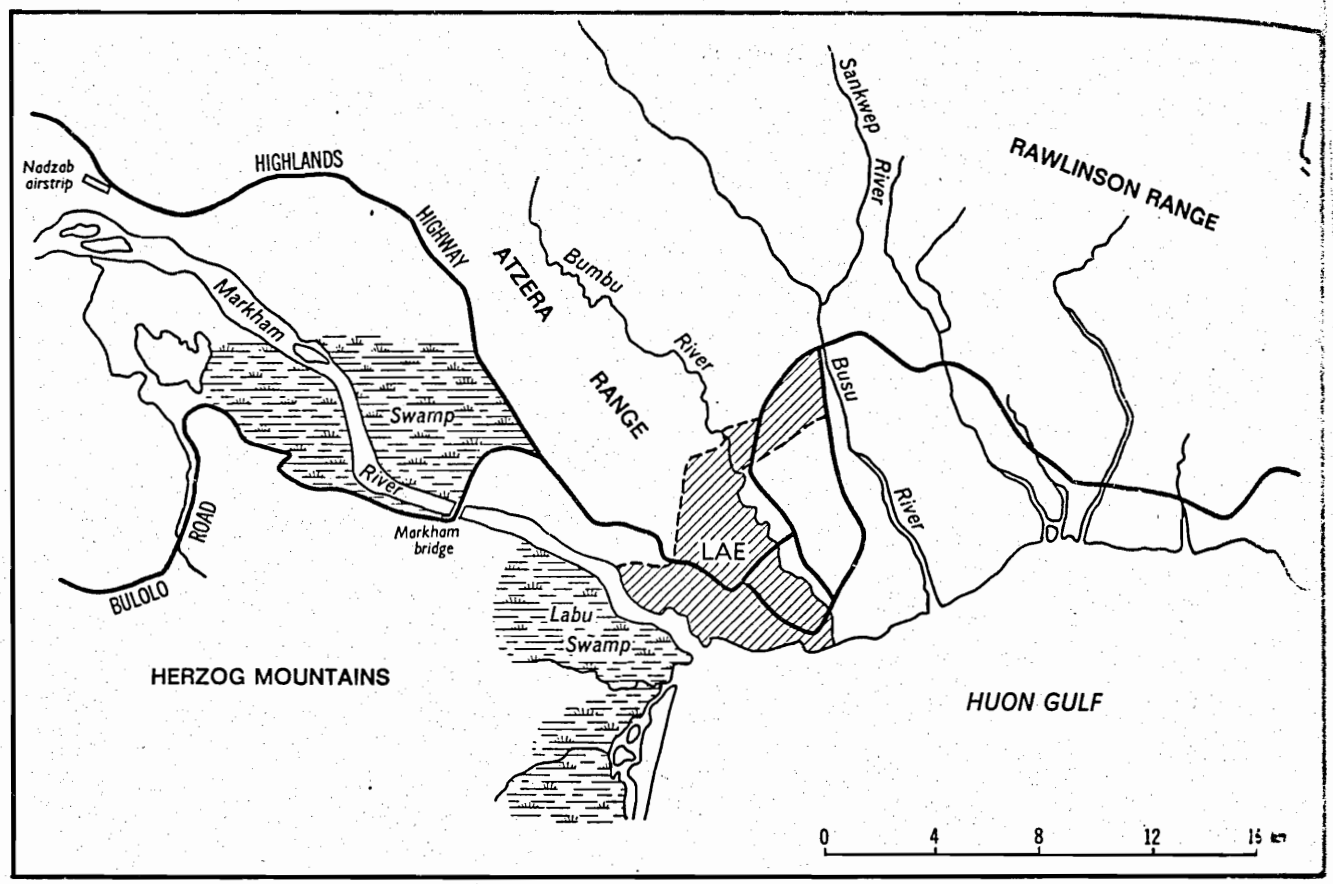


Figure 2. Lae and the surrounding area, showing the Atzera Range, the Highlands Highway, rivers, and creeks.

is inevitable. What has happened in Lae is an example of the pattern described by Longman and Jenik (1974) in *Tropical Forest and its Environment:*

> . . . along the seashore, around big towns, and in the neighborhood of industrial centres, tropical forests vanish very quickly.

They further warn:

> . . . unless the ecological factor, man, places himself under reasonable control most of these forests will soon disappear completely.

THE ATZERA HILLS PROJECT

In 1978 the Human Ecology Programme of the Department of Minerals and Energy, assisted by UNEP and Unesco (Man and the Biosphere (MAB) Project II) and, in co-operation with the Lae City Council, evolved an ecologically sound management system to arrest the rapid deterioration and loss of productive capacity of 600 ha of the Atzera Hills which adjoin Lae. Dr. Ken Newcombe, the Energy Planner in the Department of Minerals and Energy of the Government of Papua New Guinea, was responsible for the work and proved equal to the challenge.

A detailed and comprehensive ground survey of the hills was conducted and air photographs of the entire system and the neighbouring area were taken. With the aid of these photographs and the results of the ground survey, maps were prepared of waterways, topography, geomorphology, soil distribution, natural forests, kunai grasslands, major eroded patches, and other significant features. These maps helped to categorize sites for three major land uses: for ecological conservation, for ecological rehabilitation, and for food and fuelwood production. A six-year programme of food cultivation, firewood cropping, and land conservation and rehabilitation was started[1]. It is here that the principles of agro-forestry are playing a major role.

The main cause of the degradation of the hills is uncontrolled food cultivation and wanton scavenging for firewood. Because the only source of energy is firewood, a comprehensive and detailed plan was prepared to furnish food and energy on a sustained basis, to protect the eco-system, and thus to maximize the carrying capacity of the Atzera Hills. Three methods of food cultivation and fuelwood cropping have been included in this plan.

[1]The Papua New Guinea Government tentatively approved the programme in principle; it requires an expenditure of K[illegible] ($350,000) in six years.

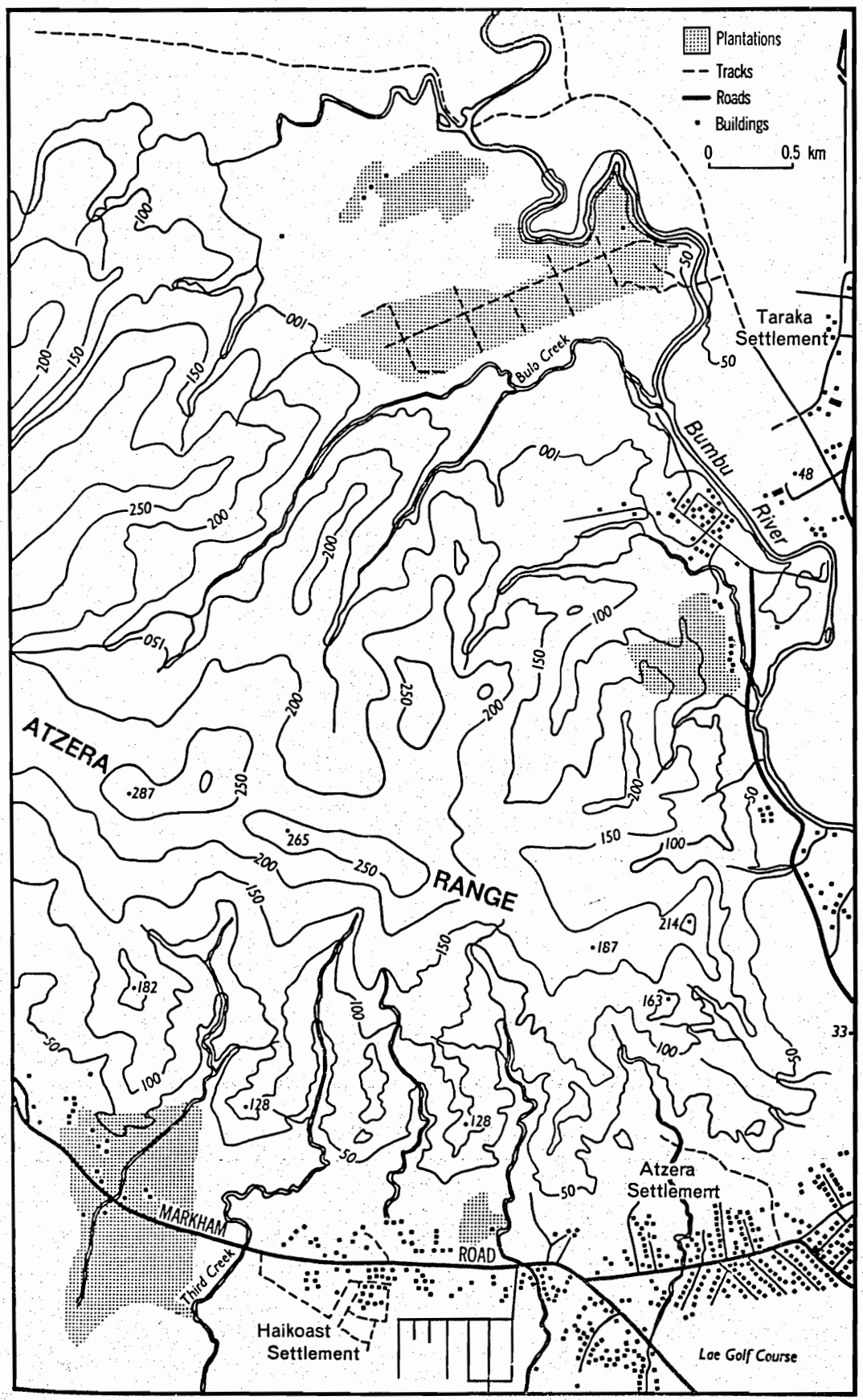


FIGURE 3. The Atzera Range and settlements.

Figure 4. A polluted stream near Lae.

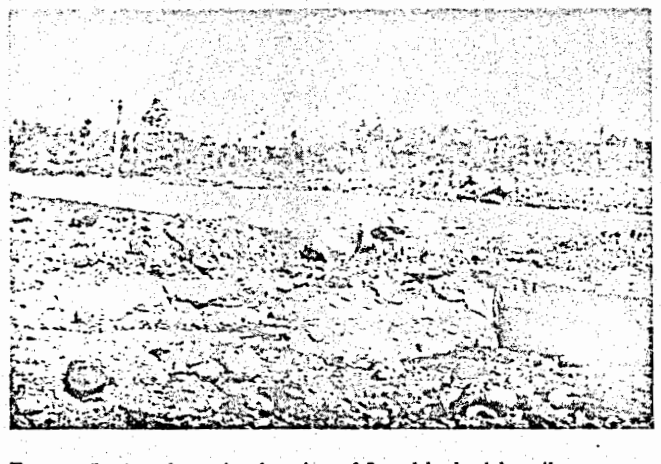


Figure 5. A culvert in the city of Lae blocked by silt.

1. *Mixed farming and forestry*

The first method, now in progress, features mixed cultivation of timber for firewood and food crops.

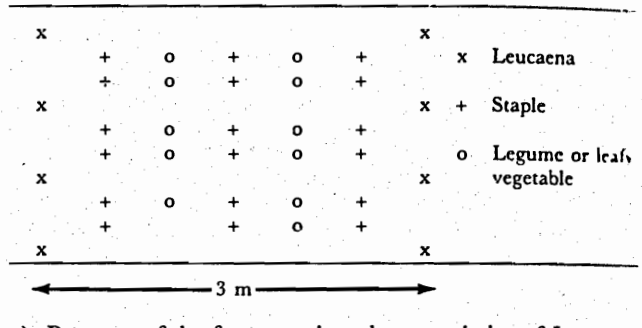
Because of repeated harvesting and replanting of food and firewood, the ground surface remains exposed for varying lengths of time. This harvesting and replanting process, especially on coarse textured soil, is likely to induce erosion. Erosion is accelerated if the site is located on steep slopes. Hence, in the Atzera Hills management system food gardening and fuelwood cropping are now being carried out on land which is either level or gently sloping and which has soil with superior fertility and binding properties.

Three sites have been chosen for these purposes namely: West Taraka, Erima, and Haikost.

On each site 0.4 ha plots have been divided into smaller subplots of 200–400 m² each. One subplot is given to a family of the neighbouring settlement area who had been farming in the ecologically sensitive areas of the hills and was asked to move out from there because of inherent danger. In these plots the family plants fuelwood trees and food crops in an integrated cropping scheme as follows:

a) The plots are first cleared of bush, secondary growth, and kunai grass. Students of the Faculty of Agriculture of the University of Papua New Guinea in Lae, ecologists, and rangers of Lae City Council help in clearing and developing the land.

b) *Leucaena* seeds (*Leucaena leucacephala*) are planted by Lae City Council rangers in rows, 3 m apart with 1 m spacing within rows. The family owning each garden plants food crops between *Leucaena* rows. These are staple food crops (such as sweet potato, corn, or yams), combined with a companion crop which is a legume (such as peanuts, wingbean, or some other bean), or a fast growing leafy vegetable (such as Chinese Cabbage, amaranthus, and lettuce).



c) Because of the fast-growing characteristics of *Leucaena*, it is estimated that cultivation in the inter-row space may not be feasible after 6–9 months. At this stage, the family is allocated another area where they repeat the above procedure. This movement of farmers from one site to another will continue for three years, at the end of which the *Leucaena* plants in the first plot will be ready for harvesting. The *Leucaena* will be harvested by giving the main stem a clean cut at a height of about 30 cm from ground level, but on subsequent cycles it will be harvested close to the base of the shoots. This harvesting process (coppicing) stimulates the dormant buds on the stump, producing a flush of vigorous growth, a quick and large linear height increment, and also subsequent substantial increase in girth. The stems and branches which are thick enough for use as firewood are stacked for drying before being transported to the settlements for use or for sale. The small branches, twigs, and leaves are left on the ground and finally worked into the soil. These plots will again be planted with food crops and the three-year cycle will be repeated.

2. *Food cultivation followed by forestry*

The second method is a cycle of simple food farming for one or two seasons, followed by planting of fast-growing fuelwood trees on the same piece of land and harvesting the trees after three years. The three steps of the cycle are explained below:

a) Each subplot is allocated to a family for planting short duration food crops for one or two seasons (approximately 6–9 months). At the end of this period the soil fertility of the subplot has diminished making further food cropping unprofitable. This family is then allocated a newly prepared plot, and so the transfer of the family from an old plot to a new one is repeated every six to nine months for three years.

b) The plot recently vacated by a family is planted with *Leucaena* by the Lae City Council in rows 1 m apart with 1 m spacing within rows. This replenishes fertility, improves the physical condition of the soil and prevents erosion, and also provides an additional source of fuelwood.

c) The succession of food gardening and *Leucaena* planting continues until the first *Leucaena* plantation is about three years old. Then the *Leucaena* is harvested and the plot used for food crops again for 6–9 months before being replanted with *Leucaena*; cultivation begins on the next plot after the *Leucaena* has been harvested and the cycle is repeated.

3. *Contour mounding*

The third method features continuous contour mounding. It is anticipated that, eventually, there will not be enough level and gently sloping land to meet the needs of displaced and prospective farmers. Therefore, hillsides with varying degrees of slope will have to be used. In such an eventuality, a system of gardening which is ideally suited to the Lae area will be used.

The main reason for cultivation by the methods of continuous contour mounding on steeper slope sides is to control erosion. Its effectiveness has been demonstrated by other workers in Papua New Guinea. Sweet potatoes have been planted by the continuous contour mound method on slopes of less than 20 percent over an 80-year period and this appears to eliminate erosion. The following describes how this technique will be applied:

Contours will be marked on the ground using a clear plastic tube 10 m long, with water inside and two ends closed by the use of stoppers. Two marks will be made on the tube at the same distance from each end. The two persons carrying the tube will lay it along an approximate contour, remove the stoppers and adjust the placement of the tubing so that the level of water just reaches the marks near each end. With the position of the contour indicated and the tube removed, vegetation cleared from the site will be spread along the contour in a strip about 1 m wide (Figure 6). A trench about 30 cm deep and 1 m wide will be dug along the strewn vegetation, following the contour, and the soil removed from the trench will be heaped on this vegetation, so forming a continuous mound. After the mounds have been levelled, they will be planted with three different kinds of vegetables. The middle of the mound will be occupied by a staple crop such as sweet potatoes, yams, and cassava; along the upper edge of the mound a legume will be planted. If the staple crop in the middle is of the spreading kind like sweet potato, the legume on the hillside will be a climbing or small bush-like wingbean, snake bean, or pigeon pea. Along the lower side of the contour round green vegetables or other vegetables will be planted. Again, if sweet potatoes are planted in the middle row, the green or other vegetables will be bushy, or an erect type such as Chinese cabbage, eggplant, or tomatoes.

Leucaena will be planted in the trenches between mounds about 5 m apart. Immediately before or after the *Leucaena* is harvested for firewood (after three years of planting) *Leucaena* seeds will be planted in between two *Leucaena* trees in the trench. This arrangement again will ensure the availability of food and fuelwood from the same piece of land on a sustained and an ecologically sound basis.

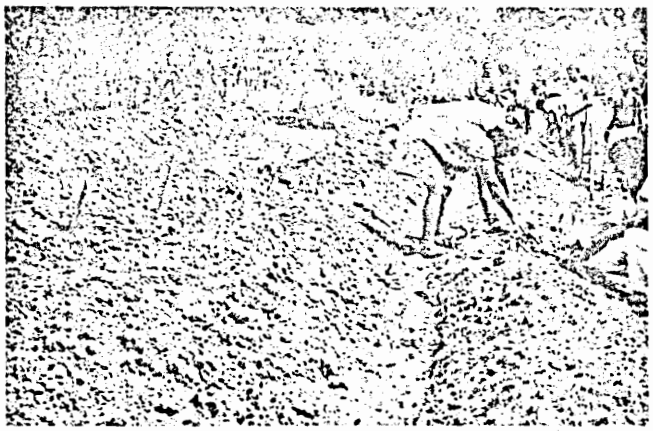


FIGURE 6. Planting food crops on a continuous contour mound.

Leucaena

Leucaena leucocephala, a robust, quick growing, and medium-sized tree from tropical America and the West Indies, is commonly grown as a coffee shade tree in Papua New Guinea. Being a legume, it fixes atmospheric nitrogen in the soil by symbiotic bacterial action and thus improves soil fertility. Because it is deep rooted, it improves the aeration of the soil and its structure. It forms a closed canopy quickly and this makes it a very suitable agent for checking soil erosion. Because it is fast growing and attains heights of 4.1 m in six months, 9 m in two years, 16.8 m in six years, it has high potential for fuelwood production. It sheds leaves regularly, building a thick litter under the trees, and so adds organic matter to the top soil to aid the recycling of nitrogen, phosphorus, potassium, and other essential nutrients. It has a vigorous coppicing ability which further reinforces its properties, particularly its ability to check soil erosion and its use as firewood. Its wood has good thermal properties and makes excellent charcoal.

These properties of *Leucaena,* combined with the unlimited availability of its planting material in Lae and its ease of growth under local conditions, were the reasons why it was chosen as the firewood tree to be planted by these three methods of food and firewood cropping.

Composting

In August 1977 Lae City Council launched a compost-making project using the City's vegetable refuse, brewer's grain from a local brewery, chicken manure from Lae's commercial poultry farms, cow manure from neighbouring cattle holdings, and sawdust from a local timber company. At the moment, the City is producing compost at the rate of 2,000 tons per year, but this will soon increase to 10,000 tons when the entire procedure is mechanized and modernized. The effect of compost on food crops has been studied and the results are encouraging. This compost will be used on the Atzera Hills food gardens for higher yields and on the firewood trees for faster growth and higher productivity.

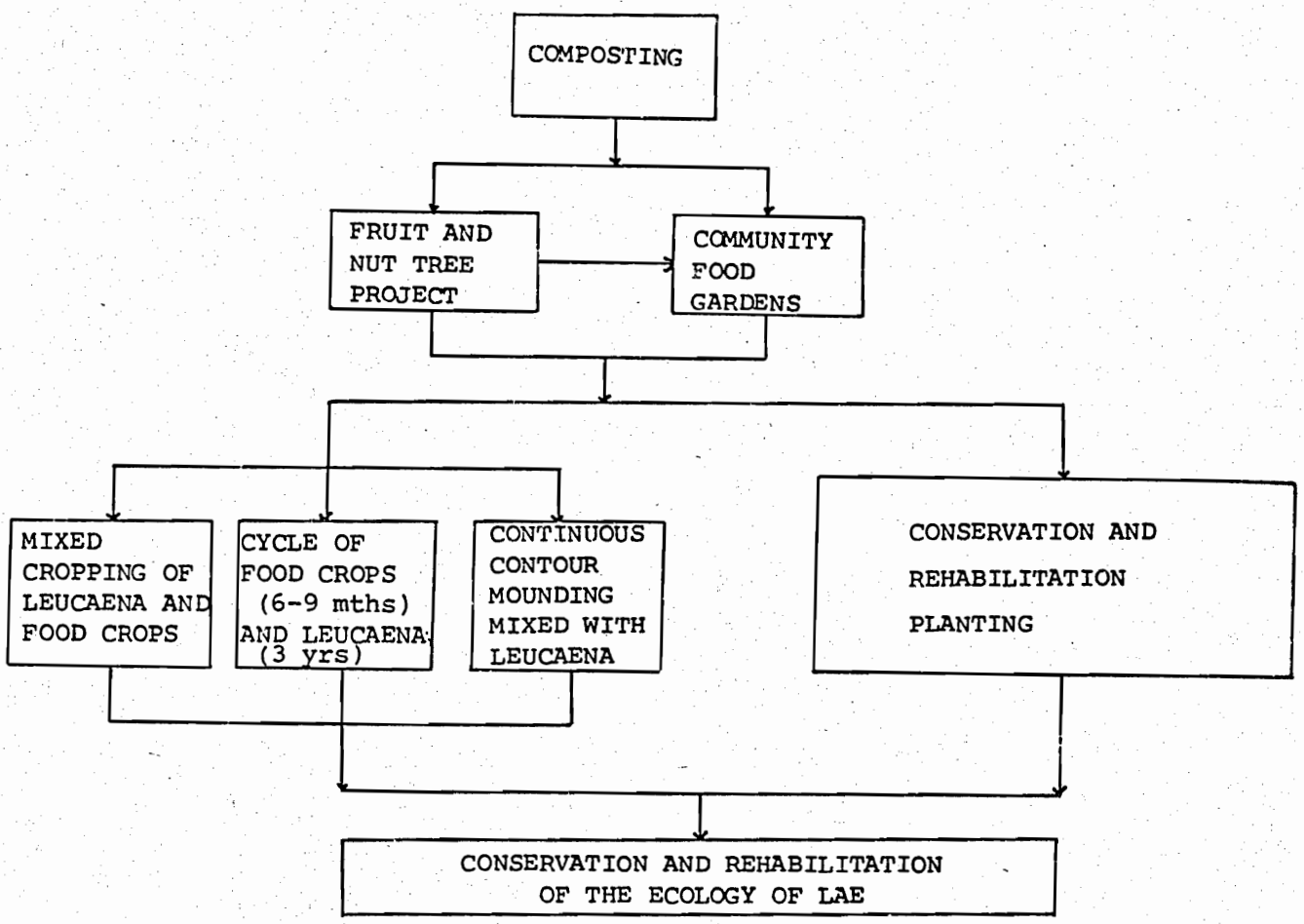


Figure 7. Composting, cultivation and conservation: the strategy employed at Lae.

Community Food Gardens

At present the wasteland within and around the city of Lae, much of which belongs to the City Council, is being developed into Community Food Gardens. Neighbouring families are given 100–200 m² plots to grow crops under the supervision of the horticulture section of the Council. Residents of the Settlement areas who cannot be given land for gardening in the ecologically appropriate location of the Atzera Hills will be encouraged to garden in these Community Food Gardens near their houses.

Tropical Fruit and Nut Tree Project

In July 1978, Lae City Council approved a tropical fruit and nut tree project which is concerned with identifying, developing, popularizing, and distributing tropical fruits and nuts suitable for Lae, its surroundings, and the Markham Valley. This project is underway and a 3.5 ha plot is already being planted with different kinds of fruits obtained from different areas of Papua New Guinea, Queensland, and other tropical regions. While the fruit trees are still young the land between rows of trees is available for growing short-term crops, a practice which will also benefit the fruit trees considerably, especially with the additional application of compost. For this purpose, a comprehensive food garden programme with improved cultural practices for common food crops has been tested and developed. Seeds of improved cultivars have been imported from research stations in Papua New Guinea and other areas and tested under Lae conditions, and improved agronomic practices have been developed. The planting material of improved cultivars of these fruit trees (rambutan, mango, cashew, for example) and of vegetable crops (peanut, corn, sweet potatoes, capsicum, cucumber, tomatoes, rockmelon, and mungbean) are being distributed to the community and the food gardens in the Atzera Hills.

The Atzera Hills gardeners, in particular, will be encouraged to plant fruit trees in the hills. These fruit trees will not only be an additional source of food and income but more important, they will contribute to the conservation and rehabilitation of the Atzera Hills.

CONCLUSIONS

This programme of conservation and rehabilitation of the Atzera Ranges is still in its infancy. It promises increased food supply and improved nutrition for the residents of Lae combined with increased opportunity for employment through small cropping activities and marketing of vegetables and firewood, as well as long-term security in the local supply of energy (Figure 7). Furthermore, the programme will reduce erosion runoff and flood damage and the overall preservation of the natural environment will be realized in the coming years.