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ENVIRONMENTAL CASE STUDIES

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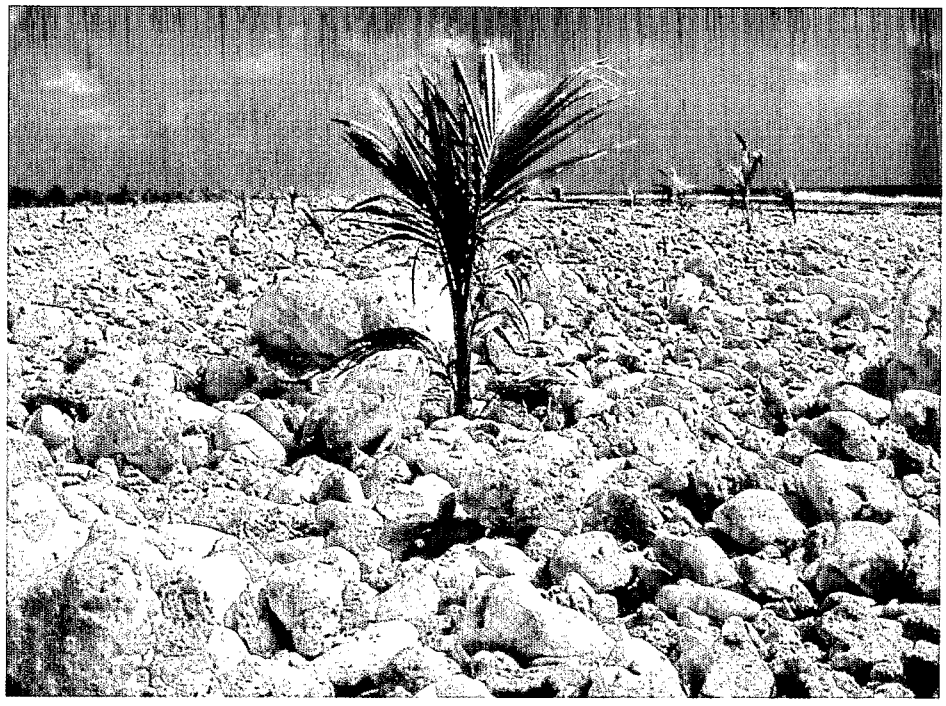
South Pacific Study 3

ATOLLS AND THE CYCLONE HAZARD: A CASE STUDY OF THE TUAMOTU ISLANDS



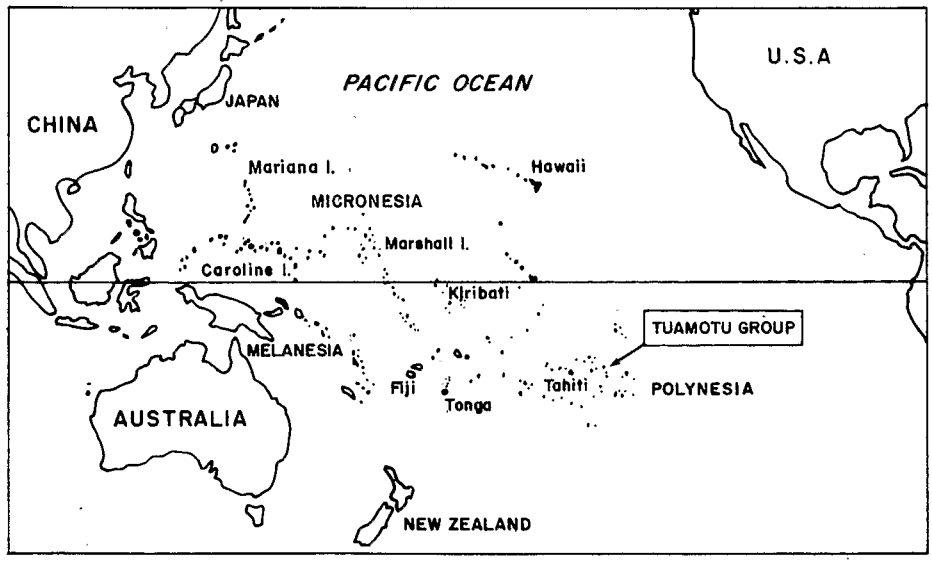
THE ENVIRONMENT OF THE ATOLLS

Among the islands of the inter-tropical area of the Pacific Ocean, most of the very low-lying land is made up of atolls.

Atolls are the visible part of living coral reefs that have developed on the summit of isolated oceanic volcanoes. When the sea-level drops and tectonic movements occur, part of these constructions emerge and a feature of most atolls is a ring of narrow islets which are only a few metres (3 to 10 metres) above average sea-level. Inside this ring is an area of shallow water (the lagoon).

The islets are for the most part composed of wave-born deposits, mainly coral and sand, and may be submerged by the waves in strong storms and particularly during summer tropical cyclones. This debris is deposited on or beside the emerged remainders of old coral structures. Natural disasters, such as cyclones, droughts or tsunamis, regularly interrupt and impair the continuity of the process of occupation of this environment by plants and animals.

Winds in tropical cyclones are detrimental to the low islands' vegetation as soon as they reach speeds of 75 to 80 km an hour. With the average rise of the sea-level that follows the drop in atmospheric pressure accompanying a cyclone, the waves form a storm surge that may flood the low-lying coastal land, to a depth of 4 to 6 m above average sea-level.

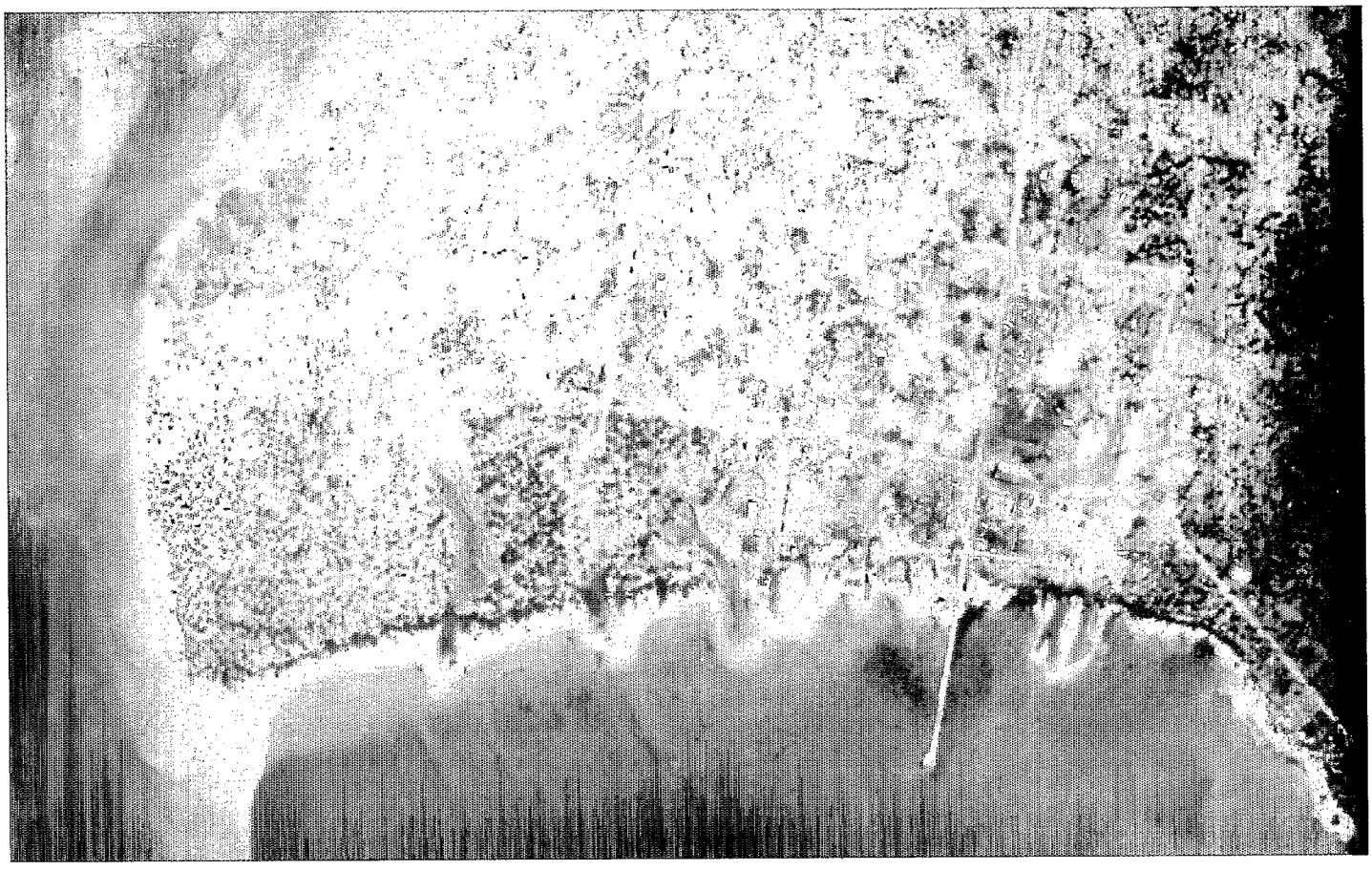


THE TUAMOTU ISLANDS AND THE CYCLONE HAZARD

The case of the Tuamotu islands will be studied from the point of view of the reaction of the particular natural environment of the atolls, and also the reaction of the people who live there, to a major environmental problem: that of cyclones. The 75 atolls of the Tuamotu group are scattered over nearly 1,500 km between 14 and 23 degrees south, 135 to 148 degrees west. The atolls are less spread out in the west than in the east, and the rainfall is only moderate (between 1,000 and 1,900 mm annual rainfall). Seasonal variations may be in excess of 50%, which is also the rate of variation from one year to another.

The archipelago as a whole does not come within the cyclone high frequency area. Observations recorded since the first third of the last century allow estimation to be made of the risk of one cyclone every 10 to 25 years (French Polynesia Meteorological Service, 1979-1982).

Man solved the basic problem of lack of fresh water by using coconuts and by collecting rain-water first in the trunks of coconut-palms and later from corrugated iron roofs. It appears too that he has always used the ground water on which the vegetation's survival depends.



The balance of the fresh water lens is all the more delicate as the lens is very shallow. This balance is affected by tides, rainfall and evaporation, and the withdrawal of water by plants and, of course, by man. It may be seriously endangered by the invasion of sea-water during cyclones.

More is known now about the possibilities and limits of the groundwater resources. The problem of fresh water in the Tuamotu Islands, which has never been satisfactorily solved by the use of tanks alone, for they are susceptible to pollution by sea-water and salt spray during cyclones, could be overcome by the combined use of the traditional techniques of wells, and of new techniques for economically desalinating sea-water.

In former times the limited amount of total resources available served to limit the number of people living on the atolls. Nowadays the aim is to persuade the atolls' inhabitants to remain there, in particular by improving their living conditions. The increased population and the new needs which will thus arrive, will necessitate ever more careful management of the environment.

UTILISATION OF THE ATOLLS: HISTORY AND DEVELOPMENT

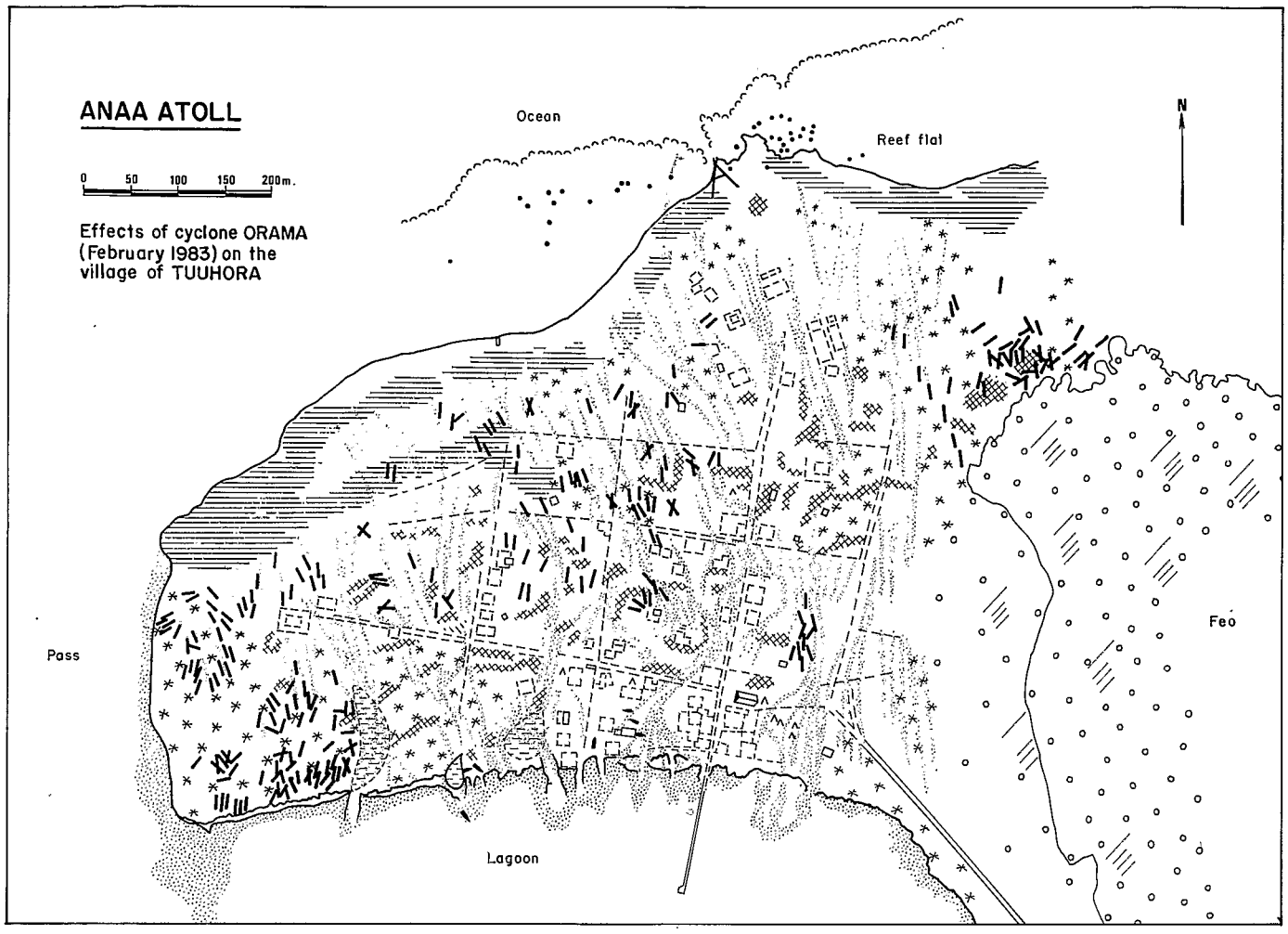
The Tuamotu Islands, because of their climate and their remote situation in the Pacific, can support naturally only a few dozen species of plants and trees. Before Europeans arrived and until the first quarter of the last century the food plants that were introduced were those used in the Polynesian way of life: pandanus, taro **(Cyrtosperma, Colocasia esculenta),** breadfruit **(Artocarpus altilis),** kava **(Pometia pinnata Forster),** a fruit tree of the lichee family, Polynesian arrowroot **(Tacca leontopetaloides),** and of course the coconut palm. The whole range of plants are found only when conditions are the most favourable (SPC, 1982).

Insecurity, the situation of the taro pits, and the social system may account for the widely scattered settlements which were the rule in every atoll. Seasonal food shortages, only slightly offset by drawing heavily on the resources of the sea, or resulting either from exceptional causes (cyclones, or droughts) or from the economic and social circumstances of the time (such as over-population), led to power struggles. The habit of building up reserves of foodstuffs using conservation procedures (making cakes from the pulp of pandanus fruits, drying or preserving of breadfruit) is evidence of the severity of the food problem. After the passage of a cyclone, losses of life caused by famine were sometimes greater than the losses caused by the cyclone itself.

From the latter part of the 18th century, exchanges between the islands led to the population concentrating in the motu (islets) that were most easily accessible by sea, that were the highest and that had the best fresh-water supply. With the spread of Christianity, the introduction of trade and European administration during the second half of the 19th Century, it became common for permanent villages to grow up near a pass in the lagoon and safe anchorage, usually to leeward, or around the mission and the church. Coconut plantations were to cause vast stretches of natural vegetation to be removed. The requirements of commercial production and the introduction of a monetary economy were to lead gradually to disuse of the taro pits. Among the many useful plants which were being introduced into the Society Islands in this period, a certain number passed on to the Tuamotus.

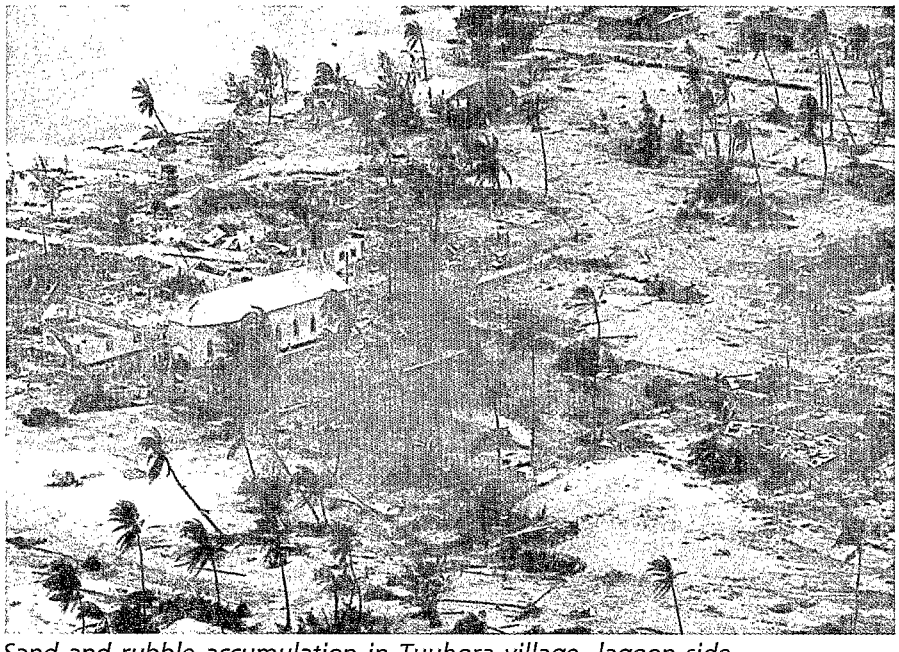
With certain exceptions, these species now serve only as supplementary foods in a diet that has for a long time been based on imported goods, in which carbohydrates, sugar, vegetable oils, and tinned goods predominate.

Since the 1970s, a policy of stabilising and re-settling the inhabitants of rural areas in order to slow down the drift to Tahiti and the urban areas of Papeete has been applied. The October 1983 census showed that the archipelago had a population of more than 8,100. The drive to develop new resources, such as tourism, fishing, pearl culture, pearlshell collecting, aquaculture – have noticeably changed the economy of the islands in the course of the last two decades. These projects are intended to take over from copra production. By the early 80's neglected coconut plantations had to be regenerated. Half of them were composed of trees that were more than 75 years old, 80% of the total number of trees being over 50 years old. They were poorly maintained, and were not harvested regularly.



LEGEND

- Outer reef slope
- Coral blocks torn off the outer reef and rolled over the reef flat (2-5m)
- Feo area: trees and shrubs on deeply weathered reef limestone (ridges and furrows): little visible damage
- Old swampy depressions, emptied by the storm surge
- Main coconut growing areas
- Fallen coconut trees
- Areas where the abrasive action of the sea was strongest
- Main lines of water flow and deposits of coral rubble by the storm surge between the ocean and the lagoon
- Sand deposits in the lagoon
- Drifted and piled up plant materials
- Church
- Ruins of wharf and lighthouse
- Recognisable traces of roads and buildings
- Boats
- Makeshift shelters erected by the inhabitants after assistance arrived



Sand and rubble accumulation in Tuuhora village, lagoon side

THE 1983 CYCLONES IN THE TUAMOTU ARCHIPELAGO

Between January and April 1983 the Tuamotus were struck by 5 cyclones, which caused 22% of the total damage estimated for all the islands of the Territory of French Polynesia taken together. More than ¾ of the 40 inhabited atolls were affected.

Damage to the environment

Storm surge and accompanying waves caused new deposits and also erosion to occur, especially on the north west side of the atolls and in the leeward area, these being, in the Tuamotu islands, usually the first and the most severely affected parts. Although most of the islands are only 5 or 6 m above sea level at high water, the villages are rarely built on the higher ground. They are usually to leeward, near the passes or on the gentle slopes of the islets on the lagoon side. The inhabited parts of the islands were flooded totally or partially to a depth of more than 1 m in most cases. The range of the storm surge was between 3 and 4 m at least.

Some spectacular displacement of heavy materials occurred with the sea's invasion: chunks were torn off the reef and carried on to the reef flat, coarse rubble was piled up in ridges or spread out in beds dozens of centimetres thick, thinning out towards the lagoon. The most obvious forms of erosion were the widening of passes already existing between the islets, and overdeepenings gouged out by the turbulent movement of water bearing various kinds of materials.

Where the erosive process was worst, the soil was not just buried under coral rubble, but was swept away, in some cases totally.

On most of the atolls the natural vegetation, the introduced species and the coconut plantations were very severely damaged. On more than half the atolls, the coconut groves lost over 50% of their trees in places. Fruit trees were sometimes totally wiped out as were the few vegetable gardens.

But the passage of a cyclone does not modify only the emerged part of an atoll. The presence of great chunks carried on to the reef-flat in front of the beaches, the preponderance of coral rubble in the deposits, and the debris from the outer reef piled up on the ocean side are evidence of the damage caused by waves breaking heavily on the coral structures of the upper part of the outer reef slope.

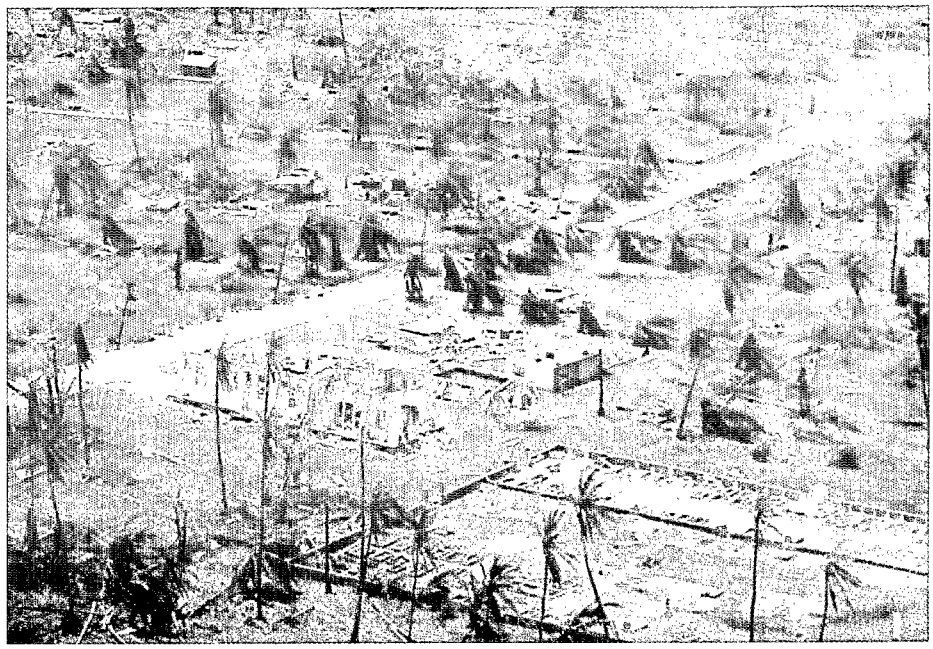
Damage done to man-made installations and human activities

The 1983 cyclones caused some ten deaths in the Tuamotus whereas in February 1878, at least 117 people lost their lives, in January 1903, 515 people died, and in February 1906, more than 120 (Dupon, 1985). Much-improved weather forecasting and the existence of an adequate and rapid warning system are doubtless among the reasons for a reduced toll. But we may also ask ourselves how the heavy toll taken by the cyclones of 1878 and 1903 might be linked to the changes brought about by new types of activity and the new population concentrations. The new commercial operations were causing people to leave the relatively safe places of habitation, to go and live in temporary camps on the more exposed islets doing seasonal work there, for example copra production (Kaukura – 1878), or harvesting pearlshell (Hikueru – 1903). The fairly general concentration of the population near the passes, where schooners can anchor or come into the lagoon, situated on the leeward side of the atoll in the area which was the most exposed to cyclones, as is the case in more than 30 atolls, shows the same kind of ambivalence. Certain villages such as Tuuhora on Anaa, have thus been destroyed several times.

Just as the populations of the Tuamotus have for a long time now been dependent on imported foodstuffs, they have also become dependent upon a whole range of materials, technical equipment and services whose inappropriateness and high cost has been shown up by the cyclones.

The infrequency of the cyclone hazard had caused the Tuamotu people to relax their vigilance. In 1983 there was no tested collective shelter capable of withstanding cyclones and tsunamis.

In point of fact, numerous villages were practically wiped out by the combined action of the wind and the sea. It may be estimated that about half the dwellings were totally destroyed by the cyclones. The invasion by the sea resulted in the family watertanks being polluted by salt water. Several administrative buildings and the churches despite their being built of durable materials, often quite recently, were damaged or totally destroyed. Thus the cyclones have shown up, in about half the atolls affected, serious shortcomings in design.



Damaged coconuts, buildings and watertanks (Arutua atoll).

Dwellings not designed to withstand strong winds were blown down (Arutua).

Damage to essential facilities, mainly ports and airports, proved all the more costly as the number of these structures had been considerably increased in the last 20 years as part of the policy of improving communication with isolated areas.

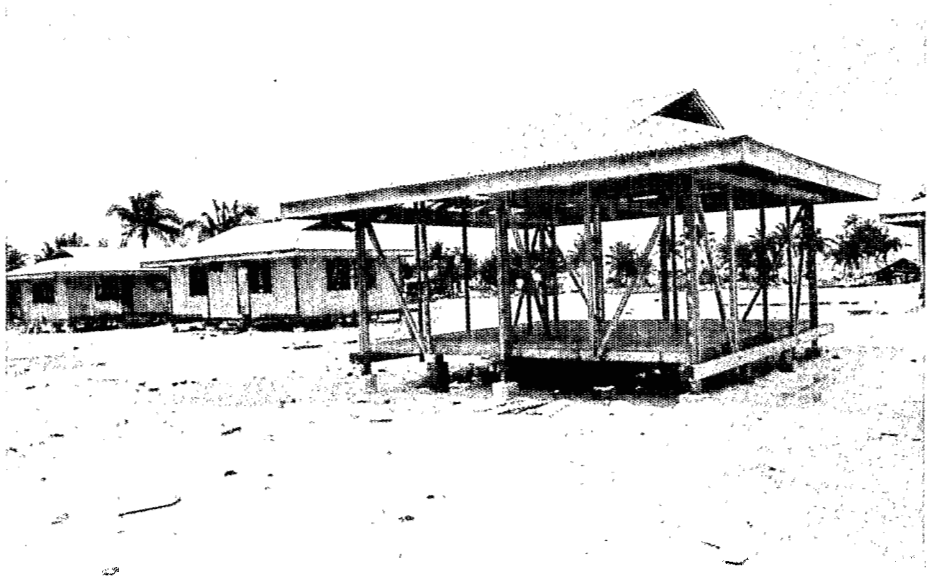
Lastly, in the most severely hit atolls some 80% of the total number of fishing boats were lost or made unusable.

In addition to these losses there were those affecting the pearl farm installations, i.e. the rafts and spat collectors, and the destruction of the fish weirs.

CONSEQUENCES OF THE CYCLONES AND THE LESSONS TO BE LEARNED

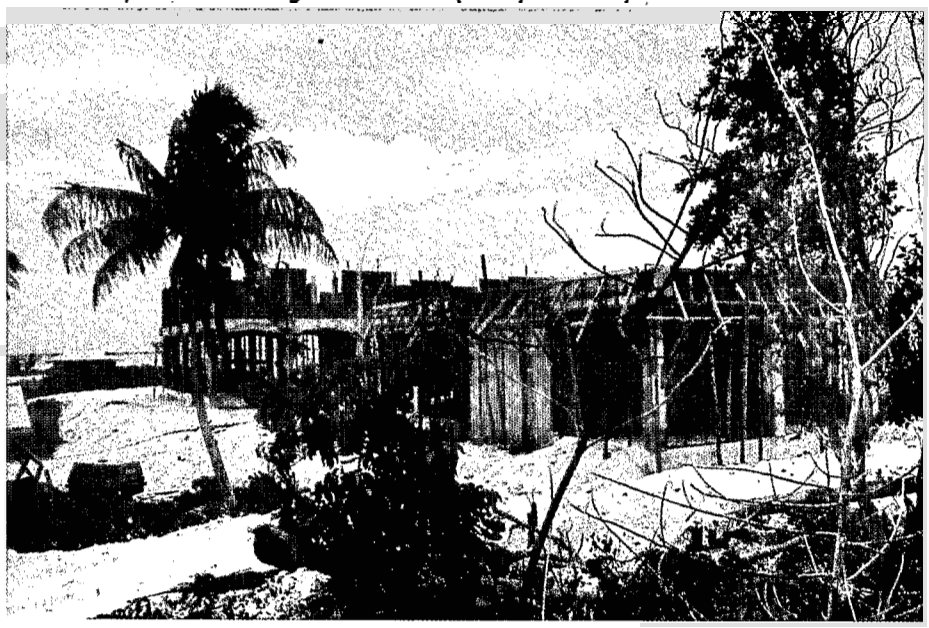
After the emergency aid provided by the French Government, rehabilitation proper was financed mainly by the Territorial Government by means of special taxes, bank loans and appropriations from its budget. The rehabilitation was carried out by a body set up especially for this purpose, the "Agence Territoriale de la Reconstruction – ATR" (Territorial agency for reconstruction) (Dupon, 1985).

The damage suffered by the coconut plantations had a beneficial selective effect in that it speeded up and genera-



A better designed construction from ATR

Community shelter being constructed (Anaa). A costly insurance.



lised the regeneration programme which had already been started before the cyclones. Production of copra which dropped considerably at first (a fall of more than 60% compared with 1982) began to rise again rapidly as early as 1984. This recovery of production suggests that the potential was under-utilised before the cyclones.

Natural regeneration of the living environment occurred within the same time period as has been observed elsewhere. Colonisation of the coral deposits by pioneer plants had begun within a year of the passage of the cyclones. In the coastal area, Laboute (1985), observed recolonization by coral in the top 15 metres within the same period, as well as the return of fish life.

For fishing and pearlculture, rehabilitation required considerable effort, and as in the case of the coconut plantation regeneration it could not be dissociated from the costly rehabilitation of the transport infrastructure.

Repair of individual dwellings was done in two ways: some repairs were carried out by the families themselves (more than half the houses), the owners being supplied with appropriate materials, while other houses had to be completely rebuilt. The "ATR" proposed a type of improved modular dwelling. Only one village, regarded as lying in too exposed a position, was relocated (Tuuhora, on Anaa).

After the 1983 cyclones had revealed the inadequacy of safety measures for the public, the authorities opted for a combination of preventive measures to be applied to all building works. The standard individual dwelling proposed by the "ATR" includes all conventional provisions to improve resistance to wind.

Secondly, the French Government decided to apply new building standards to public buildings to make them able to resist winds of speeds greater than 200 km an hour.

Lastly, it has been decided to launch a programme to construct community shelters in the thirteen atolls regarded as the most at risk. Implementation of the whole programme would affect some 30 to 40% of the population of the archipelago. The majority of these shelters will normally serve either as the mayor's office or as an infirmary. In some cases the two functions would be combined in one building: this is the case of the shelter on Anaa, which has been built on the site of the new village.

The building is raised on stilts 3 m high and equipped with a water storage tank and solar voltaic panels to produce electric power. It is planned in most cases that the shelters should also house the radio transmitting room.

Cyclones having played a part for thousands of years in the construction as well as the destruction of atolls, remain an environmental factor to be reckoned with. Neither the increased mastery of short-term meteorological forecasting, nor the hope of reliable medium-term forecasting, based on a better understanding of the interaction between the ocean and the atmosphere in the intertropical area, should cause the efforts to protect human settlements in these islands, as in other similar situations in the Pacific, to be neglected (Franco et al., 1982).

Thus, the exceptional materialisation of a low-frequency natural hazard may have value as an indicator. By bringing out the existence of the risk, it clearly demonstrated in the Tuamotus the limits of the vitality of the atoll environment and the absolute necessity of protecting that environment.

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