UNIVERSITY OF BRADFORD

DISASTER RESEARCH UNIT

Occasional paper No. 9

Report of Mission to Assess the Hurricane Factor for Planning Purposes in Fiji

Michael Gane, D.Phil., M.A., B.Sc.

January 1975

2015

UNIVERSITY OF BRADFORD
DISASTER RESEARCH UNIT

Report of Mission to Assess the Hurricane Factor for Planning Purposes in Fiji.

Michael Gane, D.Phil., M.A., B.Sc.,

OCCASIONAL PAPERS: NUMBER NINE
DECEMBER, 1974

441-1468

GD2995

PREFACE

The Disaster Research Unit was formed in December 1973 and is a research group within the Project Planning Centre for Developing Countries at the University of Bradford. Unit members are:

James Lewis ARIBA, Senior Research Fellow and Unit Leader,

Philip O'Keefe, B.A.(Hons.), Research Fellow,

Kenneth Westgate, B.Sc. (Hons.), is attached to the Unit as a Research Student.

This series of Occasional Papers will contain the results of the Unit's work. An Index of the Occasional Papers is included on the inside back cover.

Disaster Research Unit, University of Bradford, Bradford, Yorkshire, BD7 1DP, England.

Bradford (0274) 33466.

NOTE

The following pages reproduce the text of a report submitted to the British Commonwealth Secretariat and Fiji Government in 1973, which may be of wide interest to those concerned with precautions and planning for disasters in other parts of the world.

Introduction

In October, 1972, tropical cyclone 'Bebe' struck Fiji causing considerable damage and some loss of life. Afterwards, the Fiji Government asked the Commonwealth Secretariat in London for technical assistance to examine what additional precautions might be taken in future against these destructive storms which occur from time to time in this part of the Pacific. The Commonwealth Secretariat approached the writer, who previously had made a study of the risk from hurricanes following a visit to Fiji in 1967, and this, in turn, resulted in his engagement as a consultant to undertake the assignment described in this report.

The assignment lasted nearly three weeks, beginning on Sunday 10th June and finishing on Friday 29th June. Ten days were spent in Fiji (16th - 26th June); also two days in Bangkok and two days in Manila en route to Fiji, and two days at Miami, visiting the American National Hurricane Centre, Coral Gables, during the return journey.

The writer wishes to acknowledge the co-operation and assistance so freely given to him throughout. Many people were consulted and supplied information or other help. Without their aid, the mission, organised on such a tight time schedule, could not have achieved useful results.

Terms of Reference

1. To carry out an appraisal of the social and economic effects of the recent cyclone and floods indicating the reliability (or otherwise) of the figures obtained and, if possible, pinpointing short-comings in the data, which might be rectified by administrative action before the next hurricane strikes;

2. To collect the available meteorological data which could be used to predict hurricanes and floods in Fiji and thereby assist with national planning in all sectors of the economy;

3. To discuss with the meteorological authorities the possibilities and costs of providing additional and more accurate data relating to eye pressures and storm tracks, examine any other techniques which might be used to improve long-range frequency forecasting in the future and explore the feasibility (and degree of interest which might be aroused) of establishing some form of research programme;

4. In the light of (2) and (3) above, to do further research into the problems of risk in relation to strategic planning and to update and improve the computer model at Bradford in the hope that it will then become capable of producing forecasts of cyclone and flood distribution frequency which are reliable enough to be used for strategic planning purposes;

5. To determine what preventive measures, if any, might be worth attempting or might justify more detailed technical investigation;

6. To examine the extent to which the hurricane and flood factor influences national plans at present and investigate the scope for extending that influence to make national planning more responsive in the future;

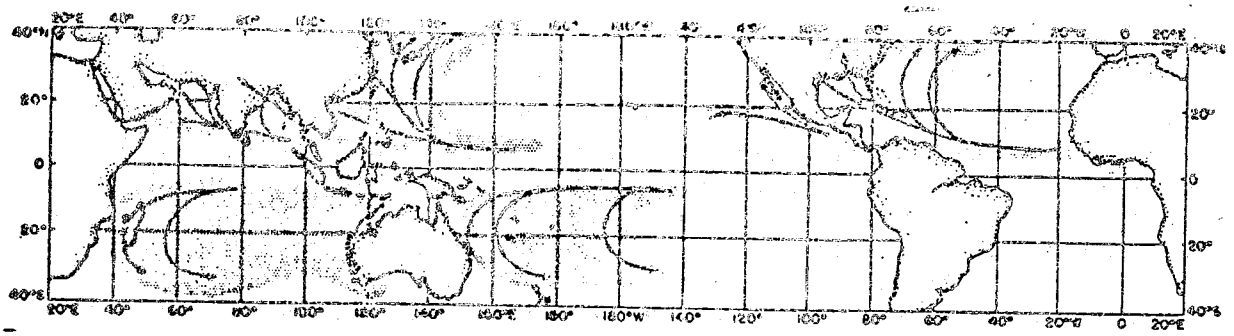


Fig. 1 *Regions most frequently affected by tropical cyclones of storm or hurricane intensity (shaded areas) and generalized mean cyclone tracks*

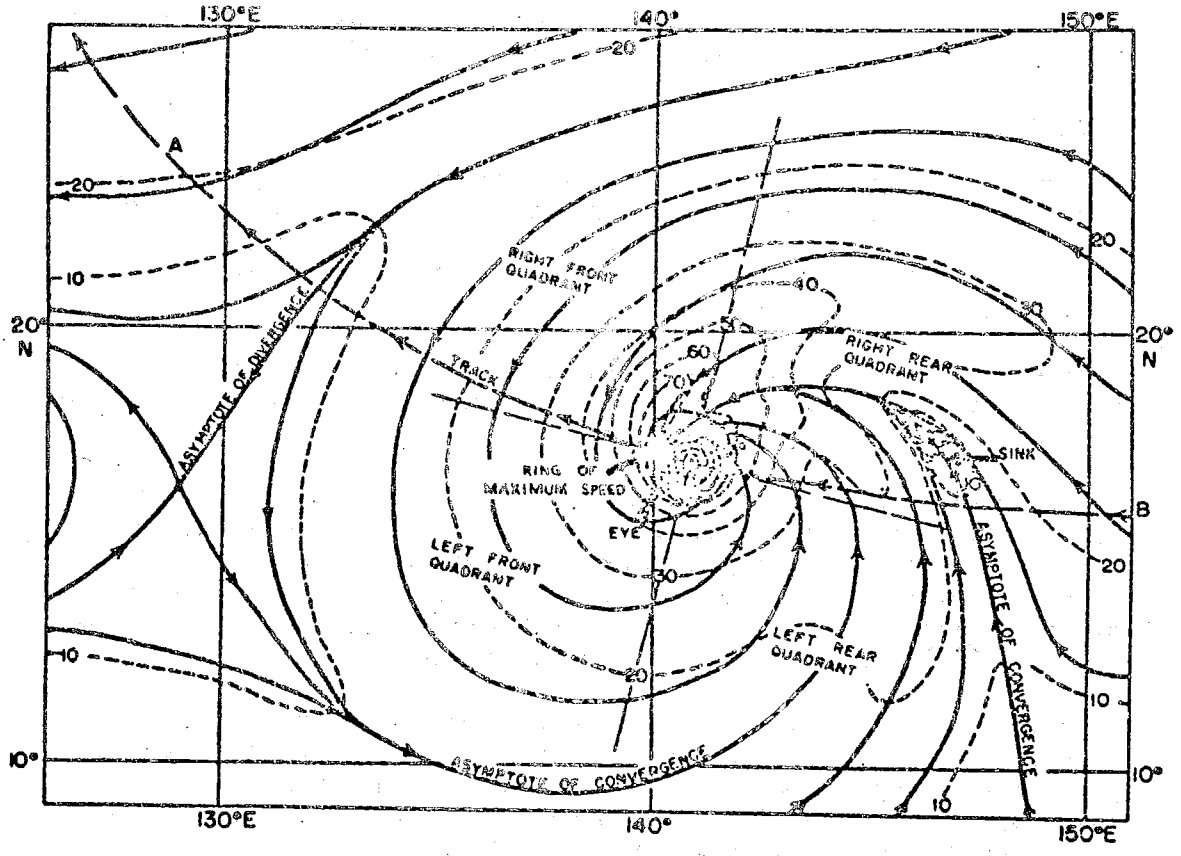


Fig. 2 *The components of a mature tropical cyclone*

Source: **'The Practical Aspect of Tropical Meteorology'**[7]

7. To suggest practical ways and means for minimising economic and human losses in the future.

General Characteristics of Tropical Cyclones

Revolving tropical storms, which are commonly known as 'hurricanes' in the Caribbean, 'typhoons' in the northern part of the Pacific Ocean and 'cyclones' or 'willy-nillys' in the southern hemisphere, generally form between about latitudes 8° and 20° both north and south of the equator. They originate over the oceans, from which they derive their enormous amounts of energy, and move westwards, later usually turning towards the poles and frequently recurving before dying away on reaching temperate latitudes. If their movement takes them onto or near land, they are liable to cause severe damage and loss of life. Once over a major land mass, however, and cut off from the warm seawater surface layers which fuel them, they tend to lose strength fairly rapidly. Therefore, their effects are worst on islands and along coasts, for distances of up to about 200 miles inland. Countries which are situated in these 'hurricane belts' on either side of the equator are at risk and, in present circumstances, must expect their coastal zones to suffer severe destruction from time to time.

The destructive effects are due to three causes: high velocity winds, torrential rain and storm surge. A tropical cyclone is a huge whirl or vortex of air with a vertical axis rising to as high as 15,000 metres altitude. Winds blow in at the bottom and out at the top of the vortex. The direction of the spin being clockwise in the southern hemisphere and counter-clockwise in the northern hemisphere. The diameter of the whole atmospheric disturbance may be as much as 500 miles in large, mature storms, but is commonly less, and may be under 100 miles. At the centre of the vortex, or 'eye', the barometric pressure is low (960 millibars or less at sea level) and the air is comparatively calm; 'eye' diameters range from about 8 kilometres (5 miles) in small cyclones such as 'Juliette', to 50-65km. (about 30-40 miles) in large storms. Round the 'eye' is the zone of maximum wind speed, known as the 'eye wall', where the pressure rises in a steep gradient, and velocities frequently exceed hurricane force (12 on the Beaufort scale = 73 miles per hour). Further out, windspeeds decline as the distance from the centre increases.

Wind damage is intensified by the forward movement of the cyclone. The whole system moves along relatively slowly, usually at less than 15-20 knots, but any object which lies in the track of the cyclone is affected first by violent winds blowing from one direction in the front part of the 'eye wall', then, after a period of calm when the eye passes, by equally violent winds blowing from the opposite direction. This change of direction is more difficult to withstand than a wind from one side only.

The ring of concentrated winds, which is the most outstanding characteristic of mature tropical cyclones, coincides with an 'eye wall' cloud surrounding the centre. The distinctive cloud shape enables a tropical cyclone to be easily recognised on the pictures received from weather satellites, so that it is now possible to plot cyclone tracks accurately and quickly, and forecast their movements with greater certainty than in the past. But the cloud also marks an area of violent convection accompanied by heavy rainfall. Remarkable figures are often recorded - 755mm. occurred in 48 hours at Naseuvou on one of the tributaries of the Rewa

river in Viti Levu during hurricane Bebe, and typhoon Gloring produced 479.6 mm. at Baguio City in the Philippines during 24 hours on 17th July, 1972. Therefore, it is not surprising that tropical cyclones and floods tend to go together.

Storm surges are due mainly to the effect of the wind piling up sea-water and thereby temporarily raising the level of the sea. They cause salt water flooding in low lying coastal areas and also raise rain swollen rivers to still higher levels by impeding their discharge. Generally, storm surge heights are greatest (up to 10 feet or more) and are to be feared most on long coastlines such as the south eastern part of the USA but small coral islands are also vulnerable, even though the sea level may rise only two or three feet, because they are so little above the level of the surrounding ocean.

The destruction attributable to revolving tropical storms throughout the world is enormous. It has been estimated[1] that in 15 countries in the ECAFE region, 7,396 lives were lost, 22.5 million people were affected, 9.6 million hectares inundated and 1.4 million buildings were damaged on average each year, during the period 1961-70, the annual damage being valued at US.$895 million. In the USA, hurricane Betsy of 1965 alone caused more than 1.4 billion dollars worth of damage and it has been claimed, in justification of the Project Stormfury hurricane modification research, that if it is possible within ten years to reduce the damage from one such hurricane by only 10 per cent, the nation would achieve a return of more than 1,000 per cent on its investment[2]. Fiji does not suffer so severely in absolute terms as some other parts of the world, but relative to the size of the Fijian economy, the occasional severe cyclones which come her way are very serious setbacks.

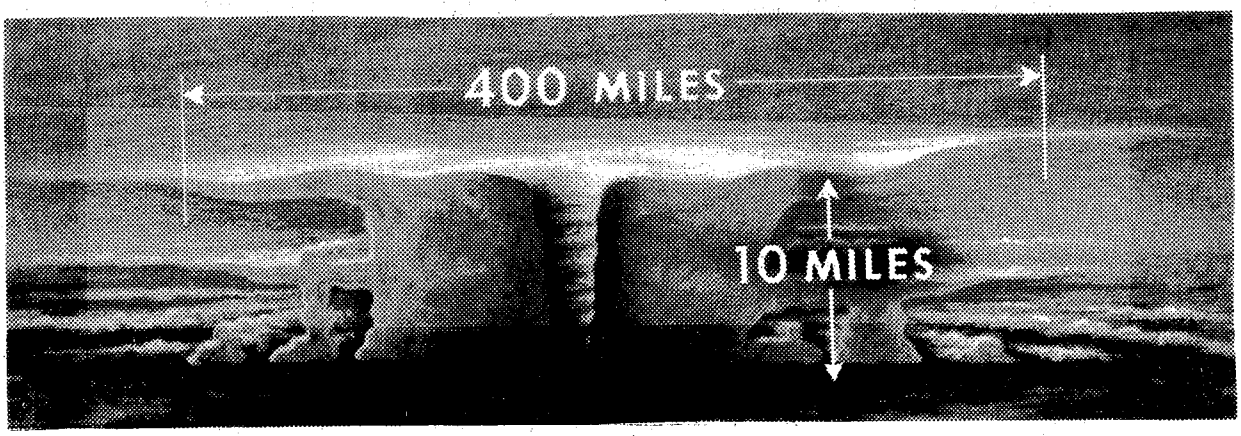
History of Tropical Cyclones in Fiji

Two sources of data are available from which estimates of frequencies in the past may be derived. The first is a set of notes on 'Tropical Storms in Fiji and the Southwest Pacific', which lists tropical cyclones since 1840 and is updated annually[3]. Second is a pair of wall maps at the Meteorological Office, Laucala Bay (reproduced on a smaller scale in Appendix 2) which show the approximate tracks of severe hurricanes through the main Fiji islands. Both, unavoidably, are much more accurate records of cyclones in recent years than those which occurred in the nineteenth century, about which most of the evidence comes from mariners' reports and which probably ignores many lesser revolving tropical storms because their effects were unremarkable. Therefore the following analysis obtained from them is likely to be an understatement of the true position.

No revolving storms during the months of June, July and August were recorded. Also it should be noted that the difference between the two lines of figures is due both to the fact that some revolving storms which passed over Fiji did not achieve hurricane intensity, while others, which were more severe, missed hitting the islands directly so that hurricane force winds were not recorded there.

The average number of storms which affected Fiji over the whole period of 134 years is 1.11 per season. The average number of hurricanes shown on the maps is 0.28 per season or approximately on every $3\frac{1}{2}$ years over the same period. However, if the calculation from the maps is made using the

Fig. 3 Satellite picture of Hurricane Bebe over Rotuma



A hurricane may be several hundred miles across and ten miles in height. Its strongest winds are found in a ring around the eye.

Fig. 4 Vertical section of a hurricane

Source: "Project Stormfury 1971" (14)

	Months									Total for all months
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb,	Mar.	Apr.	May	
Number of revolving storms which affected Fiji	1	2	10	27	35	30	28	13	3	149
Number of storms of hurricane intensity shown on maps of Fiji islands	0	1	2	9	8	6	9	3	0	38

period of 108 years, dating from the time of the first track shown to the present, the average rises to 0.35 per season or approximately one every 2.8 years, and if only the hurricanes in the last fifty years are counted the average rises still higher to 0.38 per season (one every 2.6 years). Therefore, it may be said from past experience that the Fiji group of islands may expect to be affected by more than one tropical revolving storm each year and suffer the direct effects of a hurricane about every third year on average.

This general conclusion masks several other important aspects which the writer proposes to investigate further in coming months:

1. The geographical distribution of frequencies. Only the areas in a strip along each track are affected, not the whole of Fiji. Earlier maps of hurricane tracks obtained in 1967 appeared to show that the risk of cyclones occurring in different parts of Fiji was not the same. This was born out by the results from a computer model which was developed to assist the analysis[4]. It is intended to rerun the model using the new maps, after modification of the programme to suit the bigger ICL 1904A computer now being installed at Bradford. If significant differences from place to place can be shown to exist this may have important consequences for national planning and the long term location of different types of economic activity.

2. Variations in frequency from year to year. Some seasons had several revolving storms of hurricane intensity (e.g. 1964/65 and 1972/73), other seasons produced none. Is there any way to forecast yearly variations from the average frequency and find the probability of getting a second or third storm in a year?

3. Differences in monthly frequencies. January is the peak risk month according to the records of tropical storms (upper line of the table) whereas the risk from hurricanes (lower line) appears to be greatest in December and March. Is this difference significant and is it possible to obtain reliable monthly estimates which might be used to control the size of emergency food stocks for example?

Hurricanes in Fiji in 1972/73

Two tropical cyclones of hurricane intensity struck Fiji in the 1972/73 season. The first, cyclone Bebe, 21st to 25th October, was unexpectedly early and the second, cyclone Juliette, 3rd to 5th April, was unexpectedly late. Bebe was a large cyclone, with an eyewall diameter of about 65 kilometres, which left a trail of destruction from Funafuti in the Ellice Islands through Rotuma and the Yasawas before crossing the western half of Viti Levu(5). Juliette was a small intense cyclone, with an eyewall diameter of only about 8 kilometres, which damaged crops and some buildings on the Lau group and then moved on to Tonga. The effects of Juliette have been overshadowed by Bebe, which will be remembered as one of the most serious natural disasters in Fijian history, ranking with the cyclones of 1952 and 1931.

Eighteen people were reported killed by Bebe in Fiji, an uncountable number made homeless and the extent of the damage was so serious that an international relief effort was mounted with major help coming from New Zealand, Australia, USA, the United Kingdom and lesser help from India. At one stage it was estimated that about 120,000 people (a fifth of the population) were receiving rations, and food was still being supplied in Rotuma and the Yasawas in June, 1973. Material damage to buildings was mainly due to wind; schools suffered particularly severely and were given special treatment to get them rebuilt. Floods were generally not so destructive except on the flat lands of the Rewa river, where the peak flood level at Nausori Pump Station reached 23.35 feet on the gauge with a peak discharge of about 415,000 cusecs, and the Navua river, where the peak was 35.7 feet and the discharge was about 184,000 cusecs. The Rewa flooding was comparable to that caused by the cyclone of February, 1965, and, at Nausori, the airport was put out of action and parts of the town were covered with water to a depth of three feet. The floods at Navua were said to be the worst in living memory and the main bridge on the Queen's Road collapsed(6). Telecommunications suffered widespread disruption, roads were cut at many points by washing out the approaches to Irish bridges, and water supply pipelines, which are generally laid on the surface, were fractured at many river crossings.

To deal with the emergency caused by Bebe, the government Emergency Services Committee (EMSEC) was activated. This committee has a Natural Disaster Operation Plan, prepared in 1970, for the purpose of laying down responsibilities and co-ordinating relief in the event of a cyclone or other natural disaster. About a week after Bebe occurred, a second committee was set up, under the chairmanship of the Prime Minister, known as the Hurricane Relief Committee. The function of this committee was to receive overseas aid and carry through the task of reconstruction after the immediate job of rescuing people, providing temporary shelter and restoring essential services had been completed under EMSEC control.

Damage Estimates and Cost of Relief

Although a considerable amount of information was collected by the Hurricane Relief Committee and made available to the writer, a complete assessment of the damage caused by cyclones Bebe and Juliette presents serious and perhaps insuperable difficulties. The effects of wind and flood are not separable and information about Juliette is scanty, although

the unfortunate inhabitants of the outlying islands which were hard hit for the second time in one season might be thought to deserve special attention and assistance. The following account therefore refers to the consequences of Bebe only.

A list of bures (traditional Fijian buildings), houses and schools which were damaged or destroyed was prepared for the Sub-Committee of Buildings report dated 6th November, 1972. This showed 1,697 bures, 980 houses and 28 schools completely destroyed, 2,589 bures, 1,553 houses and 30 schools extensively damaged, and 675 bures, 444 houses and 14 schools slightly damaged throughout Fiji, the major part of the losses being reported from Western Division. There has been no attempt to value the losses, however, and it would obviously be difficult to do so because in many cases local materials and family labour are used in construction for which market prices are lacking. Furthermore, the list may well be unreliable as a basis for valuation, although it was adequate for the purpose for which it was compiled, which was to assess rapidly the extent of the need to provide emergency shelter and indicate the scale of longer term assistance which was required.

The damage to crops is less comprehensively covered and, again, was reported to enable the Relief Committee to assess the need for relief. Even if an acreage survey was available, pricing problems with subsistence crops would probably arise and it would be necessary to take into account the long term effects of damage to coconuts, which take up to six years before replanted trees start to bear fruit. In other sectors, particularly communications and water supply, damage is known to have occurred, but is not specified in reports and was made good as rapidly as possible after Bebe struck without in all cases separating the special cost from the costs of normal day to day activities. In all emergency situations of this kind people cope as best they can to restore essential services; they work under pressure and often for very long hours. It is not realistic to expect them to provide reliable valuations during the immediate disaster period.

The total cost of the relief operation, up to 8th May, 1973,is put at $3.73 million (Fiji),of which $1.38 million was provided by the Fiji Government and $2.35 million from overseas governments, relief organisations and other charitable sources. Aid received/distributed amounted to $1,861,670 of which food accounted for $613,206, building materials $286,093 and clothing, tents, vehicles, aircraft charter etc. $962,371. The Prime Minister's Hurricane Relief Fund received donations amounting to $678,300 of which $475,000 had been used, the major items being $268,000 spent on schools rehabilitation and $100,000 for evacuation centres serving the Rewa area. Government expenditure totalled $1,129,132, plus $85,644 projected, and a further $ 168,000 provided to Yasawa/Mamanucas and Rotuma in the form of loans.

It is possible to try to estimate the value of the damage by the cost of relief, on the grounds that relief covers the cost of making good damage and providing replacements. However, this approach also yields an incomplete assessment of the total loss because the principles adopted by the Relief Committee were to give assistance according to need and to encourage self help to the maximum extent possible. The value of reconstruction work done by Fijians themselves (sometimes using materials provided by the Committee) and the costs of reconstructions paid by individuals and firms from their own resources or from insurance claims are unknown, although they must surely amount to a considerable sum. The value of food relief does not

measure the full extent of agricultural crop and livestock losses, as cash crops are not covered and the long term effects of reduced coconut production or other tree crop damage is no allowed for. Moreover, the validity of equating imported foodstuffs, such as flour, with Fijian staples, such as tapioca, sweet potatoes and yams is questionable and the imported foods had in some cases to be brought in by air at heavy additional expense. A final source of discrepancy arises because the Controller of Government Supplies has increased his stocks of food, building materials, etc. by as much as five times, three Disaster Centres have been created out of relief funds as additional precautions against future disasters and school buildings have been reconstructed to higher specifications, using permanent materials, than those which were blown down.

The true cost of cyclone Bebe to the Fijian economy therefore remains a question mark. It is conceivable that sufficient extra information exists in fragmented form amongst various government departments, which, if collected, sifted and collated, would enable a reasonable estimate to be arrived at, but this task was more than the writer could undertake in the time available. The Secretary of the Relief Committee (Dr. Lasaqa) stated it was intended to produce a final report about the end of July, which would include damage estimates. If this can be done it will fill an important gap. Probably the total figure lies somewhere between 5 and 10 million dollars; it is unlikely to be as high as the unofficial figure of $20 million suggested soon after Bebe occurred(5). Further than this it is not safe to go at this stage.

A loss of this magnitude is equivalent to between 2.3 and 4.6 per cent of the Gross National Product. Obviously the loss must adversely affect the general development effort and divert resources away from it. Foreign exchange reserves, particularly, must suffer, first on account of relief and reconstruction purchases overseas and second from the loss of agricultural export earnings from crops such as coconuts, sugar cane and bananas. The total foreign exchange cost is not likely to be less than about $2 million and may be as much as double this figure, depending on the seriousness of the effects of the cyclone on export crop production which are not fully known.

Loss Minimization Strategy

The frequency of tropical cyclones in Fiji in past years and the magnitude of the losses and disruption attributable to Bebe show clearly that these storms create a recurrent problem for the Government which is not to be taken lightly. Admittedly, other parts of the world suffer much worse - the Philippines has recorded an average of 19.2 cyclones per year - but this does not reduce the need for Fijians to face the problem as it affects Fiji and to seek ways of developing an effective strategy for coping with it in future. The tendency of most people in most countries, up to now, has been to regard natural disasters as unavoidable afflictions which must be suffered because nothing can be done about them. Fortunately there is a minority which is not completely fatalistic and some ad hoc precautions are usually taken, such as the creation of a warning system. In a few countries like Fiji (much to her credit) where forethought has progressed further, emergency plans exist for dealing with the immediate crises of rescue and relief. But these separate measures do not add up to a care-

fully thought out, coherent and comprehensive strategy. Fiji should seek to build on what has been achieved by evolving such a strategy and the purpose of the remainder of this report is to suggest the form which the strategy might take.

The purpose of the strategy should be to prevent or reduce to the greatest extent possible, the losses and disruption from future tropical cyclones. But this aim cannot be pursued regardless of cost and regardless of other national aspirations. In particular, it is necessary to bear in mind that hurricane precautions as well as hurricane relief use up scarce resources and leave that much less available for economic development. Tropical cyclones interfere with development and cause losses; so also may precautions if they are excessive. For this reason the loss minimization strategy should form part of the wider strategy of national development and should be included in future national development plans In fact, cyclones are bound to influence the future course of development in one way or another and it is somewhat surprising that past national planning has ignored them, not only in Fiji but elsewhere too. Every sector of the economy and every individual is at risk and an equally pervasive strategy is needed throughout the planning process.

Recommendation 1: Fiji should mitigate as far as possible the damage, disruption and suffering due to tropical cyclones, by adopting a strategy of loss minimization which forms part of the general strategy of development and is included in future national plans.

Factors to be considered when evolving the strategy include first the risk, i.e. the probability of different types and severity of losses in different places, and second, the costs of various precautions weighted against the benefits they generate or their effectiveness in reducing damage and casualties. It seems obvious that where the risk is high it is likely to be worth spending more on precautions than where the risk is low; it also seems obvious that scarce resources should be used to the best possible advantage, not forgetting the psychic or social advantage obtained from greater personal and economic security for which people may be willing to pay. A third factor is contingency, because plans to cope with disasters should provide for states (or levels) of preparedness and say what actions are to be taken (or considered) if and when each level is reached. For example, the EMSEC plan contains instructions about things to be done at the preliminary hurricane warning stage, while further action is laid down in the event of the risk increasing and a final warning being issued. Fourth is flexibility to enable the strategy to be modified as circumstances change, as new information becomes available and as development priorities alter.

These factors need to be combined at several levels to answer important questions. At national level, how much should Fiji spend annually on precautions overall and how should the national total increase or decrease in future? Within the national total, it is necessary to consider which combination of alternative precautions or states of preparedness is best and which individual precautions are, or are not, worthwhile. The contingent problems to prepare for, in case a hurricane occurs, include choices of priorities for relief and reconstruction and possible ways of solving the budgetary and balance of payments problems that may ensue. Obviously the information needed to provide the answers to these questions is not available

at this time and can only be made available by special efforts to collect it in future. For this reason the strategy of loss minimization must evolve and improve as time goes on; reasoned guesses are unavoidable at the start, but should be revised and replaced as new data become available and the lessons of experience are learnt.

A pause is appropriate at this point to consider the validity of a general argument against precautionary planning which the writer heard expressed. It was suggested that a hurricane such as Bebe benefitted Fiji because it generated a large flow of external assistance which would not otherwise have come to the country. With this outside help, it was possible, for example, to replace schools housed in bures by new buildings in permanent materials. If precautions were taken and the need for relief was removed, this additional source of aid would be lost and Fiji would be the poorer.

This cynical view does not stand up to close examination. Only $268 thousand was spent on schools rehabilitation out of a total cost of relief of $3.75 million and it should be remembered that the former amount includes repairs to many permanent buildings as well as bures. It is true that in some cases, relief assistance from abroad has been used to improve and not simply to replace, what existed before, but this is no more than common prudence, as for example in the Rewa delta, where schools have been rebuilt at strategic points to serve as evacuation centres in future. But the total amount of improvement for which foreign aid has been used, amounts to perhaps $250 thousand at most and is quite insignificant compared with the total value of damage done to the Fijian economy. There are also other objections. The critics of precautionary planning assume that external aid will be provided as generously in future as it has been in the past, which may not be the case, particularly if Fiji is thought to be so lacking in national pride that she is deliberately relying on international charity. In any case, the effects of a hurricane cannot be measured solely in narrow economic terms. It is surely important to try to reduce hardship from future cyclones on humanitarian grounds and those in authority who subject the population to unnecessary suffering because they have failed to exercise reasonable foresight, may find that people turn against them as a result.

Having made out the case for strategy of loss minimization and precautionary planning, the next stage is to consider its components, i.e. ways of reducing losses in future and possible improvements in the emergency planning arrangements. This will be done under the following headings, making specific recommendations where they appear justified:

1. Hurricane modification research

2. Forecasting and warning systems

3. Emergency and relief planning

4. Sectoral precautions

5. Long term and national planning.

1. Hurricane Modification Research

Scientific research during the last quarter century has contributed a great deal to meteorological knowledge of cyclone structure and properties. Not surprisingly, serious thought has been given to the possibility of upsetting the balance of forces which control the winds in the storm core and thereby reduce the maximum wind speed. Hurricane prevention is not a possibility at this stage. A moderate hurricane releases as much condensation heat energy in a day as the nuclear fusion energy of 400 twenty megaton hydrogen bombs, so there is not much point in attempting removal by brute force. Furthermore, even if tropical cyclones were preventable, it is doubtful whether their total removal would be wise. They are also beneficial because they bring up to one-third of the total rainfall in some parts of the world, which are liable to drought, such as India and the south-eastern United States[8][9]. But hurricane modification is a different proposition, and by achieving quite a small (say 5 or 10 per cent) reduction in the maximum windspeed, a corresponding decrease in damage many times larger would be obtained. This prospect, coupled with the rapidly rising curve of damage in recent years in the United States, has led to a programme of hurricane seeding experiments by the US government, known as Project Stormfury.

Project Stormfury is a cooperative venture of the Department of Commerce National Oceanic and Atmospheric Administration (NOAA) and the Department of Defense. The Project was formally organised in 1962 after an attempt at modification of hurricane Esther in 1961 had produced encouraging but not conclusive results[2]. The National Hurricane Research Laboratory at Miami, Florida,is the base for the programme, which up to now has been confined to hurricanes in the adjacent parts of the Atlantic Ocean. In 1963, hurricane Beulah was seeded with similar results to hurricane Esther. In both cases the experiment was done by releasing silver iodide crystals into the eyewall cloud from an aircraft, while other aircraft monitored the hurricane for some time before and after the seeding took place. Both hurricanes were seeded once on each of two consecutive days. After seeding, a drop in windspeed and an expansion of the eye were observed, which accorded with theoretical expectations, but could not be definitely attributed to the seeding, as such changes are known to occur naturally in unseeded storms.

The purpose of the seeding is to raise the temperature of the eyewall clouds. The clouds contain super cooled liquid water droplets which turn to ice, when provided with silver iodide nuclei, and release latent heat. The rise in temperature creates a drop in pressure, reduces the pressure gradient force and displaces the eyewall. Finally, outward displacement of the eyewall leads to a decrease in the maximum windspeed as the vortex expands.

The history of hurricane seeding experiments goes back to 1947 when a hurricane was seeded with dry ice. After seeding the hurricane reversed its course and struck the Georgia coast. Although its turnabout was most unlikely to have been the effect of the seeding, a restriction has been imposed on Project Stormfury experiments, confining them to an area in the Atlantic Ocean from which no hurricane on record has ever struck a highly populated coast within 36 hours. This limitation has greatly reduced the number of hurricanes available for seeding[8]. After hurricane Beulah in 1963, a multiple seeding experiment was planned for the season 1965-66

but no hurricane occurred in a suitable place in that year, or subsequently, until August, 1969, when hurricane Debbie appeared.

Debbie was seeded five times at two hour intervals on 18th and again on 20th August by aircraft flying across the storm at 10,000 metres altitude and dropping lines of silver iodide generators radially outwards from the eyewall. The experiment involved thirteen aircraft and the storm was monitored from six hours before the first seeding to six hours after the last one each day. On both days, windspeeds dropped from shortly after the second seeding until at least 5 or 6 hours after the fifth seeding. The decrease was most marked on 18th August when it reached 31 per cent. The decrease on 20th August was 15 per cent. The probability of such reductions occurring naturally is thought to be low, but still lies within the range of changes observed in unseeded storms and the Director of the Project concludes[10] that 'since the 1969 experiments suggest strongly that modification was accomplished, such experiments must be repeated on one additional storm, or more, as soon as practical to seek confirmation'. Unfortunately, before this can be done, extensive re-equipment with new aircraft and instruments is necessary. Also, recent US budget cuts will affect the NOAA programme so that it will be 1976 at the earliest before Project Stormfury can undertake another hurricane seeding. When this happens, it seems likely that it will be carried out from Guam, or possibly the Philippines, to take advantage of the much higher frequency of tropical cyclones in the Pacific and avoid the area restriction difficulty which applies in the vicinity of the south-east United States.

The Philippines government is believed to be interested in starting to seed hurricanes on its own account, following the very severe destruction caused by cyclones Konsing, Edeng and Gloring in June and July, 1972 [11][12]. Two aircraft are being prepared for this work, which will be enough to enable silver iodide to be dropped but not enough to monitor the results. The wisdom of this is open to question. Even on this scale, it is expensive and its possible merits as a political gesture could very easily backfire if the seeding fails. Stormfury is strictly a research project and has not yet yielded conclusive results of successful modification lasting even a few hours. Furthermore, a degree of caution is advisable in attempting to tamper with any natural phenomenon as powerful and destructive as these storms. In the writer's view, hurricane modification research is very important and has reached a most encouraging stage, but still has a long way to go before it can provide a practical and safe method of control, which can be widely applied. If the United States by herself is unable to finance continuation of the research programme at a fast enough rate, there is a strong case for inter-national assistance or some form of cooperation between hurricane-prone countries. But it is premature for the smaller developing countries, like the Philippines and Fiji to start trying to modify these storms independently.

Recommendation 2: A watch should be maintained on the progress of hurricane modification research elsewhere, but Fiji should not, at this stage, attempt to modify storms herself.

2. Forecasting and Warning Systems

Reliable forecasting of cyclone movements has become much easier since weather satellites came into use in the last decade. Pictures are

received at Nadi Airport every six hours which show clearly the circular storms and enable their movements to be tracked. Even with the aid of satellite pictures, however, forecasting their future movements is not an exact science. Cyclones usually recurve, but the amount of recurvature is difficult to estimate - had Bebe not recurved after passing over Rotuma Island, it would have passed harmlessly out at sea to the west of Viti Levu. They also change speed and move erratically at times, as for example, the hurricane of February 1931. Therefore, it is an advantage to be able to watch them continuously, using ground based radar, when they are in the vicinity of populated areas. In Fiji the only radar installation suitable for weather surveillance is at Nadi and the effectiveness of this is seriously curtailed because its range is restricted by the high hills inland from the airport. It was suggested that a good weather surveillance radar, with a range of about 200 miles might be located either on Mt. Victoria, near Nadarivatu, the highest point on Viti Levu, which has an altitude of approximately 4,300 feet, or on Mt. Evan, 3,921 feet, which is only about nine miles from Nadi, if the shadow effects there are not too bad. The cost of this proposal is not known, but it would be necessary to include the equipment, plus the cost of an access track to get the equipment up the mountain initially and subsequently to maintain it, plus also the cost of a relay system to pass the information collected by the radar to Nadi. The benefits of the proposal are difficult to judge. Tangible benefits would be the loss reduction attributable to improved forecasting and better flood warnings; intangible benefits would accrue from the prevention of casualties and, in the long term, from improved understanding of local cyclone behaviour. However, the forecast and warnings put out for Bebe were said to have been very good, so the writer is doubtful whether the marginal improvement and marginal loss reduction that would be achieved by installing the radar would be sufficient to justify it. Therefore, the proposal is not specifically recommended for further examination at this stage, although it may be borne in mind as a future possibility.

A significant improvement in the quality and coverage of meteorological data available in Fiji can be obtained at relatively small cost by providing additional anenometers for measuring windspeed (there are only two recording instruments situated at Laucala Bay and Nadi at present) and digital or mercurial barometers for measuring pressures. The benefits to be derived from these are intangible, but, in the absence of an adequate network of ground recording stations, analysis of the risk from cyclones is severely hampered. An improved network would also assist agricultural planning and other development activities.

Recommendation 3: The number type and distribution of meteorological recording instruments throughout Fiji should be reviewed and, where necessary, the coverage should be improved to provide adequate records of local cyclones and for general development purposes. The outlying islands should receive particular attention in the review.

The importance of an effective warning system is obvious. In the USA, the graph of deaths due to hurricanes has steadily declined since the beginning of this century as the warning system has become more efficient. Damage figures, in contrast, have risen steadily because the value of property at risk has grown. Nevertheless, hurricane warnings do reduce damage by giving people a chance to fasten many smaller movable objects and secure

their homes. The amount of warning and forecast of the path that hurricane Bebe was expected to take, provided by the Meteorological Service at Nadi, give no grounds for criticism. However, Mr. Anfinson, the Meteorologist-in-Charge pointed out that some confusion in the minds of the general public can result from the terminology at present used in the official warnings. A preliminary hurricane warning is issued to indicate the existence in the area of a cyclonic disturbance with winds of 73 mph or more. A final hurricane warning is issued when the storm is close at hand and the places in its path are known with reasonable certainty. The first is intended to alert people over a wide area and the second is a warning of imminent danger for those directly affected. It is difficult to get people to appreciate the difference between these two types of hurricane warning, particularly when they have to be put out over the radio in three different languages. A series of 'hurricane warnings', which come to nothing because they refer to cyclones which pass out to sea, are likely to be taken as false alarms and could lead to people ignoring future warnings. This difficulty can be overcome by adopting the American system.

Recommendation 4: The hurricane warning system should be altered so that a preliminary hurricane warning is in future called a 'hurricane watch' and a final warning becomes a 'hurricane warning'.

The published document describing the warning system[13] requires minor alteration in another respect. It refers to a 'hurricane season' lasting from November to April inclusive whereas hurricane Bebe occurred in October.

Recommendation 5: The official hurricane season be extended to include the months October to April inclusive.

This change will affect the timing of rehearsals and other preparations made by government departments which need to be completed at the start of each season.

3. Emergency and Relief Planning

Immediately after hurricane Bebe occurred, the Emergency Services Committee (EMSEC) went into action and was in control for about one week before handing over to the Disaster Relief Committee. EMSEC is a civil service committee, under the chairmanship of the Prime Minister, and the police and military play a major part in its activities. It can be activated to deal with all kinds of national emergency, not only natural disasters, but in the event of a hurricane, flood, earthquake or tsunami, it operates according to a 'Natural Disasters Operation Plan' which was prepared in 1970. The Secretary to EMSEC is the Permanent Secretary, Ministry of Home Affairs and he described the Plan as a skeleton which needs further filling in of details by individual departments. It contains a main plan, written on four sides of foolscap, which specifies the headquarters location, chain of command, procedure, communications, transport, etc. The main plan is supplemented by seventeen appendices prepared by Divisional Commissioners and government departments such as the Public Works Department, Marine Department and Police, altogether making up a document about half-an-inch thick. The need now is for a major plan revision to stream-

line procedures, cut out unnecessary repetition and include the valuable lessons to be learnt from the emergency created by Bebe.

Recommendation 6: A new Natural Disasters Plan should be prepared and brought into operation as soon as possible. Parts of the plan should be rehearsed and introduced, as they are finished, during the forthcoming hurricane season and the complete plan should, under no circumstances, be delayed beyond the start of the 1974/75 season.

In order to ensure that this major task is carried through successfully, it is envisaged that the Fiji Government will have to make special arrangements by freeing a person of appropriate seniority and standing from normal duties.

The existing plan is repetitive because similar descriptive details of types of natural disaster and control room organisation are included for each division. Also, the amount of detail on which procedures are laid down is very uneven. The Divisional Commissioner, Western Division, has a plan written on a side-and-a-half of paper which states that 'every disaster produces a different pattern and it is vital ... that the Divisional Commissioner should not be tied down to carrying out a prescribed set of conditions', i.e. in effect a plan for not planning. This contrasts with the plan for the Central Division which is much more detailed, and clearly lays down the functions of different organisations and persons. The importance of information collection and reporting is fully understood in the latter, whereas the former apparently has not appreciated that these functions are quite distinct from the actions to be taken in the light of the information received, which it may not be feasible to prescribe in advance. In spite of these criticisms, the plan as a whole was undoubtedly useful in the Bebe emergency and, furthermore, was much more than a paper plan, because it had been rehearsed in October 1971 and was about to be rehearsed again when Bebe occurred. Such rehearsals are an essential component of successful emergency planning.

These difficulties can be overcome by arranging the new Plan in four sections with supporting appendices. The appendices should enlarge on and provide detailed applications of the Plan to each division and Suva city, section by section, so that the document maintained in each division contains the text of the four sections of the main plan plus a divisional appendix for each section. The practice of having separate departmental instructions in every division, each of which is a numbered appendix in the existing plan, should be discontinued. It encourages a piecemeal approach instead of interdepartmental co-ordination. The Plan should concentrate on defining responsibilities, laying down procedures and systematizing information flows. It should not interfere with the freedom of officials to respond in the way they think best to the exigencies of an emergency, but should aim to assist them by providing reliable information on which they can base their decisions.

Recommendation 7: The Natural Disaster Plan should be arranged in four sections, with supporting appendices to describe its application locally:

A. Basis of the plan,

B. Warning systems,

C. Emergency procedures,

D. Relief and reconstruction.

Appendix 1 contains a draft outline for the Plan, with details of the items which need to be included in each section and the appendices.

The present EMSEC plan is classified as secret and it was only after some delay that the writer managed to obtain a copy to study. EMSEC is concerned with national security and has wider responsibilities than coping with emergencies due to natural disasters. Therefore, there may be good reason for not revealing all its arrangements to the public. However, there seems no valid reason for keeping secret the plans for coping with natural disasters. In fact, the opposite is true, because the organisation to cope with the disasters needs to be created in a dormant form in advance, each member of the organisation must have a clearly defined role, as laid down in the Plan, which he understands and may rehearse, and the members cannot be expected to perform satisfactorily unless they are familiar not only with their roles but also the parts to be played by others with whom they have to work. A widespread understanding of the Plan is essential at all levels and this cannot be obtained by keeping all copies of the Plan locked away in government safes. Furthermore, it is likely that there are other advantages of making the Plan public. In the event of a disaster it may be helpful if the general population is aware of what to do, e.g. moving to the nearest evacuation centre in the event of floods, and there may even be political kudos to be derived by a government which shows such foresight for the wellbeing of the people.

Recommendation 8: The Plan should be declassified and copies should be distributed widely to ensure that all persons concerned are fully aware of its contents.

EMSEC is a central government committee which has responsibility for the whole of Fiji. Its function is to provide and co-ordinate relief measures during the immediate post disaster period, and it is assumed that emergency legal powers could be invoked, if necessary, for this purpose, although they were not needed for Suva city, and although the plan is not clear on this point, it is believed that comparable committees under the chairmanship of the Divisional Commissioner also exist in each division. The national EMSEC can only operate effectively if it is supplied with information from divisions and districts. Divisional EMSECs (and divisional operations rooms) with the job of collecting information from district level, sifting it, directing appropriate action and passing information at regular intervals to the national EMSEC are therefore essential and need to be expressly provided for in the new plan.

Recommendation 9: The Plan should provide for the operation of the National Emergency Services Committee (EMSEC) indicating its function, membership, activation procedure, location and method of working, during the period immediately following a natural disaster. The national EMSEC should be supplemented by divisional EMSECs operated according to local procedures in the appendices to the Plan.

The EMSEC plan refers to ration scales and relief, thus indicating an original intention that this Committee should be responsible for these functions. However, in the event, a new committee was created after hurricane Bebe to handle the longer term problems of relief and rehabilitation. This Hurricane Relief Committee is still active although its task, created by the two hurricanes of the 1972/73 season, is now virtually complete. Up to the time of the writer's visit, it had met thirteen times and was expected to produce a final report at the end of July, including proposals for its possible continuation in the future. The Prime Minister is Chairman and there are sixteen members, altogether, of whom only three are civil servants, the remainder being drawn from different parts of the private sector. The justification put forward for creating this second committee to take over from the first, is that EMSEC is not geared to carry through the task of reconstruction which demands considerable support from private groups and individuals. It also seemed essential that a national committee, not composed only of civil servants, receive on behalf of the nation all offers of aid from overseas and internal sources.

These reasons are weighty and are supported by the argument that although the task of reconstruction needs co-ordination by a top level committee, it is not necessary or desirable for that committee to wield the emergency legal powers with which EMSEC may be equipped. It follows that in the event of another natural disaster of comparable dimensions occurring, it would again be necessary to create a Disaster Relief Committee if the present one is disbanded. Therefore the Committee should continue in a dormant state, but capable of being activated at any time, after the fashion of EMSEC. The new National Disaster Plan should provide for this and, by logical extension, should also include divisional Disaster Relief Committees to which the divisional EMSECs would hand over.

Recommendation 10: A Disaster Relief Committee (DRC) should be created and its functions, membership, activation procedure, location and method of working, after it takes over the task of relief and reconstruction from EMSEC, should be laid down in the National Disaster Plan. The national DRC should be supplemented by divisional committees, whose local procedures are described in the Plan appendices.

The questions that follow from the recommendation concern the transition and smooth handover of responsibility to the Disaster Relief Committee. When is the appropriate time to change over and how best to co-ordinate it so that the momentum of the relief effort is not impaired? The timing seems to be a matter of judgement. It should not be before rescue and evacuation are complete and special military or police operations are no longer necessary; it should not be later than the start of consultations with representatives of foreign powers and international agencies to obtain relief supplies and financial aid. Possibly the latter task should be started by activating the national DRC soon after the disaster and passing to it the necessary information collected by EMSEC. The two committees might run in parallel at this stage, although EMSEC should be in control, transfer of responsibility for relief passing to the DRC at the time that EMSEC is stood down. A problem may also arise at local level where the appropriate transition point might not necessarily correspond with the national handover. The writer does not feel competent to answer these questions, which need to be carefully considered by the Fiji Government, and therefore recommends as follows:

Recommendation 11: The Plan prescribes the arrangements for handing over responsibility for relief operations from EMSEC to the Disaster Relief Committee, both at national and local level, so as to ensure a smooth transition.

Co-ordination of the transition is likely to be most satisfactory if the two committees have overlapping membership. This has happened, in fact, at national level, first (and most important) through the Prime Minister, who is Chairman of both EMSEC and the Hurricane Relief Committee, and second because two senior civil servants serve on both committees. The transfer might be eased further if the overlap was increased and not only the Chairman, who may not always be able to attend, but also the Deputy Chairman was the same person on both committees. It also seems essential for the Controller of Government Supplies to sit on both.

Recommendation 12: The membership of EMSEC should be revised at the same time as the composition of the DRC is determined. An adequate overlap to ensure smooth transition should be provided.

An important part of the DRC's task should be to handle offers of aid. There have been conspicuous failures to organise this properly in other countries where serious natural disasters have occurred, with the result that unwanted and useless supplies have arrived, and other items, although useful, have failed to come at the time they were needed. Fiji avoided such chaos by waiting until a reasonable assessment of damage and list of requirements had been compiled - this took two weeks - and then arranging meetings with the representatives of overseas governments and international agencies who were anxious to help. The success of this depends on obtaining a rapid flow of reliable information from the districts to the centre. It ought to be possible to reduce the time lag between the disaster and the compilation of the list of requirements if the procedures for collection and passing information are set out clearly and carried out automatically under the provisions of the Disaster Plan. What takes time, and should be avoided, is the need for EMSEC or the DRC to send out requests for routine information instead of it flowing in as a matter of course.

Recommendation 13: In drawing up the Plan, special attention should be given to systematizing the flow of information and report procedures from the districts to the centre, to avoid unnecessary delay. A feature of the system should be the nomination of individuals responsible for the provision of situation reports in each area, the method of transmission to be used and a standard form of report.

One result of the recent hurricane has been the erection of three Disaster Centres containing emergency stocks of food, building materials, etc. and also a number of items of equipment, such as outboard motors and power saws, plus a fleet of twentytwo heavy duty vehicles of military pattern. These Centres are located at Suva, Lantoka (Nadi) and Labasa. Before Bebe occurred, the Controller of Government Supplies held food sufficient to feed about 10,000 people for one month. From now on it is intended to hold ten times this amount and similar increases

in the stocks of timber and other building materials have been built up. The wisdom of creating permanent Disaster Centres at strategic points is beyond doubt, but there are also some dangers which should be guarded against. Food is liable to deteriorate unless excessively expensive storage facilities are provided. Therefore the Controller of Government Stores has a scheme for 'turning over' the stock by selling it off to local traders and replacing from abroad. He could carry the process one stage further by varying the stock levels with the time of year, running them down in the months when cyclone risk is low and building them up in the hurricane season. Similarly with other materials, the stock should fluctuate, thereby reducing the costs of maintaining the Disaster Centres. Generally the point is to avoid excessive stock-holding, and therefore excessive precautionary expenditure, in relation to the risk of a disaster. Second, it is essential to ensure that the equipment and vehicles at the Centres are properly maintained and responsibility for this needs to be firmly pinned down in the Disaster Plan. Overall responsibility for the Centres and the determination of appropriate stock levels and equipment should be undertaken by the DRC.

Recommendation 14: Disaster Centres, located at strategic places, should be maintained on a permanent basis. The Plan should specify the officials who are responsible for running them under the general control of the DRC, and the stock levels, items of equipment etc. to be maintained at each Centre. It should also make clear the procedure to be followed for making use of the Centres' resources in the event of an emergency.

Adequate training and rehearsal of the role allocated to each person in the Plan is essential if the Plan's aims are to be achieved. EMSEC has already instituted rehearsals at the start of each hurricane season and these should be continued and extended to all levels. The same principle should be adopted as far as it is possible to do so with the DRC. For example, those responsible for food distribution and repairs should know from where they are to receive instructions and supplies and how to store and dispose of the supplies locally.

Recommendation 15: The Plan should provide for instruction where necessary and an annual rehearsal in the first week of the hurricane season so that all persons understand their respective roles and know what is expected of them. Subsequently, random spot checks should be made to maintain efficiency.

Revision and improvement of the Plan is essential to keep pace with changes in communications and new technology as Fiji develops and the movements of population. In addition to these gradual changes, a major review should be undertaken after every disaster to benefit from the lessons of experience.

Recommendation 16: Minor amendments to the Plan should be issued from time to time as they become necessary. A major review and Plan revision should be undertaken after every disaster. The responsibility for amendment and revision should rest with the DRC after consultation with EMSEC.

4. Sectoral Precautions

Emergency and relief planning improvements are short term measures which apply to earthquakes and tsunami as well as tropical cyclones and the floods associated with them. However, the latter appear to be the most important hazards in Fiji and the development of a loss minimization strategy over a longer time period needs to concentrate particularly on them. Two aspects need to be considered: first, the possibility of mitigating the effect of hurricanes on various sectors or types of economic activity, which is discussed below, and second the effects they may have on national development as a whole which is dealt with in the final section of this report.

Hurricane Bebe caused significant damage to schools, but practically no damage to government buildings or others built to conform with the legal standards laid down in the various building regulations and by-laws. These standards are intended to provide effective protection against earthquakes but also serve against hurricanes. Unfortunately, the serious shortage of competent building inspectors in Fiji means that many buildings put up by private persons or firms do not comply with the regulations. The extreme case of substandard building occurs in schools, which suffered most severely because their governing bodies are in the habit of stretching the government grants they receive by putting up more classrooms than the grants are intended to cover. This needs to be remedied.

Recommendation 17: Steps should be taken to enforce the existing building regulations and to prevent the erection of substandard buildings wherever possible by training and recruiting more building inspectors. All government building subsidies should in future be made conditional on inspection to ensure that they comply with the laid down standards.

The possibility of making it compulsory to insure against hurricanes all permanent buildings, at least in towns, was considered and rejected as too sweeping. Unlike third party vehicle insurance, the possibility of claims against the owner is highly improbable and on moral grounds it may be argued that to force the owner of a building to pay to protect his own property is an infringement of his liberty. However, there is much to be said for initiating discussions with insurance companies on tariff structures with the aim of discriminating against buildings, which are not up to standard, by charging higher premiums.

Specific recommendations are not easy to make for other sections of the economy without a much closer and lengthier examination than the writer had time for. If it can be shown clearly, by further analysis of the cyclone tracks with the aid of the computer model, that the risk from hurricane force winds varies from one part of Fiji to another, this could have important consequences for the location of new sectoral developments. However, it would be premature to draw conclusions about this now. The only firm general recommendation that is called for is that all major new development projects should be examined and, if need be, modified to allow for hurricanes and floods. Two important irrigation schemes - the Rewa (15) and Navua (16) projects - were checked from this point of view and the former provides a useful example of what is needed. The Rewa report considers the possibility of erecting a flood embankment on the left bank of the river and rejects it. It was estimated that the embankment would cost $356,000 to cope with a flood of the magnitude of 1965. This cost compared very unfavourably with the anti-

cipated benefits of the embankment, the benefit/cost ratio being put at 0.53.

Recommendation 18: The consequences of hurricanes and floods on all major development projects in Fiji in future should be examined and, where appropriate, they should be modified accordingly. This requirement should be included in the terms of reference given to consultants preparing project reports.

5. Long Term and National Planning

Reliable statistical knowledge of the effects of tropical cyclones is an essential preliminary to effective long range planning and the full development of a damage minimization strategy. The difficulties of arriving at an estimate of the total economic loss attributable to hurricane Bebe have ready been explored. Some of the gaps may be filled, for example the value of insurance claims in the private sector and the losses of some exports, but others, which relate to domestic production and consumption, are more intractible. A deliberate effort to rectify these shortcomings is called for the future, involving the co-operation of a number of government departments and in some cases, special sample surveys of damage.

Recommendation 19: Reports describing the effects of hurricanes and floods on the national economy should be produced as necessary in future years. Data for the reports should be provided by government departments or specially collected through the DRC. The reports should be compiled by the Bureau of Statistics.

Whatever the quality of the statistics, the losses from a hurricane such as Bebe and the risk that such losses will be repeated at more or less frequent intervals, make it essential to take account of the hurricane factor in national development plans. In Fiji, as in many other countries, natural disasters form part of the development scene, adding an important uncertainty factor with which the planner should attempt to grapple. Unfortunately the techniques of national planning are not yet adequate for this task and, up to now, natural disasters have been largely ignored by the planners, although this does not cause the difficulties to disappear. What should be included? First, it is useful simply to draw attention to the existence of the hurricane factor and indicate the possibility of one or more occurring during the period of the plan. Second, the plan should outline the loss minimization strategy to be adopted, pointing out the sectors and areas of greatest risk and any special measures to reduce damage and casualties in them. Third, and most difficult, the plan can attempt to project the growth of GNP with and without hurricanes and prescribe, on a contingency basis, what should be done to ameliorate the adverse financial and balance of payments effects.

Recommendation 20: The next Fiji Development Plan should contain a section on hurricanes and floods, dealing with their probability, economic significance, and loss minimization strategy to be adopted and special measures to reduce damage and casualties. If possible, the section should go on to forecast the likely effects of a disaster occurring within the plan period with contingency provisions to ease the strain on the domestic budget and foreign currency resources.

APPENDIX 1

OUTLINE FOR THE NATURAL DISASTER PLAN

A. Basis of the Plan

Plan objectives.

Types of natural disasters affecting Fiji.

Risk of different types of disaster.

Likely effects and danger points.

Strategy on which plan is based.

Plan amendment and revision.

B. Warning Systems

Types of disasters for which warnings are possible.

Description of warning system.

Responsibility for issuing and receiving warnings.

Seasons, danger periods and states of preparedness.

C. Emergency Procedures

Function of national and divisional EMSECs.

Composition of national and divisional EMSECs.

EMSEC activation procedures.

Chain of command and departmental responsibilities when EMSEC is active.

Operations rooms: location, equipment, staffing, log maintenance, etc.

Information collection and transmission procedures.

Responsibility for and frequency of situation reports.

Form and content of situation reports.

Departmental tasks and priorities at national and local level.

Restoration of communications and water supplies.

Evacuation centres and the provision of shelter.

Medical and public health arrangements.

Disaster Centres: location, staffing, stocks and equipment to be held, responsibility for supervision, etc.

Procedure for drawing on Disaster Centres in an emergency.

Rehearsal and training.

D. Relief and Reconstruction

National and local Disaster Relief Committees: function, composition and responsibilities.

Transitional arrangements from EMSEC to DRC.

Operating procedures of national and local DRCs.

Departmental responsibilities and co-ordination through DRCs.

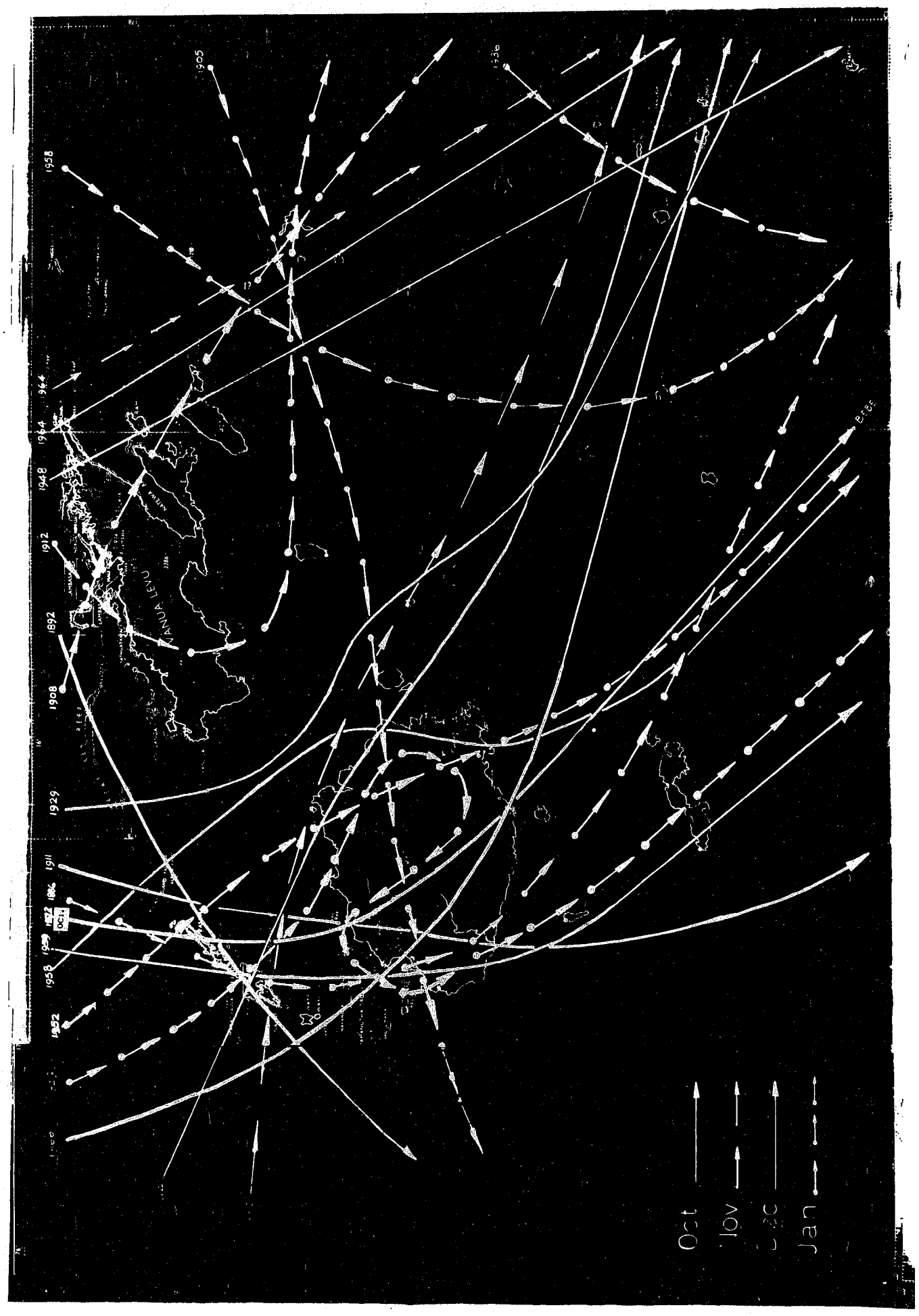
Persons responsible for relief distribution.

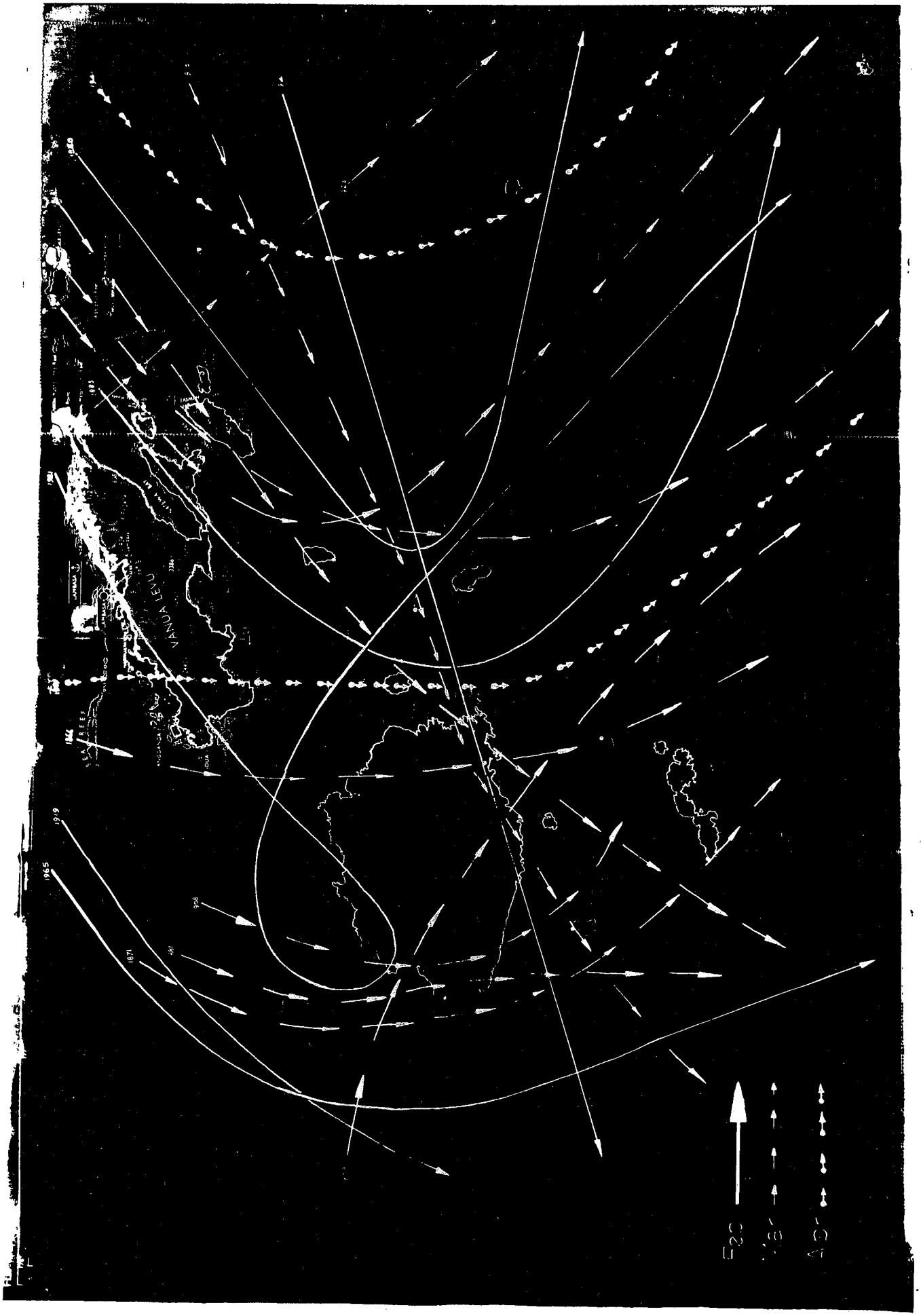
Information collection and transmission procedures.

Financial control.

Appendices

To be arranged by sections in respect of Suva City and each administrative division.


1905
1936
1958
1964
1944
1948
1912
1892
1908
1929
1911
1886
1958
1952
ARIZONA
CALIFORNIA
MEXICO
Oct
Nov
Dec
Jan


1919
1965
1871
908
1893
1883
1880
1881
1891
1882
1884
1885
1886
1887
1888
1889
1890
1892
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934

REFERENCES

1. ECAFE Secretariat. 'Damage caused by typhoons, cyclones and accompanying storm surges'. Report to UCAFE and WMO Typhoon Committee Fifth Session, 15-21 November, 1972, Bangkok.

2. R.C. Gentry. 'Project Stormfury'. Bulletin of the American Meteorological Society, 50, 6, (June 1969), pp. 404-409.

3. New Zealand Meteorological Services. 'Tropical Storms in Fiji and the Southwest Pacific, 1840 to date'. Meteorological Office, Laucala Bay, Suva, mimeo.

4. M. Gane. 'Hurricane risk assessment in Fiji'. Commonwealth Forestry Review 49, (3), No. 141, September 1970, pp. 253-257.

5. New Zealand Meteorological Services. Report on 'Hurricane Bebe, from 21st to 25th October, 1972'. Mimeo.

6. Fiji Public Works Department Hydrology Section 'Report on the hurricane and floods - October 23rd to 25th, 1972'. November 1972, mimeo.

7. C.E. Palmer, C.W. Wise, J.L. Stempson and G.H. Duncan. 'The Practical Aspect of Tropical Meteorology'. Air Force Surveys in Geophysics No. 76, Atmospheric Analysis Laboratory, Geophysics Research Directorate, Air Force Cambridge Research Center, Bedford, Massachusetts, September, 1955.

8. Joanne Simpson. 'Hurricane Modification Experiments'. Proceedings of Hurricane Symposium, October 10-11th, 1966, Houston, Texas. American Society for Oceanography, Publication No. 1, pp. 255-291.

9. Arnold L. Sugg. 'Beneficial Aspects of the Tropical Cyclone'. Journal of Applied Meteorology, February 1968, pp. 39-45.

10. R.C. Gentry. 'Hurricane Debbie Modification Experiments, August 1969'. Science 168, 24th April, 1970, pp. 473-475.

11. Presidential Task Force on Rehabilitation. 'Reconstruction and Development', Republic of the Philippines, 1972.

12. Philippines Weather Bureau. 'Tropical Cyclones of 1972'. Report No. 25 Climatological Division, Weather Bureau, Quezon City, Philippines, 1973.

13. New Zealand Meteorological Service. Weather Information and Warning Services 1972-73, Fiji, Tonga and the Gilbert and Ellice Islands, Govt. Press, Suva.

14. National Oceanic and Atmospheric Administration. 'Project Stormfury, 1971'. US Department of Commerce, NOAA.

15. UNDP/FAO. 'The Development of Rice Growing in the Rewa River Basin'. Report No. 422, FIJ UK 55, 3 vols.

16. Hunting Technical Services and Sir M. MacDonald & Partners. 'Navua Pre-investment Study', undertaken for the Govt. of Fiji and the Ministry of Overseas Development, London Vol. 1, December 1969.