CHAPTER 11

A TROPICAL CYCLONE WARNING SYSTEM

Chapter 2 contains an account of tropical cyclones and their main features, which include very strong winds and heavy and prolonged rainfall. The associated effects of tropical cyclones, in particular floods and storm surges, are also described. In addition, Chapter 2 includes brief notes on the observational techniques used in monitoring the existence and development of tropical cyclones, on the telecommunication facilities a Meteorological Service requires and on methods used for the preparation of forecasts and warnings concerning the movement of a tropical cyclone and the possible incidence of strong winds, floods and storm surges. For technical and general background information on all these matters it is suggested that reference should be made to Chapter 2 so that unnecessary repetition in the present chapter may be avoided.

The organization for disaster preparedness is in large measure an operational system which springs from a state of readiness into one of high alert when the national Meteorological Service issues a message giving information on the position of a tropical cyclone and on the possibility that the country might be affected. This first message gives a certain amount of time, not always adequate, for completing those preparations for an emergency which are not carried out until such a message is issued.

It is of paramount importance that the forecast and warning service should function at a high level of technical efficiency. If this service is ineffective – for example, if it lacks the basic facilities without which efficiency would not be attainable – the rest of the organization for disaster preparedness, however well it is structured and trained for emergency, would be very severely handicapped. In other words, a good forecast and warning service combined with, and indeed forming part of, a highly effective disaster-preparedness organization can often bring the loss of life caused by a tropical cyclone to near zero. The essential ingredients are that the warnings be accurate and motivate responsible authorities and the general public to respond promptly, that the distribution system be effective in passing warnings quickly to all concerned, officials and the public, and that the public be sufficiently well informed as to know what to do on receipt of instructions or, if necessary, on its own initiative.

It should be emphasized here that the issue by the national Meteorological Service of a warning on tropical cyclones or by the national Hydrological Service on the possibility of flooding would not of itself constitute an order to the preparedness organization. Officials in the preparedness organization have the responsibility to issue whatever orders or instructions are required and in this task they are helped by forecasts and warnings together with supplementary advice provided by the Services responsible for meteorology and hydrology. Because of these considerations, there should always be close contacts between the forecasting Services and the officials with the executive responsibility for action in emergency.

The objectives of the warning system may therefore be summarized as the provision of timely and accurate warning of tropical cyclones in order to contribute to the protection of lives and property, to the mitigation of human suffering and economic losses and to the maintenance of the normal life of the affected community to the maximum feasible extent.

A warning system for tropical cyclones operates under three functional headings: environmental monitoring, the preparation of forecasts and warnings and finally the dissemination of forecasts and warnings. These three functional areas are highly interdependent and must be fully co-ordinated. For example, the monitoring function must be based on the known requirements for forecasts and warnings to be used as a basis for making decisions in emergency and giving instructions to the public. Furthermore, accurate forecasts and warnings would be useless if dissemination

could not be assured to those who require them. In this connexion operational communication facilities are of vital importance.

Environmental monitoring

The science of weather forecasting is dependent upon the availability of basic data from observations made frequently at the surface and in the upper air over a large area. The collection of basic data for the assessment of environmental conditions and for the preparation of forecasts and warnings requires an elaborate system of telecommunications. The purpose of monitoring is to provide a continuous or near-continuous picture of the state of the atmosphere so that, in critical conditions such as the approach of a tropical cyclone, up-to-date information and advice in the form of forecasts and warnings may be issued.

Environmental observing networks, composing a variety of facilities which are mentioned briefly in Chapter 2, are required on a scale set forth in the WMO World Weather Watch programme and, for hydrology, in the WMO Operational Hydrology Programme. However, for the most complete and accurate warning services, supplementary networks consisting mainly of weather radars and auxiliary reporting stations are also required Figure 10, taken from a publication of the Australian Bureau of Meteorology, illustrates how tropical cyclone ADA (January 1970), was first detected and followed by means of satellite pictures. Gale warnings were issued to shipping. Later, an automatic weather station on a reef hundreds of miles from the Australian mainland gave information on the intensity of the cyclone and the first of a series of warnings to the public was issued, some 30 to 36 hours ahead of landfall. Tropical cyclone ADA caused 13 deaths and damage to property which was valued at millions of dollars.

In the review that follows each tropical cyclone occurrence, the Meteorological and Hydrological Services should be called upon to report the adequacy of their monitoring facilities for providing forecasting and warning services of the required standard.

Preparation of forecasts and warnings

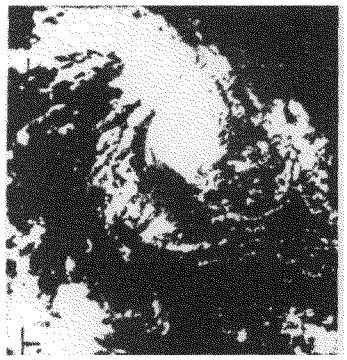
Forecasting techniques are referred to in Chapter 2 and here it may be sufficient to mention that WMO's programme of World Weather Watch has integrated national forecasting services into a world-wide organization, World Meteorological Centres and Regional Meteorological Centres providing national centres with a regular supply of weather charts, broadcast by facsimile, giving actual and forecast conditions at the surface and in the upper air. This information is made possible by the three main components of World Weather Watch – the Global Observing System, the Global Data-processing System and the Global Telecommunication System. National Meteorological Services are thus able to function within the widest possible framework, giving detailed attention to national responsibilities for the provision of forecast and warning services. Generally a national Meteorological Service would receive its first intimation of the existence of a tropical cyclone from the appropriate Regional or World Meteorological Centre.

When the possibility of a tropical cyclone threatening the country is recognized, the Meteorological Service would carry out the following procedures:

(*a*) Preparation of routine forecasts and other advisory messages in order to keep the responsible authorities informed about the tropical cyclone's intensity, its location and anticipated movement;

(*b*) The issue as appropriate of warnings of dangerous winds, high storm surges, torrential rains and river flooding.

Forecasts, as distinct from warnings, would normally be issued at fixed times, at intervals of 6 or 12 hours or, of course, more or less frequently according to individual requirements. Warnings are issued when the tropical cyclone poses a threat to lives and property. As the tropical cyclone continues to approach, warnings would be updated, normally becoming more specific in such matters as time and place of landfall, maximum wind strength to be expected, time of onset of rain and the expected intensity, and the coastal areas most liable to storm surge. By arrangement



FOLLOW THAT LADY

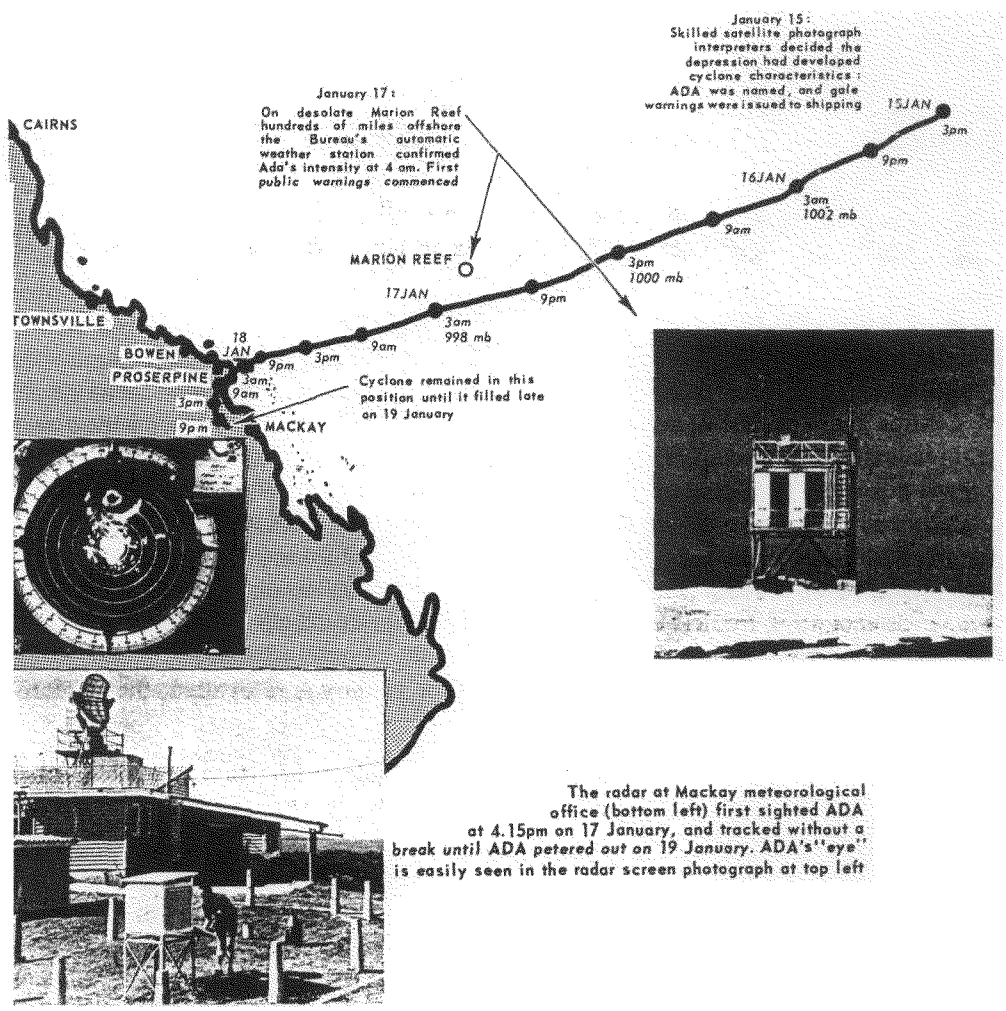
HOW CYCLONE ADA WAS TRACKED

SPIED ON BY SATELLITES (TOP RIGHT), NOTED BY AN OFFSHORE ROBOT WEATHER STATION, TRACKED BY RADAR FROM HER LANDWARD STRIKE TO HER DEATH INLAND, AND FOLLOWED BY THE MAINLAND OBSERVING NETWORK, CYCLONE ADA HAD NO PRIVACY . . . .

January 5:
The tropical depression that was to become ADA was detected by weather satellite and mentioned in notes on the weather chart

January 15:
Skilled satellite photograph interpreters decided the depression had developed cyclone characteristics: ADA was named, and gale warnings were issued to shipping

January 17:
On desolate Marion Reef hundreds of miles offshore the Bureau's automatic weather station confirmed Ada's intensity at 4 am. First public warnings commenced



The radar at Mackay meteorological office (bottom left) first sighted ADA at 4.15pm on 17 January, and tracked without a break until ADA petered out on 19 January. ADA's "eye" is easily seen in the radar screen photograph at top left

Figure 10 – Monitoring the progress of a tropical cyclone *(From CYCLONE!, Bureau of Meteorology, Australia)*

with the authorities, warnings should be so worded or labelled as to indicate clearly the nature of the action that should be considered by those to whom the warning is issued.

The warning service should study the needs of its customers, preferably by direct consultation. First, there are the authorities responsible for implementing the disaster-preparedness measures and the general public but there are, in addition, many special interests. The warnings may need to be expressed differently and be for different time periods according to various customers' requirements. The fishing fleet, for example, may be more than a day's sailing from safe harbour and would clearly need much earlier warning than the home owner, who might be concerned only to place shutters over his windows. The manager of a chemical plant may require up to three days' warning in order to arrange a safe and smooth close-down whereas the owner of a shop may be able to secure his premises in a matter of two or three hours. The operators of off-shore oil rigs have numerous problems in preparing for a tropical cyclone and a comprehensive service covering wind speed and direction, state of sea, swell and other parameters is required.

In order to assist the efficient preparation of forecasts and warnings, the requirements of all potential users should be analysed and plans for distributing the messages should be made long before an emergency arises. Determining how long in advance a particular user needs to receive a warning is an important question but those who require early warning, perhaps two to three days before the tropical cyclone makes its landfall, should understand that the accuracy of a warning decreases with the length of the warning period. The forecaster will try to ensure that warnings are issued in good time but the further ahead the warning, the greater the chance that it may prove to have been unnecessary and therefore that it would eventually be cancelled. This means that customers who require warnings more than about 18 to 24 hours in advance may occasionally find that they take precautionary measures which will not be needed. This is an aspect that the customer should take into account when placing his requirements with the warning system.

A problem which should be given special study is that of a low-lying populated area where the emergency measures include the evacuation of the population. The possibility should be kept in mind that the escape routes may be closed by rising water before the dangerous winds arrive. This is an example of emergency action which depends on several factors and care must be exercised to ensure that all are considered.

Dissemination of forecasts and warnings

Effective dissemination is a vital part of the warning system. If the organization for disaster preparedness is to function rapidly and efficiently in emergency, forecasts and warnings must reach all responsible officials and the general public with the least possible delay. Unless this objective is reached, there may not be sufficient time for making decisions and carrying out protective measures to mitigate the effects of the approaching tropical cyclone.

Dissemination to responsible officials and agencies

For the dissemination of forecasts and warnings to officials and agencies which have decisions to make and tasks to perform in the approaching or actual emergency, the main requirement is an adequate network of operational communication facilities connecting the warning service to all who must receive warnings and to one another for consultation and co-ordination of effort. Figure 11 is taken from a report on disaster preparedness addressed to the United States' Congress. The figure shows in schematic form how the hydrological forecast system receives basic data from a variety of sources and how the resulting forecasts and warnings are prepared for a whole range of interests.

An efficient system of communication facilities is of vital importance for exchange of information between agencies concerned with disaster-preparedness activities and for rapid conveyance of information on the development of the disaster situation to the general public. Establishment and proper maintenance of such a communication system therefore constitutes an essential component of the national plans for disaster preparedness. Each agency must

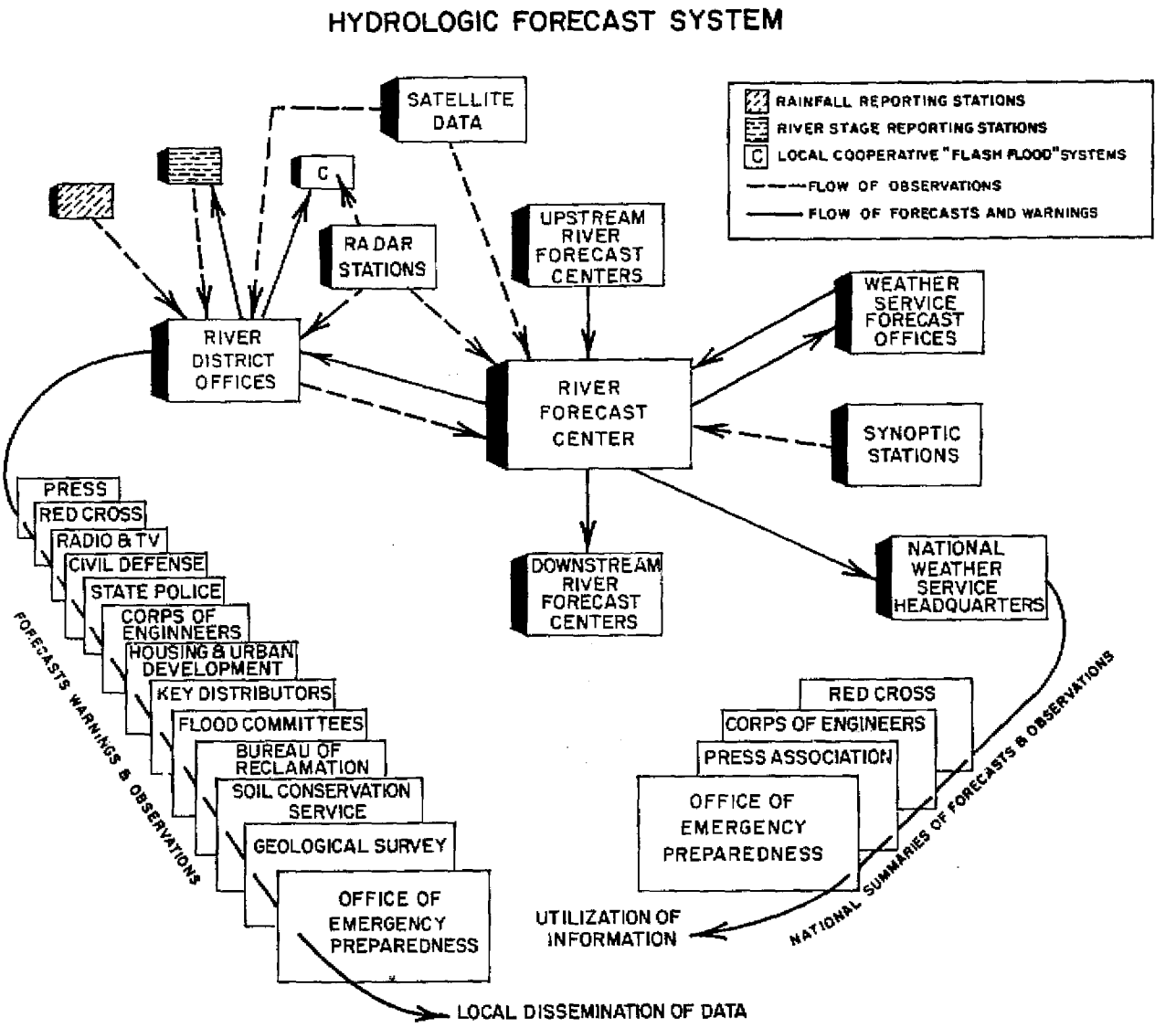


Figure 11 – River and flood forecast and warning service information flow *(National Weather Service, U.S.A.)*

be promptly provided with up-to-date forecasts and warnings, the latest information on the disaster, the damage already inflicted or anticipated and on the co-ordination of the relief action needed to meet the emergency. The telecommunication facilities used for this purpose should be capable of withstanding high wind, heavy rains or floods associated with tropical cyclones, as failure of the communications at critical times can cause serious confusion and may lead to losses of life and damage that might otherwise have been avoided.

The national laws for disaster countermeasures should include provision for full utilization of the existing communication facilities at the time of natural disasters. Such provisions already exist in the basic law for disaster preparedness in several countries. Special arrangements are made to maintain the public communication facilities at the time of disaster and to utilize communication facilities owned by disaster-preparedness organs or local public bodies, such as the meteorological, flood-control, fire-fighting and police or traffic agencies or electricity enterprises. When public communications or exclusive communications for the disaster-preparedness organization are interrupted during disaster, communications for the safety of life and relief are secured by the integrated operation of all usable communication facilities.

In considering the mode of communication for disaster preparedness activities, landline circuits are the most commonly used. It is obviously more economical to use existing landline circuits, provided they are well maintained so as to be reliable during the rainy season. However, experience shows that landline circuits are not always sufficiently reliable and proper maintenance involves practical difficulties. In Japan, special precautions are taken to ensure continuity of telephone service to important subscribers such as the forecast and warning service and those government and public agencies responsible for disaster-preparedness activities. For this purpose, the cables to important subscribers are buried underground. If there is heavy traffic, telephone calls from important subscribers are given special priority. In some countries, some of the disaster-preparedness agencies including the warning service are linked by direct telephone lines which are more reliable and have proved to be very useful in time of emergency.

Today, radio communication systems (HF, VHF, UHF) are being widely adopted for reliable communications and give fewer difficulties in maintenance. Japan, for example, has already established an exclusive UHF communication system in the Ministry of Construction at Tokyo linking all provincial offices responsible for disaster-prevention activities. This UHF system is supplemented by hundreds of mobile and portable VHF communication sets, thereby providing a dense country-wide network. The system is used for the exchange of disaster information in parallel with other existing communication circuits owned by public agencies, television and radio stations, etc. This integrated communication system has already demonstrated its usefulness during natural disasters. Although the UHF communication circuits were established exclusively for the dissemination of forecasts and warnings and for the exchange of disaster information, the system is also used during non-disaster times for administrative services and is thereby permanently maintained as a standby for emergencies.

The provision of suitable communication facilities for the exchange of information between agencies responsible for disaster-preparedness activities must be well planned, consistent with the disaster risks involved and the resources available to the country. The following steps are proposed for this purpose:

(*a*) Survey the existing communication facilities and consider to what extent these facilities could be used for disaster-preparedness purposes;

(*b*) Provide additional facilities, such as direct telephone lines or radio circuits linking the agencies most vitally concerned in disaster preparedness;

(*c*) Assign responsibility for proper maintenance of these important communication systems and provide for adequate technical staff and spare parts for this purpose.

A schematic diagram showing communication links between the National Disaster Control Centre, other concerned agencies and the provincial centres is shown in Figure 12. Cost estimates for the establishment of exclusive radio communication circuits are given in Table III.

TABLE III

Cost estimates for the establishment of exclusive radio communication circuits for disaster-preparedness activities

Type of equipment	*Number of channels*	*Distance applicable*	*Estimated cost of equipment per circuit (two sets)*	*Remarks*
VHF or UHF radiophone for mobile or portable station	Single	50 km	US $1000-2000	
VHF or UHF radiophone for fixed station	Multiple (5 channels)	50 km	US $15000-20000	(1) For longer distances than 50 km, additional cost US $15000-20000 will be needed for setting up relay station for each 50 km. (2) The estimate includes cost of antenna, but does not include cost of building construction.
HF SSB radiophone for fixed station	Single channel with 4 selectable frequencies	2000 km	US $10000-20000	Reliability is not as high as for VHF or UHF circuit, but involves less expenditure for long-distance circuits.

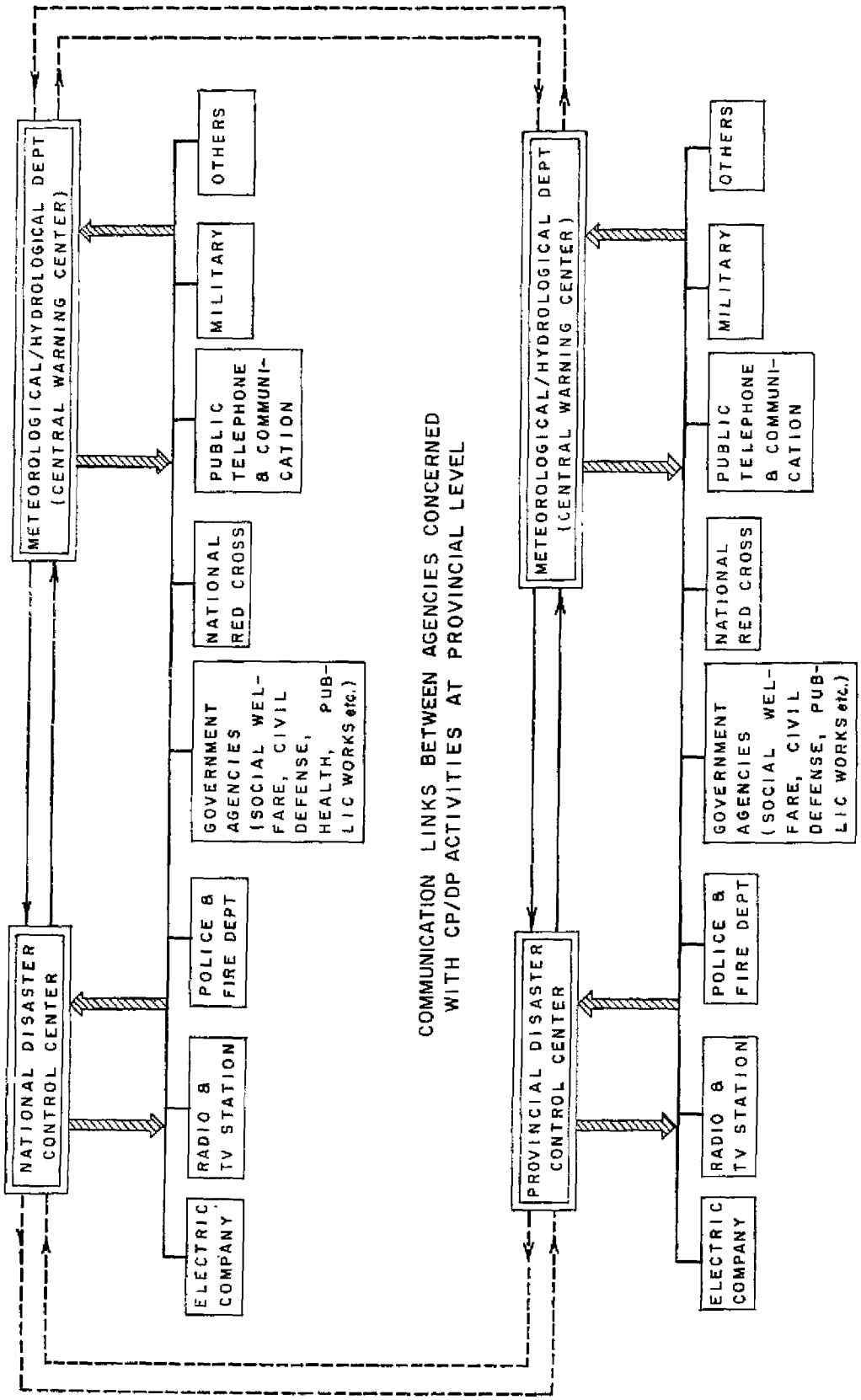


Figure 12 – Communication links between agencies concerned with disaster-preparedness activities at national headquarters

Dissemination to the general public

The co-operation of the public during the approach and actual state of an emergency is best guaranteed by ensuring that full information and advice about the dangers threatening are readily available to all. For this purpose the mass media – radio, television and the press – are extremely important. Experience shows that the media invariably co-operate in the broadcasting and publication of all warnings prepared and issued by the national Meteorological Service and, in addition, of all advice and instructions promulgated by responsible officials of the organization for disaster preparedness. For all these messages radio is probably the surest means of reaching everyone or nearly everyone. It is suggested therefore that when the Meteorological Service first issues a tropical cyclone warning, the public should be advised to keep their receiver permanently switched on and tuned to a specific frequency so that all relevant forecasts, warnings and other instructions will be received.

If the Meteorological Service has its own means of direct access to the public, for example, by means of a "dial the weather" telephone facility or by a radio station used exclusively for weather information, full use should be made of such facilities in making available to the public the latest information about the tropical cyclone, its progress, the associated winds, rainfall and so on.

The operational centres of the disaster-preparedness organization would also have means for alerting the public when necessary. Sirens, radio and television announcements are some examples of systems that may be used to gain the attention of the public.