東南アジア諸国における
洪水防禦パイロットスタディー

―1981年度洪水防禦コース報告書―

1982年2月

建設省河川局・土木研究所
国　際　協　力　事　業　団
筑波インターナショナルセンター

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目　　　　次

ま　え　が　き

国連台風委員会の長期計画に基づく総合的な水害防禦技術（構造物のみでなく非構造物対応を含めたもの）に関する国際的な研修コースが設立されて1979年10月にその第１回研修が開かれたが，今回の第３回研修1981年８月から９月にかけて行われた。本レポートは第３回研修の報告である。

この第１回から第２回の間の1980年１月から２月にかけて，台風委員会より総合的な水害防禦対策，特に非構造物対策の具体的説明とパイロット・スタディー河川の選定協力のために，アドバイザリー・チームがタイ，マレーシア，フィリピン，中国，韓国に派遣された。各国のパイロット・スタディー河川の特徴，研究テーマ等についてのアドバイザリー・チームの報告は，第２回研修報告書に全文収録された。

第３回研修では９ケ国，９人が参加し，一般的な講義，現場見学とともに各国の河川のパイロット・スタディーを行った。研修員の国々は，西はパキスタンから東は韓国まで含まれていて，各国河川の置かれている状況は自然的にも社会的にも大きく異なっている。この状況のため，各国共通の対策は少なく，各国特有に対処されねばならない課題がほとんどである。共通としてあるのは治水対策を提防・ダム等の構造物のみに絞るのではなく，土地利用，洪水予報等流域を含めて検討しようということである。研修の成果である研修員の報告も本レポートに含まれているが，研修員が所持してきた資料の状況により，その内容に大きな差があるのは仕方のないことであろう。しかし，若干でも各国の新らしい情報が含まれ，今後の各国の河川の認識について寄与するところがあると考えるので，ここにその報告を公表する次第である。

1　研修コース設立の背景

東南アジア各国において，総合的な水害防禦に関する技術開発の問題に関心が高くなったことについては，台風委員会の活動について述べることが分り易いと思われる。

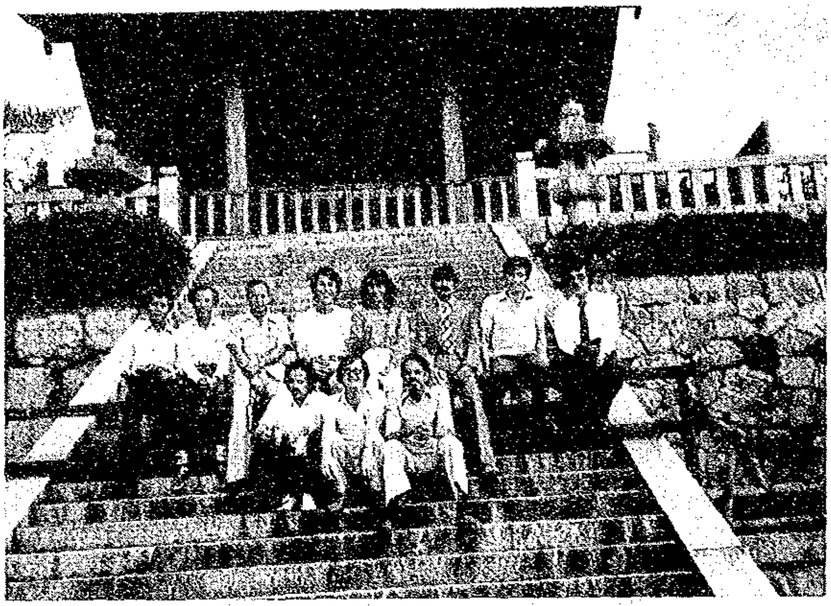
台風委員会は，今から約10年程前1968年に東南アジアの台風常襲地帯に位置する７ケ国が集まって，台風の発生，進路の予測や，台風によってもたらされる被害の軽減を図るための研究や調査など情報交換を主体とする国際機構をつくり上げたことに端を発している。活動は年１回の委員会において，その年の各国の台風に関する諸活動を報告しあい，討議を通じ啓発するとともに地域的なセミナーなどの開催により国際的な活動を展開してきた。台風委員会への加盟国は1981年現在10ケ国で次のような国で構成されている。香港，韓国，マレーシア，フィリピン，タイ，ラオス，ベトナム，クメール，中国，日本。

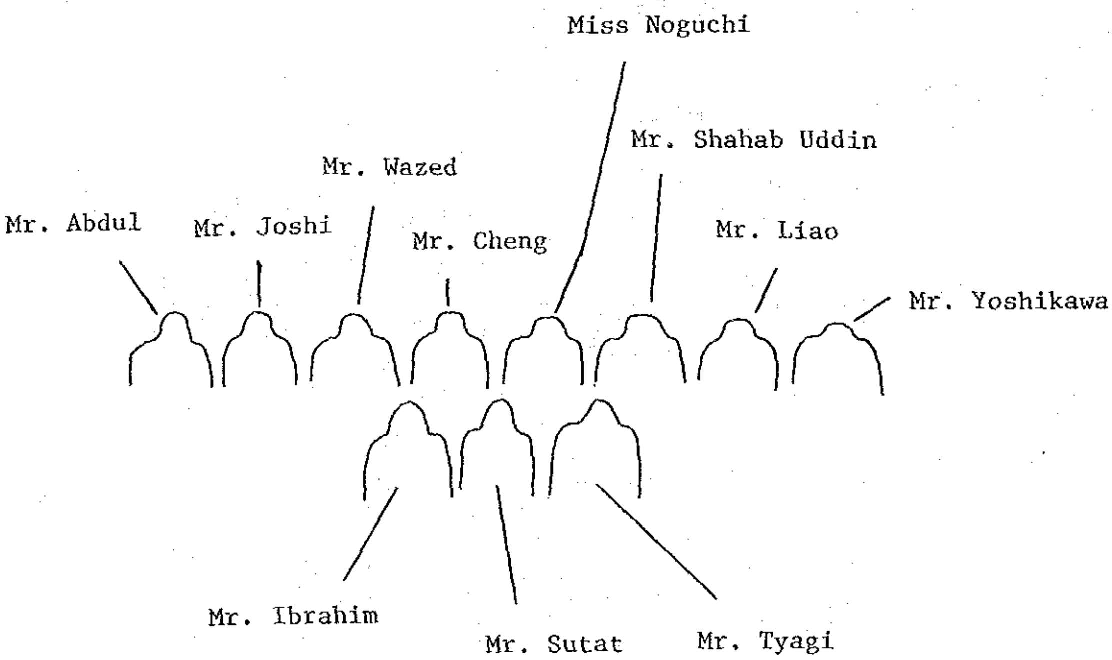
1978年に委員会発足10年を迎え，これまでの委員会活動の成果を明らかにし，さらに台風に関する加盟国の抱えている問題点を把握し，今後の活動方針を探る意味で7ケ国を訪問し問題点を討議するレビューミッションが企画され，実行された。

レビューミッションの報告書は，1978年10月の台風委員会に提出され了承されたが，この報告書では今後の台風委員会の活動テーマとして，特に水文部門の活動として，これまで10年間の洪水予備警報システムに関するめざましい発展をふまえ，構造物対応のみではない非構造物対応を加えた総合的な水害防禦対策を実施することの必要性が強調されている。

台風委員会は，この問題の重要性を認め，水文部門における今後の活動の重要な柱とすることとしたが，まず手はじめに各国それぞれ試験流域を設定し総合的な水害防禦の技術的な検討を始めることとした。河川改修や治水ダムの建設などいわゆるハードな治水対策は，各国での行政活動そのものであり，これらの問題まで組み込むことは，台風委員会の性格上あまり適当でないという判断があり非構造物の課題を中心とすることとし，また，代表流域で事例的に研究された手法は他の流域にも適用可能であり技術開発のやり易い方法として採択されたものと考えられる。

発展途上国に対する集団研修やセミナーの開催なども台風委員会活動の主要な柱であり，日本で従来から実施している河川工学コース研修も台風委員会の活動の一環である。1978年の台風委員会では，総合的な水害防禦対策に関する調査・研究活動を提供するに当り，この新しい問題に関する研修についても要望が出され，日本政府がこれに対応することを約束したわけである。これが1979年に始めて本集団研修コースが発足した経緯である。コースは河川工学コースと同様ＪＩＣＡベースで行われ，参加国は台風委員会加盟国に限らず，広く門戸が開放された。




Miss Noguchi
Mr. Shahab Uddin
Mr. Wazed
Mr. Abdul
Mr. Joshi
Mr. Cheng
Mr. Liao
Mr. Yoshikawa
Mr. Ibrahim
Mr. Sutat
Mr. Tyagi

2　研修員氏名および研修カリキュラム

第3回洪水防禦コースは，1981年7月30日から9月25日にかけて行われた。参加者および研修のカリキュラムは以下のとおりである。

Country	Name of Participant	Age	Office Address	Home Address
Pakistan	Mr. Shahab Uddin	29	Section Officer (Floods), Cabinet Division, Govt. of Pakistan Rawalpindi	House No.412-F, Satellite Town, Rawalpindi-Pakistan
India	Mr. A. C. Tyagi	29	Deputy Director, Central Water Commission Sewa Bhawan, R.K. Puram New Delhi-110029, India	S/O Shri O.P. Tyagi, House No.343-A Vill & P.O. Hastsal New Delhi-110059, India
Malaysia	Mr. Ibrahim Bin Jusoh	24	Drainage & Irrigation Department, Jalan Bukit Kecil, Kuala Trengganu, Trengganu, Malaysia	33, Taman Salwa, Gong Badak, Kuala Trengganu, Trengganu, Malaysia
Bangladesh	Mr. Abdul Wazed	34	Executive Engineer, Chuadanga Water Development Division, Chuadanga, Kushrina, Bangladesh	Vill-Faila, P.O. Naldanga, Dist-Jessore, Bangladesh
Korea	Mr. Chung Hyo Sang	33	Central Meteorological Office, Observation Division, #1, Song Weol-Dong, Jongro-Ku, Seoul, Korea	RM #22-501, Kukdong Apt. Sucho-1st -Dong, Kangnam-Ku, Seoul, Korea
Thailand	Mr. Sutat Chantrapornlert	30	Sepervisor Construction Section, Technical Division, Bureau of Drainage & Sewarage. Rama 6 Road, Chareonpole Square, Bangkok 5 Bangkok, Thailand	7-9 Tee-Theng Street, Bangkok 2, Bangkok, Thailand
Indonesia	Mr. Abdul Aziz	31	Directorate of Rivers, J.L. Pattimura, No.20 Kebayoran Baru, Jakarta, Indonesia	JL. Dr. Saharjo, GG. Sewadaya 3rd Rt 009/08, Jakarta, Indonesia
China	Mr. Yincheng Liao	34	East China Technical University of Water Resources, No.1 Xikong Road, Nanjing Jangshu Province, People's Republic of China	Hydraulics Branch, Mechanic Department, East China Technical University of Water Resources, No.1 Xikang Road, Nanjin China
Nepal	Mr. G. R. Joshi	36	Department of Irrigation, Hydrology & Meteorology, Panipokhari, Katmandu, Nepal	11/12 Tuilako, Jole, Lalitpur, Nepal

Table 3 The schedule on the 3rd group training course in flood loss prevention and management (1981)

DATA		SUBJECT (CONTENTS)	LECTURE
7--30	Thu.	Arrival in Japan	
8-- 3 ∫ 8-- 7	Mon. Fri.	Briefing by JICA	
8--10	Mon.	Visit to the Ministry of Construction. (Leave Tokyo to TBIC)	
8--11	Tus.	Visit to the Public Works Research Institute.	Dr. Tominaga
		Orientation of the course.	Mr. Yoshino
		Problems on the flood loss prevention in the pilot rivers.	Mr. Yoshino
8--12	Wed.	Comprehensive flood loss prevention measures (I). (Outline, countermeasures, assessment, administration)	Mr. Yoshino
		Flood risk mapping in the south-east Asian rivers. (Special lecture)	Dr. Ooya
8--13	Thu.	Flood problems in the Asian rivers (Special lecture).	Dr. Shiigai
		Inspection of PWRI facilities.	Miss Honma
8--14	Fri.	Comprehensive flood loss prevention measures (II). (Floodplain management)	Mr. Yoshikawa
		Comprehensive flood loss prevention measures (III). (Flood fighting, evacuation, rescheduling)	Mr. Yoshikawa
8--17	Mon.	Country report.	Mr. Takemura Mr. Kuriki Mr. Yoshino Mr. Yoshikawa
8--18	Tus.	Country report.	
8--19	Wed.	Hydrological observation and its application to floodplain management.	Mr. Okura
		Technique of radar pluviometer.	Mr. Okura
8--20	Thu.	Sabo planning. (Outline, application to watershed management)	Mr. Watanabe
8--21	Fri.	Runoff analysis and its application to floodplain management.	Mr. Sago Mr. Terakawa
8--24	Mon.	Flood forecasting and warning (Special lecture). (Outline, application to floodplain management)	Dr. Kinoshita
8--25	Tus.	The history of development on the Tone River Basin (Special lecture).	Dr. Mushiake
8--26 8--27 8--28	Wed. Thu. Fri.	Field trip to the Tone, Edo, Naka and Arakawa River Basins.	Mr. Akagiri Mr. Yoshikawa
8--31	Mon.	Geomorphology of rivers and flood risk mapping technique.	Mr. Akagiri
9-- 1	Tus.	Geomorphology of rivers and flood risk mapping technique.	Mr. Akagiri
9-- 2	Wed.	Discussion on the flood risk mapping of the pilot rivers.	Mr. Yoshino Mr. Akagiri Mr. Yoshikawa
9-- 3	Thu.	Compilation of flood risk map of the pilot rivers by participants.	Mr. Akagiri Mr. Yoshikawa
9--4	Fri.	Compilation of flood risk map of the pilot rivers by participants.	(the same members)
9-- 7 9-- 8	Mon.	Discussion on the flood loss prevention planning of the pilot rivers by participants.	Mr. Takemura Mr. Kuriki Mr. Yoshino Mr. Yoshikawa
9-- 8	Tus.	Flood loss prevention planning of the pilot rivers by participants.	(the same members)
9-- 9	Wed.	Flood loss prevention planning of the pilot rivers by participants. (Preparation of the report)	(the same members)
9--10	Thu.	Discussion of the report on flood loss prevention plan for the pilot rivers by participants. (Leave Tsukuba to TIC)	(the same members)
9--11	Fri.	Case study; Flood loss prevention in the Tsurumi River.	Mr. Kobayashi
9--14	Mon.	Field trip to the Tsurumi River Basin.	Keihin Construction Office
9--15	Tus.	Free	
9--16 9--17 9--18 9--19	Wed. Thu. Fri. Sat.	Field trip to the Yodo River Basin. Flood forecasting system of the Yodo River.	Mr. Yoshikawa
9-21	Mon.	Preparation of the final reports by participants.	Mr. Yoshino Mr. Yoshikawa
9--22	Tus.	Preparation of the final reports by participants. Evaluation discussion on the course	Mr. Takemura Mr. Kuriki Mr. Yoshino Mr. Yoshikawa
9--23	Wed.	Free	
9--24	Thu.	Preparation for the return	
9--25	Fri.	Return to the home country.	

表－2　第3回洪水防

月　日	曜日	課　題　（内　容）	講　師
7／30	木	来　日	
8／3〜7	月〜金	ブリーフィング　JICA	
10	月	建設省表敬　移動（東京→筑波）	
11	火	土研表敬・セミナーコース紹介 パイロット河川の課題	富永・吉野 吉野
12	水	洪水防禦法（総論） （特）東南アジア河川の洪水危険図	吉野 大矢
13	木	（特）アジアの河川の洪水問題 土研施設見学	椎貝 本間
14	金	洪水防禦法（流域管理） 〃　（水防，復旧等）	吉川
17	月	カントリーレポート発表	竹村・栗城 吉野・吉川
18	火	〃	〃
19	水	水文観測と洪水防禦計画への応用 〃　レーダ雨量計	大倉
20	木	砂防と流域管理	渡辺
21	金	流域特性と流出，洪水防禦計画への応用	佐合・寺川
24	月	（特）東南アジア河川の洪水予報と洪水防禦計画への応用	木下
25	火	（特）利根川開発と治水	虫明
26	水	利根川・江戸川・中川・荒川現地調査	赤桐・吉川
27	木	〃	〃
28	金	〃	〃
31	月	河川地形論 水害危険図作成手法	赤桐
9／1	火	〃	〃

禦コースカリキュラム

月　日	曜日	課　題　（内　容）	講　師
2	水	パイロット河川の水害危険図討議 〃	吉野・赤桐 吉川
3	木	パイロット河川の水害危険図の整理	赤桐・吉川
4	金		
7	月	パイロット河川の洪水防禦計画討議	竹村・栗城 吉野・吉川
8	火	パイロット河川の洪水防禦計画等の作成	竹村・栗城 吉野・吉川
9	水		
10	木		
11	金	鶴見川総合治水計画	小林
14	月	鶴見川現地見学	京浜工事事務所
15	火	祭　日	
16	水	淀川洪水予警報システム 淀川現地調査	吉川
17	木		
18	金		
19	土		
21	月	最終報告書作成	吉野・吉川
22	火	Evaluation, Discussion, 閉講式	竹村・栗城 吉野・吉川
23	水	祭　日	
24	木	帰国準備	
25	金	帰　国	

3. 研 修 員 報 告

By: Shahab Uddin
Pakistan

Name of country: PAKISTAN

Name of the basin: INDUS RIVER BASIN

The catchment area of the Indus Basin is 372,700 sq. miles. It is located at 23°N to 37°N (latitude) and 61°E to 76°E (longitude).

GENERAL DESCRIPTION

Indus River Basin stretches from the distant highlands of Tibet (China) to the Arabian Sea over a length of about 2,000 miles (3,200 km with a total drainage area of about 336,000 sq. miles (860,000 km^2). Indus River Basin consists of the Indus River and its six major tributaries namely Kabul, Thelum, Chenab, Ravi, Satlej and Beas. Out of the five (excluding Kabul which rises in Afghanistan and joins Indus @ Attock) Satlej, Ravi and Beas, called the eastern rivers are with India while Chenab, Thelum and Indus, called western rivers are with Pakistan under the Indus-Waters Treaty 1960. After the cessation period of 10 years transition period in 1970 both the countries are now entitled to full utilization of all the rivers respectively.

Population of about 80 million is mostly dependent upon the irrigated agriculture in the Indus Basin as the country is basically agrarian one. This is served through the world's largest contiguous irrigation system in the Indus plains developed over the last 100 years are so. The system is fed through 16 diversion dams/barrages and 580 km long inter-river link canals. In addition, the system has three major storage reservoirs namely Mangla, Tarbela and Chashma at the upstream rim of the Indus plains which regulate as well as supplement the water for agriculture and flood control purpose.

Indus derives their flows from snow, glacier melt and heavy rainfall in the catchment areas. The rainfall in the basin shows two peaks, one in winter occurring in March and another occurring in July, August. The annual precipitation varies from less than 250 mm to 1,800 mm.

In southern region of the basin rainfall is mainly associated with westwards passage of easterly low pressure systems generally preceded by early advance of monsoon into southern most areas. The intensity of rainfall and thunder depends upon the intensity of the easterly low pressure system involved and the extent of interaction with the westerly low pressure system moving across areas lying in the north.

The economy of the area is largely dependent upon the agriculture. The major crops cultivated are: Rice, cotton, wheat and sugarcane. The industrial sector has also contributed in appreciating manner. This sector is famous for high production gains in sugar, fertilizer, jute goods, cement, vegetable ghee, and cotton yarn.

Historical Floods and Damages

The Indus plain being flat and broad experience heavy floods which are commonly considered to be an unusually high stage of the river at which the river carry surplus runoff much in excess of the channel capacity and as such water spills over the banks causing severe damages to precious lives, property and even disruption of daily life. In short all floods are primarily due to surface runoff resulted either by intensive rainfall or snow melt or combination of both.

The following flood events has been recorded in the history of basin.

year	direct losses in million dollars	lives lost	villages affected
1950	97.7	2,910	10,000
1955	75.9	679	6,945
1956	63.7	160	11,609
1957	60.6	83	4,498
1958	20.9	90	2,459
1959	47.3	88	3,903
1973	1,091.5	474	9,719
1975	137.5	126	8,628
1976	693.8	425	18,390

The floods of 1973 and 1976 were severe as shown in the above table. In both the years the peak discharges on some major rivers were recorded as under which even surpassed the capacities.

Year	River	Location	Capacity	Peak discharge
1973	Chenab	Pajnad	14,000 Cumecs	6,060 Cumecs
1976	Ravi	Sidhnai	3,600 "	4,880 "
1976	Indus	Gudu	22,000 "	24,000 "
1976	Indus	Sukkur	18,000 "	24,020 "

Existing Flood Control Measures

These measures are classified into two categories, structural and non-structural measures.

Structural Measures includes the strengthening of old embankments/bunds, construction of new ones, construction of dams, barrages and diversion channels. Though many flood losses can be reduced through non-structural flood control measures but the need still arises for a comprehensive effort in both non-structural measures to mitigate recurring flood losses.

Non-structural Measures - Flood Forecasting and Warning System

As flood forecasting is a real phase of reduction of flood losses, the effort has been made towards successful modernization of flood forecasting and warning system for Indus River Basin. The system comprises of three components.

Component I deals with the Expansion and modernization of basic hydrological collection system. In this regard river and raingauge with telemarks at 41 stations, 36 telecom stations with VHF data transmitters, data sensors, repeaters, receivers, display terminals and high frequency voice communication stations and 60 meter high receiving tower at Lahore in the Punjab province have been installed.

Component II consists of a quantitative precipitation measurement radar at Sialkot and hydrological and meteorological readout station at Lahore.

Component III Flood forecasting and warning centre at Lahore alongwith 7 automatic river and raingauge, 8 automatic raingauge with telemetric system including 3 caliberation stations in the catchment areas of the Indus River Basin have been established.

The system is very helpful where the floods are likely to disrupt normal activities, cause material damage and threatens the safety of flood control structures.

Annextures

1. Location map of Improved Hydromet Network.
2. Organization Set up of Flood Management.

Flood proofing

This includes a wide range of measures that essentially percludes flood water from contact with the protected structures. This may include raising a structure using reinforced brickwork constructing a structure on earthfill or buildings a ring bund or flood walls around a structure. For dry interior measures of closing low level openings, water proofing of exposed walls above or below the ground, provision of sum pumps and planning check walls on ground lines.

In the selection of flood proofing measures, consideration is always given not only to the magnitude and frequency of inundation but also to the method of construction.

Disaster Prevention Legislation

National Calamities Act 1958 in the country provide legal cover to all kinds of disasters including floods. The purpose of this act is to provide for maintenance and restoration of order in calamity striken area for prevention and relief.

This acts needs revision for drawing up the proposals both at national level and provincial level. In Japan in addition to the basic law for disaster prevention, there are separate laws for river, earthquakes etc.

Disaster Relies Plans

Disaster Relief Plans at Federal level, Provincial level and District levels have been prepared. These plans streamline the functions and responsibilities of each department and their functionaries.

At the time of disaster these plans are fully operational and hence make it easier to provide relief to the victims of any disaster.

Evacuation

The evacuation of the people and their property is carried out only when the floood warning is issued, as such. They are brought to safer places. The response of the general public is worth appreciating.

Land Use Regulation

It is mainly concerned with the restrictions of the use of basin area. Two aspects are kept in view, one to reduce the concentration of population, their assets and another to reduce unnecessary development.

To minimize the chance of floods, the emphasis therefore may be given to Land Use Regulations.

In Japan in addition to basic law, the River Law, Erosion Control Law, Landslide Prevention Law and Law for Prevention of Disasters due to collapse of steep slopes etc., there are laws which concerns the land use, under such laws, regulations, zoning of the urbanized zones, urbanization controlled zones, disaster vulnerable zones are defined.

Comprehensive Flood Protection Plan

Federal Flood Commission is working towards achieving the goal of flood management planning to reduce situations, threatening life and health of the people economic losses, costs of emergency, evacuation and relief, losses of public revenues and impairment of national security by fostering a unified programme of structural and non-structural flood management.

In this regard a draft of flood protection plan has been prepared and will be finalized very soon.

The following are the objectives:

a) To reduce flood losses and suffering due to flood in an economically sound manner such that the benefits of flood damage abatement measures exceed their costs in so far as possible.

b) To give priority for flood protection to areas of greatest economic flood damage hazard and greatest potential for human sufferings as far as possible.

c) To provide as far as possible, adequate protection from flood damages to areas lying outside active flood plains of the rivers in particular to protect cities, irrigation works, communication of facilities and other vital infrastructural installations.

d) To make maximum use of existing flood control protection facilities by improvement where necessary to bring them to the level of functional capability and reliability to confirm to adopted standards.

e) To obtain maximum flood control utilization of multiple purpose facilities without adversely affecting other functions or compromising the safety of the facility.

f) To promote appropriate land use by avoiding the growth of flood vulnerable development in the flood hazard areas and adjusting land use where possible to be compatible with the frequency and duration of flooding.

g) To minimize adverse effects on natural ecosystems and an environmental values.

Proposals

In view of the detailed discussions held in various sessions of the training programme, observation tours and keeping the problems of Indus River Basin in view of the following proposals are made:-

1) Reserach Work and Intensive Training Programmes may be given top priority in the fields of hydrology, meteorology and disaster prevention.

2) Planning and Coordination at the inter-country and inter departmental levels may be emphasized.

3) Regulations for the control of land use may be improved.

4) Control plans may be prepared for conservation of low lying areas.

5) For preparation of flood risk map ,geomorphologic approach may be adopted.

6) Afforestation in the upper catchment areas of the Indus River Basin on large scale may be done.

Conclusion

The floods, if not controlled result heavy losses on the life and property so more efforts on hydro-meteorological data collection system may be made in order to take up proper flood control measures.

<u>Preparation of Flood Risk Map</u>

Flood risk map is one of the essential tools of flood plain management. It depicts the degree of susceptibility in flood prone areas.

For preparation of flood risk map the following requirements are to be fulfilled.

The first and foremost requirement is a topographic map alongwith contour map.

The second requirement is a hydrological/meteorological data for example rainfall (hydrograph), discharge of water levels (hydrograph) of the past floods.

Flood inundation map of the historical floods showing the time and depth of inundation in different zones. It assists in evaluation of scale of damage, cause of damage.

Geomorphologic maps and aerial photographs. These items generally help in delineations of vulnerable zones and require more hydrologic/hydraulic analysis.

The data about the capacity of the reservoir and other flood control works in the basin helps in the flood plain management.

For successful preparation of flood risk map, briefly speaking, it will require the above data.

There are so many approaches for preparation of flood risk map.

a) Geomorphologic Approach
b) Historical Approach
c) Hydrologic-hydraulic Approach
d) Hydrologic-hydraulic Damage Susceptibility Approach

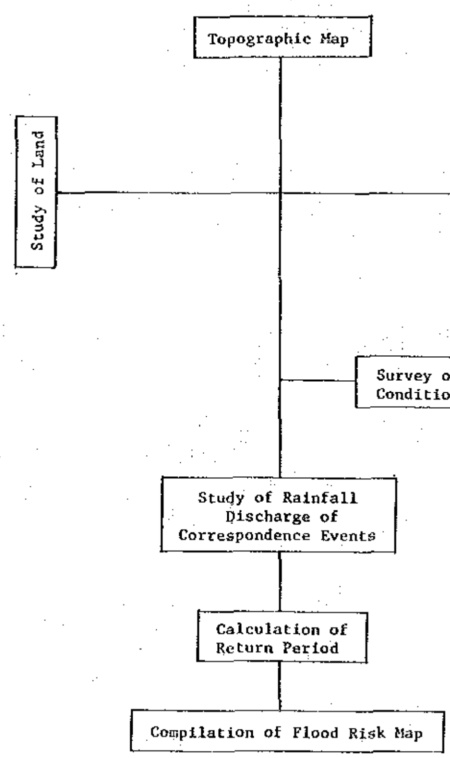
a) Geomorphologic Approach

The geomorphologic maps streamlines the landform units which are marked on the basis of shap, genesis, material etc. By following the steps, mentioned as under it will be very easy to compile the geomorphologic map.

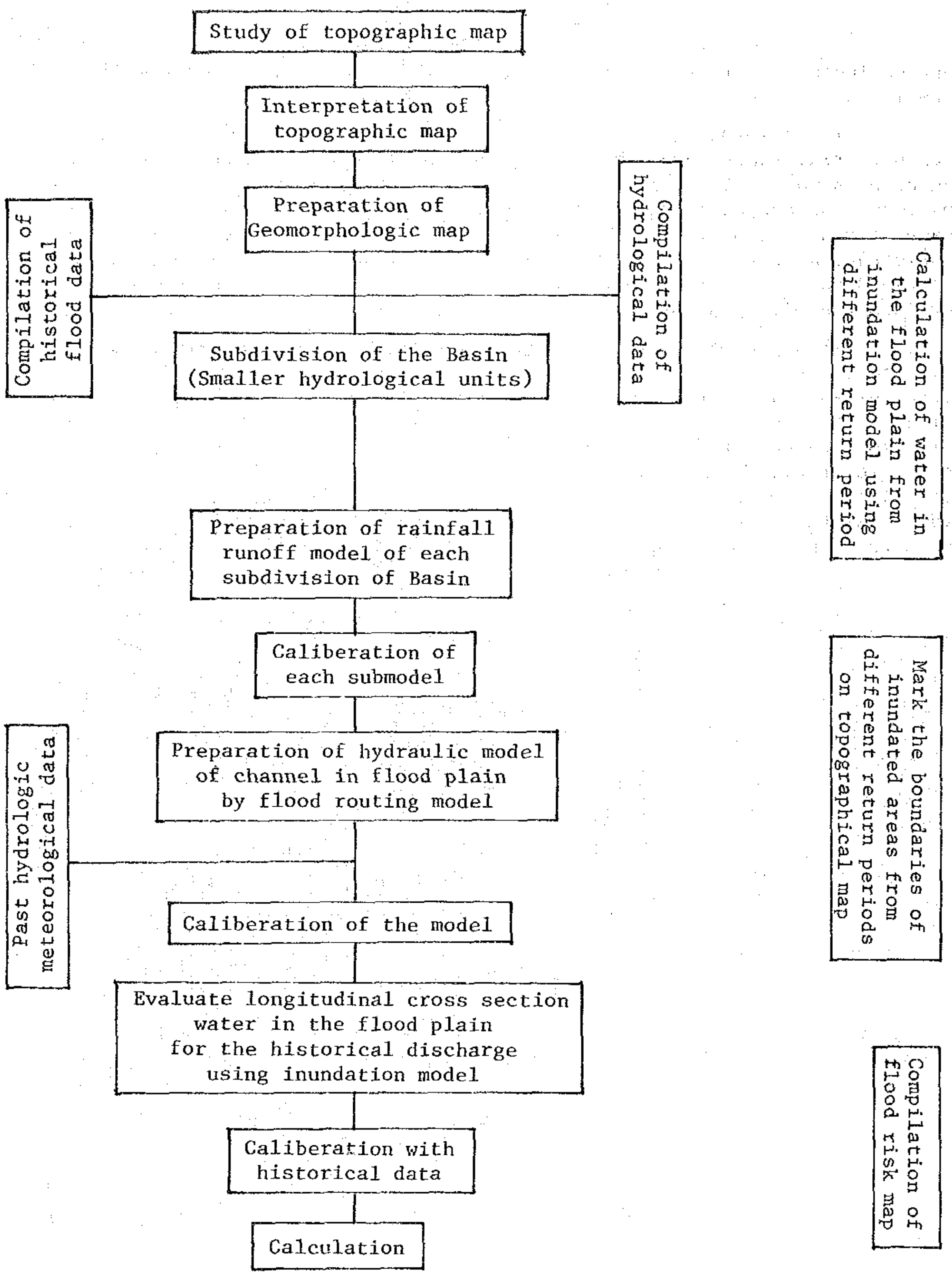
—Topographical map of the area 1/40,000
—Aerial photographs
—Interpretation of aerial photographs to delineate the landform units
—Compilation/preparation of land condition
—Historical data checks
—Finalization of geomorphic map

b) Historical Approach

It is based on the data of inundation in the past floods. It also requires a topographic map of the basin. Survey of inundated areas and collection of historic data.



Hydrologic-hydraulic Approach



The Report of Case Study Based on Geomorphological Approach for Flood Risk Mapping, in case of one of the Japan's River, a Requirement of the Training Programme

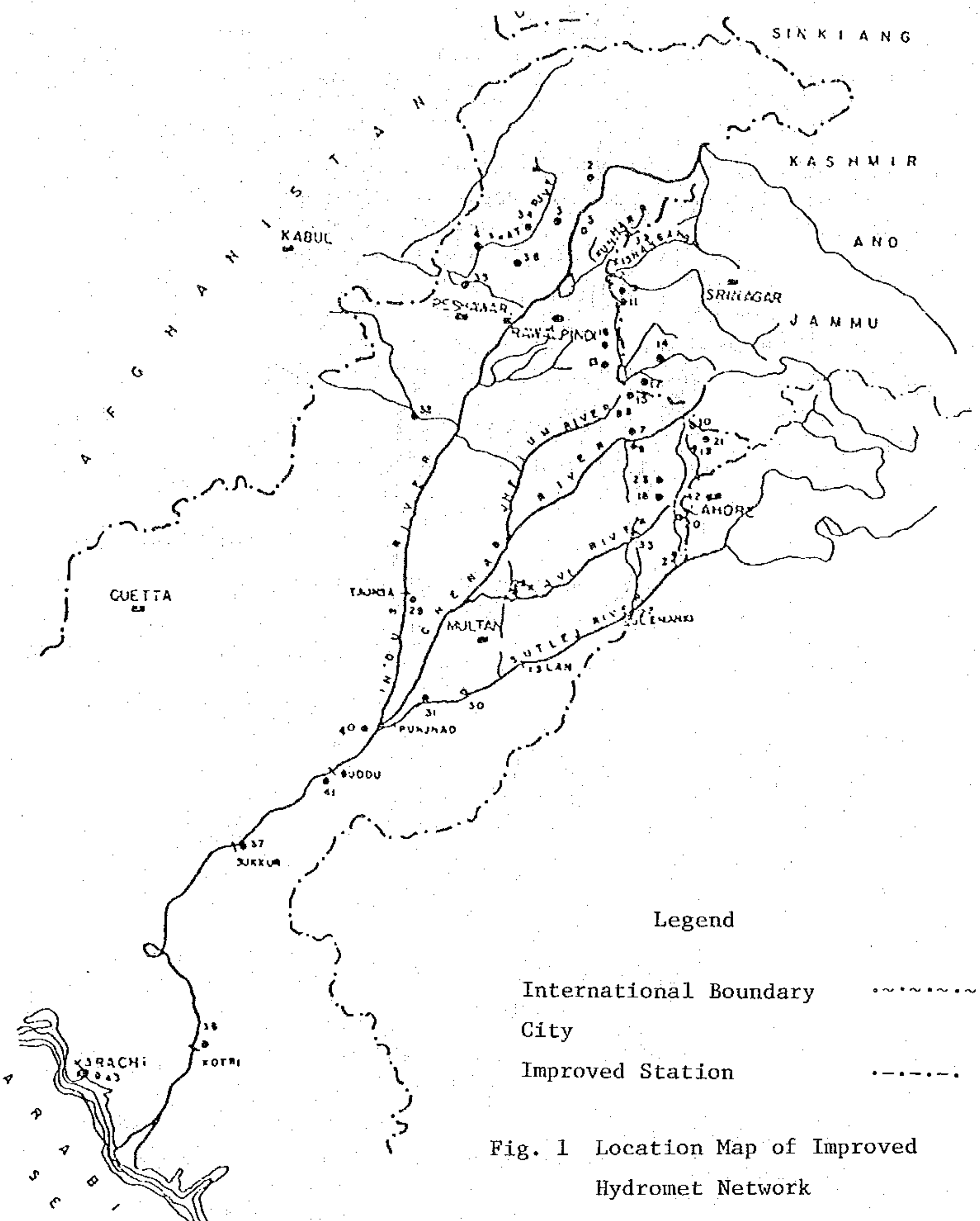
Otoshibari River

This river starts from mount Ida and runs upto the sea. At the very beginning, there are many tributaries which if we make any measuring of formulation of mountain.

The rainfall will flow down through the mountaneous region with high potential energy and will result the landslides. It will carry some ingredients to the foot of the mountain. The process continues for centuries and forms the coarse valleys. This is how mountaneous regions have taken the shape of many tributaries. Keeping the geomorphologic knowledge it may be mentioned that river originates from the mountains and runs upto the end of the sea depositing heavy ingredients from one place to the other and it receives the mild gradients i.e. deposition of big fans at the foot hills.

This phenomenon can be seen nearby railways lines in case of Otoshibari River. After this process the carrying capacity of the river decreases and fans takes in its way and deposits the coarse material forming delta. After this Lagoon formation starts. Being a low land, there may be some flow channel and when flooded, forms natural levees. People while keeping sense of floods in view starts constructing houses. It can be seen that both sides of low land there is elevated high lands on the left and right sides. As the river starts from mountains and ends at the coastal region hence the deposition of sand dunes.

Annexture 1



Legend

International Boundary ·~·~·~·~·~·

City

Improved Station ·–·–·–·

Fig. 1 Location Map of Improved Hydromet Network

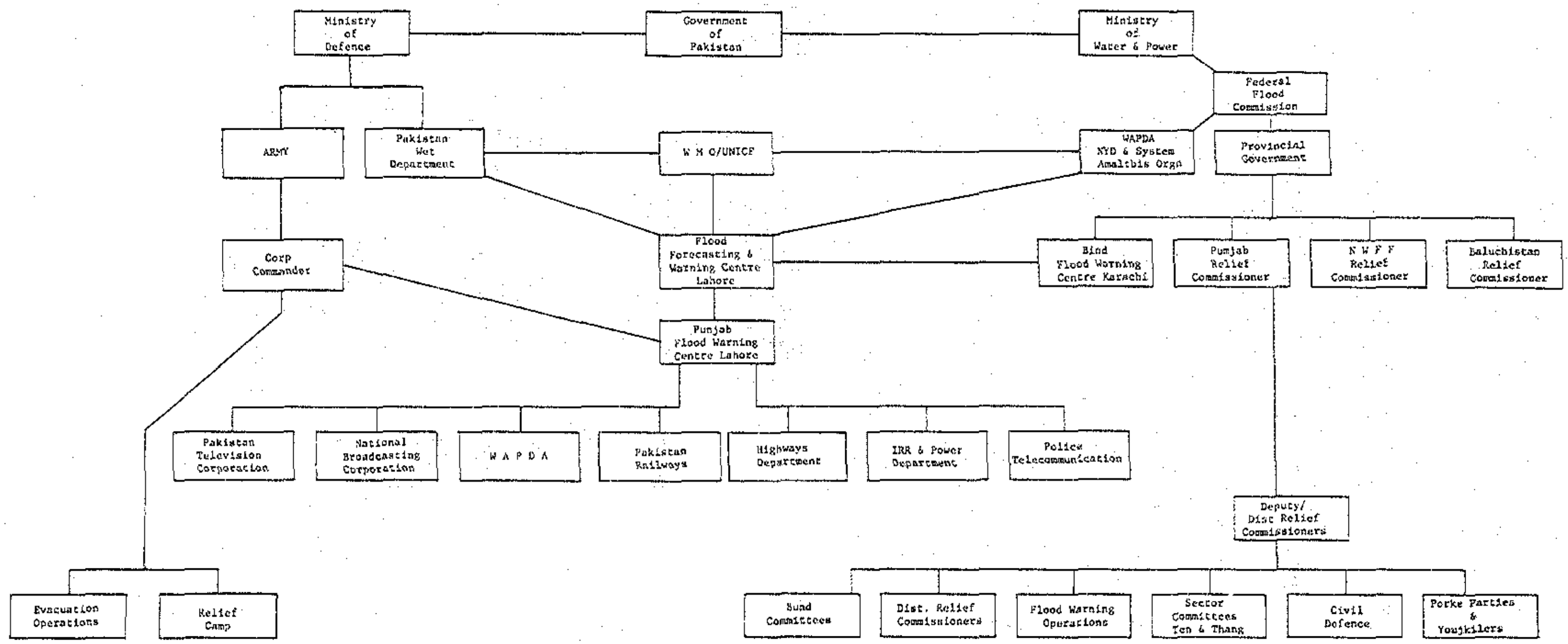
Annexures 2

PAKISTAN

ORGANIZATIONAL SET-UP FOR FLOOD MANAGEMENT

INCLUDING

FORECASTING AND WARNING SYSTEM



By: A. C. Tyagi
India

1.0 COUNTRY: INDIA

2.0 DESIGNATED RIVER BASIN:

2.1 Basin name and area:

Although there is no specified river basin as pilot river basin, Brahimini river basin has been considered as the pilot river for the purpose of this report. The total catchment area of the Brahimini river basin is 39,033 km. sq.

2.2 Location:

Brahimini river basin is bound between latitude 20°35' N and 23°35' N and longitude 83°3' E and 85°30' E.

2.3 Topographical map of the basin:

The topographical map of the basin at a scale of 1:100,000 is attached as Fig. 2.1.

2.4 Index map:

An index map showing the location of Brahimini basin on the map of India is shown in Fig. 2.2.

2.5 General description of the basin:

Topography and geology:

Brahimini basin is bound in the north by the Chottanagpur plateau, on the west by ridge separating it from the Mahanadi basin, on the south also by the same ridge and on the east by the Bay of Bengal. The basin is of long sausage shape. The basin has four well defined topographical features; a) the north plateau, b) the eastern ghats, c) the coastal plains and d) the erosional plains of the central table-land. The northern plateau and the eastern ghats are well forested hilly regions. The coastal plains cover the deltas formed by the river and are well suited for cultivation. The hills are comprised of Precambrian Igneous rocks.

Brahiminis known as South Koel in its upper reaches rises at an elevation of 600 m, at north latitude 23°20' and east longitude 85°12'. It flows initially in a south westerly direction for 47 kms. Changing directions from south and south-east, the river continues to flow for a distance of 121 kms., receiving many small tributaries from both banks. A major left bank tributary, the Karo, joins South Koel at the 218th km of the later's run from the source. At about 306th km. of its run from the source, the river receives a major right bank tributary, the Sankh. Below the confluence of South Koel and Sank the river is known as Brahimini. Further downstream, a major right bank tributary, Tikra, joins it at the 497th km., flowing in a generally easterly direction for a further length of 220 kms., and receiving several small tributories river Brahimini emerges into coastal plains near Jenapur. Here it is divided into branch rivers namely, Brahimini, Patia, Khursuan,

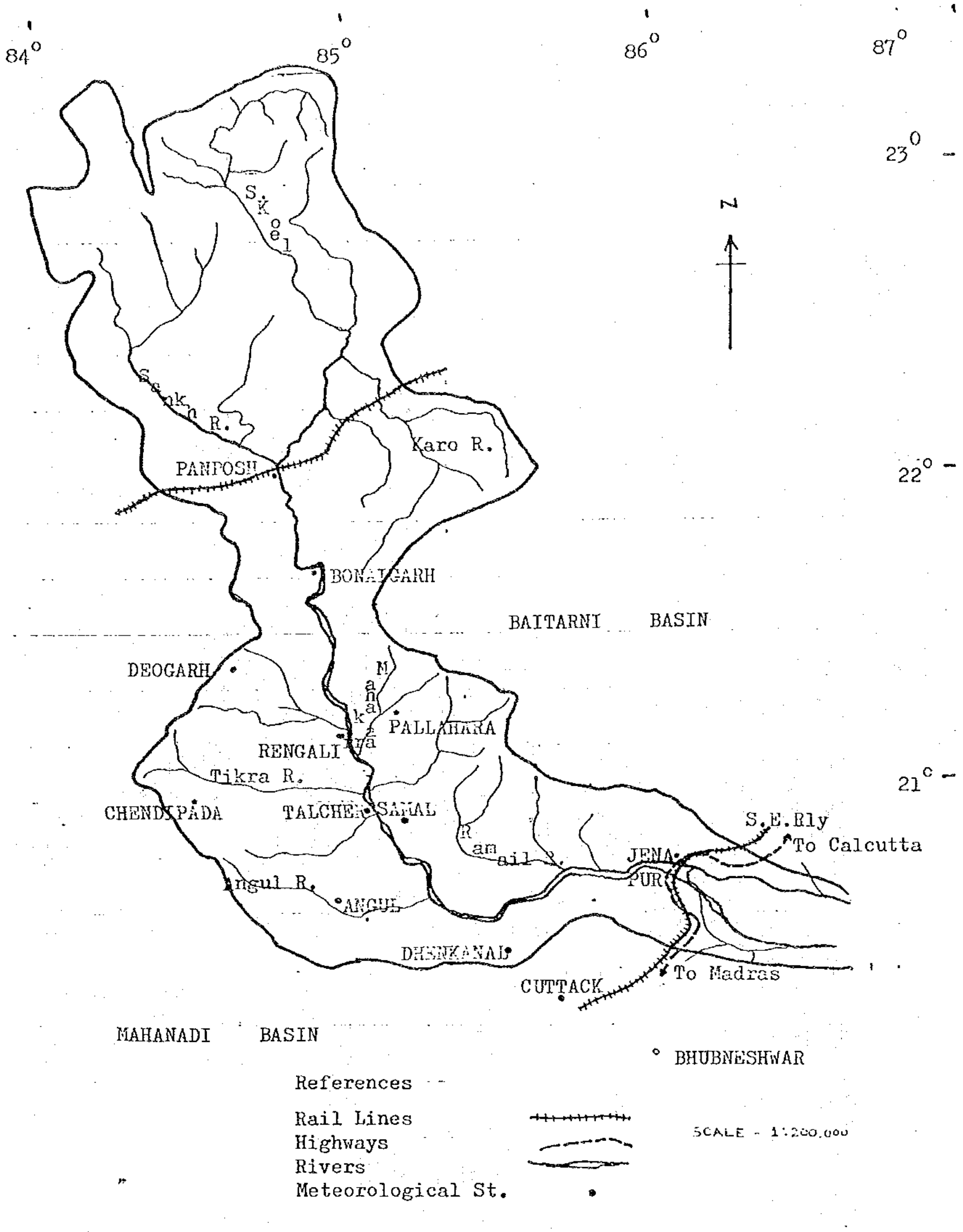


Fig.2.1 Topographical map of the Brahimini basin.

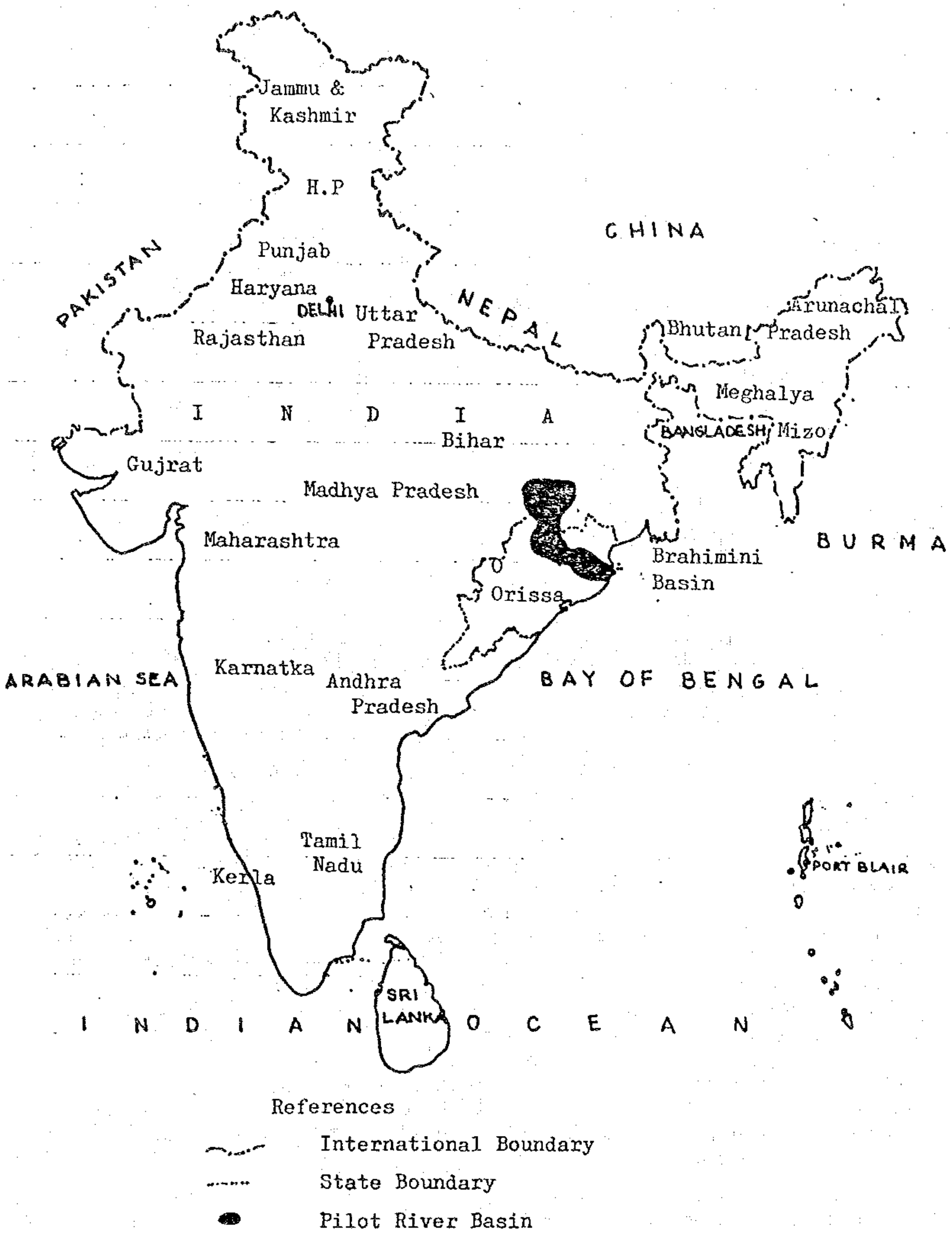


Fig.2.2 Index map showing location of the Brahimini basin.

Kimiria and the Kelua. Each of the branch river forms its doab and again joins the main river. A schematic diagram of the river system is shown in the Fig. 2.3.

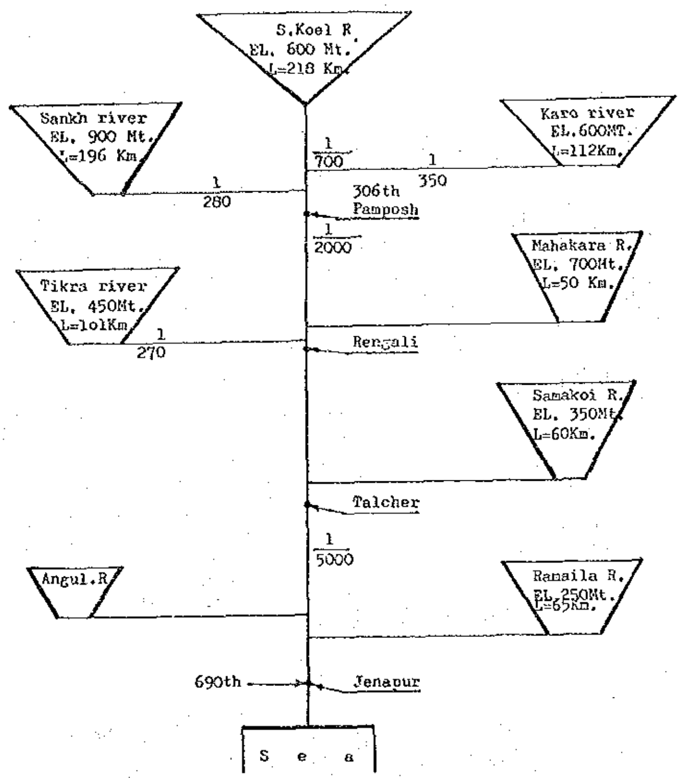


Fig.2.3 Schematic representation of the Brahimini river system.

There are four distinct seasons in the basin. They are a) cold weather, b) hot weather, c) monsoon season and d) the post monsoon season. In the cold weather the winds are generally light and blow either from north and north-east and the atmosphere is bright. During January very little precipitation occurs, but during February, there is some precipitation in association with passing western disturbances and is mostly confined to the hilly part of the basin. The hot season commencing in March lasts till the middle of June by which time the south-west monsoon sets in. The monsoon continues to be active till the first week of October. During this period the basin receives over 90% of its total annual rainfall. The monsoon withdraws by the first week of October. After withdrawal of the monsoon a few thunderstorms continue to occur. The weather clears up by the end of November and it is cool thereafter.

There are about 20 raingauges in the basin. The distribution of the station is not uniform and sufficient in number. The basin receives about 1500 mm to 1600 mm of rainfall annually. Total average evaporation in the basin is 1220 mm. with a maximum generally reaching in the month of May when it is about 170 mm.

Floods in the basin are mainly confined to the coastal areas after the river emerges into coastal areas downstream of Jenapur.

On the basis of tentative figures worked out from 1981 census, the total population of the basin is 6.9 million, with a population density of 177 persons per km. sq. against the national figure of 210. The coastal areas are more densely populated. There is no large city in the basin with a population above 200,000. Out of the total population 88.4% of the people live in rural areas.

Forests occupy the 23.7% of the total area in the basin. The culturable area comprises of 61.9% of the total area, out of which 66% is provided with irrigation facilities. Rice is the most important irrigated area in the basin. Three crop seasons prevail in the basin which are; a) the Kharif, b) the Rabi and c) the hot weather. The important Kharif crops are rice, maize, and millets, whereas during the Ravi the main crops sown are rice, wheat, barley and pulses. The hot weather crops are rice and chillies. In addition, cash crops like cotton and jute are also grown.

There are no major hydro-electric projects in the basin although the potentials as assessed are 1,155 MW at 60% load factor. The basin has a rich variety of mineral wealth spread all over the area. The principal minerals found in the area are Iron, Copper, Bauxite, Chromite, Coal etc. Important industries locate in the area are steels and fertilizers.

The basin is served by the South-Eastern Railways. A number of railway lines connecting important places pass through the basin. The National Highway connecting Calcutta with Madras and Bombay also pass through the basin. In addition there are a number of other state highways. The river is navigable in its lower reaches being interlinked with the adjacent Mahanadi delta canal system. Goods and passengers are carried between Cuttack and the deltas of Mahanadi, the Baitarni and Brahimini in their tidal reach by numerous tidal creeks.

The economy of the area largely depends on agriculture, which in view of the uneven incidence of rainfall, provides a low level of subsistence except in parts of the basin where irrigation facilities have been provided.

2.6 Past floods and damages:

There have been a number of floods in the basin of small and big magnitudes in the reaches of river Brahimini, almost every year. However there were floods of large magnitudes in the basin during flood season of 1959, 1960, 1969, 1973, 1976 and 1980. Average annual damage due to floods in the region is of the order of 15 million US $, taking average of period 1953 to 1980. However, 80% of these losses can be contributed to crop damage.

3.0 FLOOD PROTECTION AND RELATED WORKS IN THE BASIN

3.1 The map showing the flood protection works such as embankments, dams, diversion channels are given in Fig. 3.1.

3.2 Dams

Some of the dams which have been built in the basin are listed in Table 3.1.

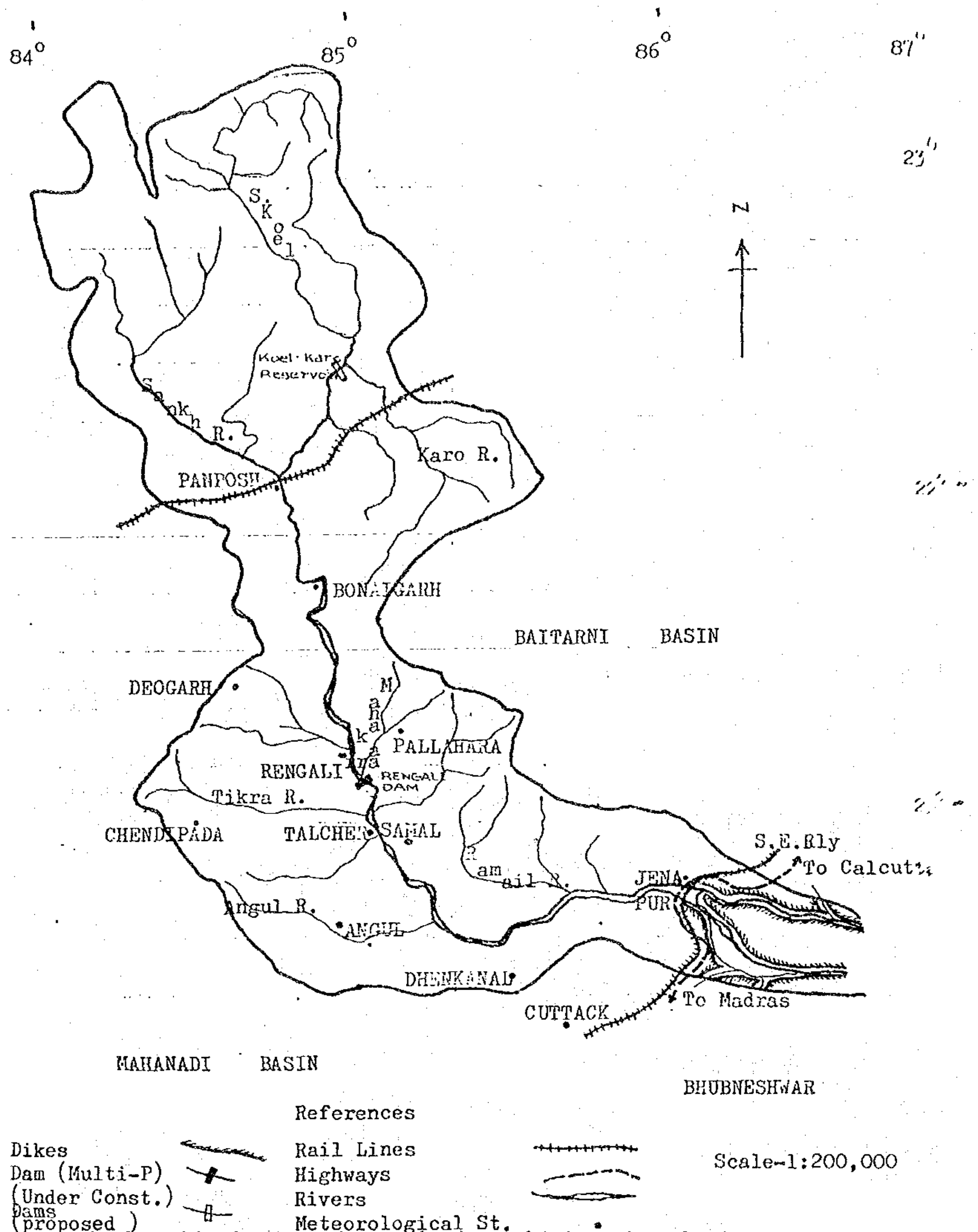


Fig.3.1 Flood protection works in Brahimini river basin.

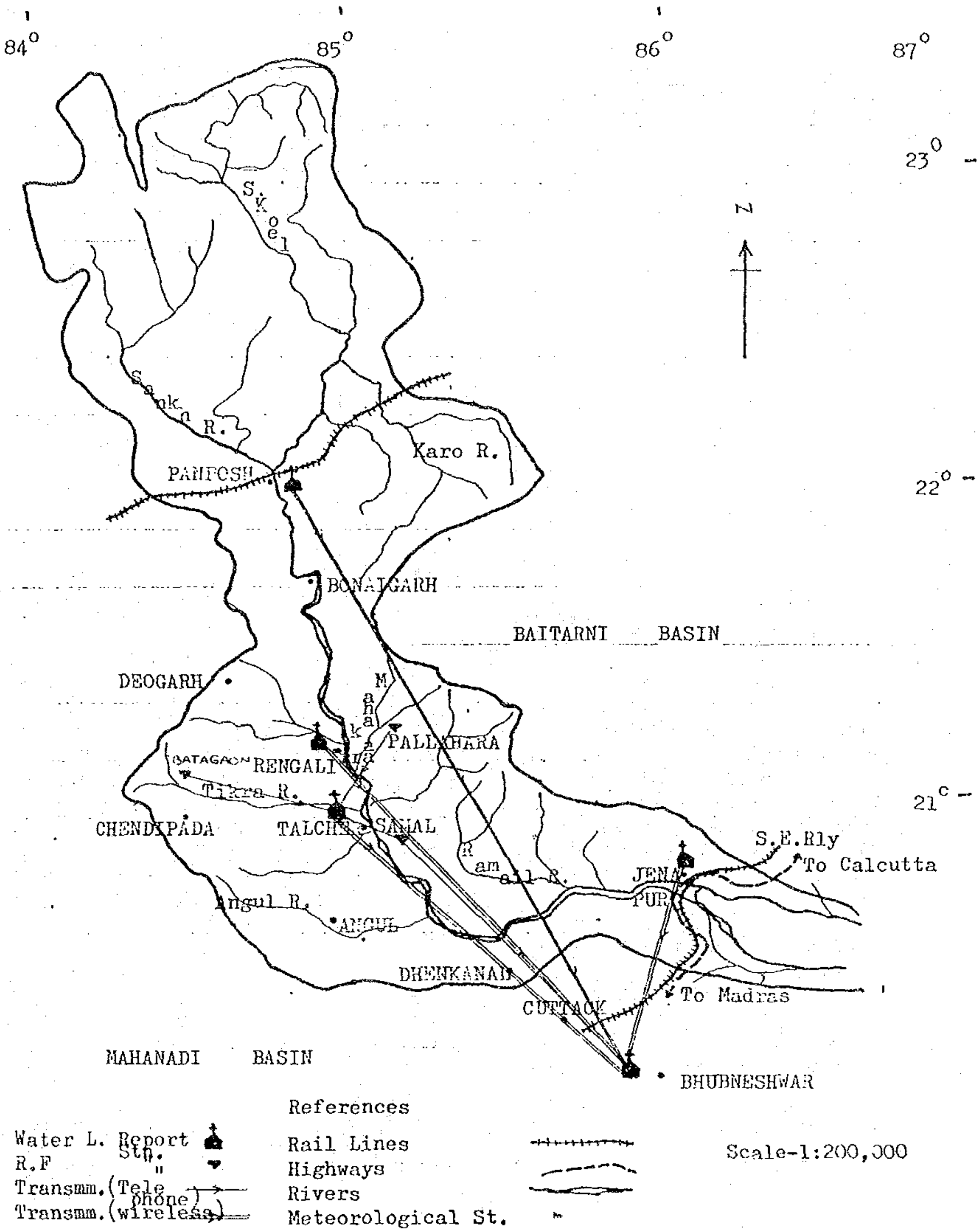


Fig.4.1 Flood forecasting network of Brahimini basin.

3.3 General description of the other works in the region:

The flood control measures taken up in the pre-independence period were mainly confined to the construction of local embankments known as Zamindari embankments. The recent flood control works carried out in the basin comprise mainly of strengthening of these embankments, construction of new embankments, construction of diversion channels and local town protection works. In addition, Rengali Dam a multi-purpose reservoir is under construction on river Brahimini and is likely to be completed in 1982. The reservoir is expected to moderate the floods in the Brahimini river within safe limits in the delta area downstream of Jenapur. The distribution of flood waters into the various diversion channels of the Brahimini downstream of Jenapur also helps in mitigating to a large extent the floods in lower reaches of the deltaic area.

4.0 EXISTING FLOOD FORECASTING AND WARNING SYSTEM

4.1 Map:

A map showing the flood forecasting network and the mode of data transmission is shown in Fig. 4.1.

4.2 General information:

The flood forecasting system in river Brahimini is established with the view to provide the flood forecasts at Jenapur Railway Bridge and Jenapur Highway as the area downstream of it is flat and deltaic and is flooded if there are large discharges at Jenapur Railway Bridge. The target area has therefore been selected as the area below Jenapur.

The constructural measure of flood loss prevention were started in India in 1959 with the commencement of flood forecasting works in Yamuna basin near Delhi. However, flood forecasting was started in a big way only in 1969 when Government of India opened flood forecasting centres in almost all the major rivers prone to floods. At this time a flood forecasting centre was started to provide flood forecasting services in different rivers of Orrisa state with its headquarters at Bhubneshwar. This centre provides flood forecastings for rivers Mahanadi, Brahimini, Baitarni, Subernrekha and others. The forecasting centre known as the Central Flood Forecasting Division, Bhubneshwar, is under the administrative control of Member (Floods) of Central Water Commission, Ministry of Irrigation, Government of India. There are about five hydrologists-cum-engineers, about twenty telecommunication operation staff and other 200 semiskilled staff working in the centre. Only one-fourth of the above staff is engaged in flood forecasting of river Brahimini, others being engaged in the flood forecasting work of Mahanadi, Baitarni, Subernrekha etc.

There is a table top programmable calculator provided at the headquarters of the centre, Bhubneshwar.

Total annual operating costs of Brahimini basin flood forecasting system is about 50,000 US$.

4.3 Data collection system:

Raingauge stations located in the basin are listed in Table 4.1. The density of the raingauge stations is not considered and efforts are afoot to establish an efficient raingauge network.

Table 4.1 RAINGAGE STATION

No.	Name	Location (approxi.)	Altitude(m) (approxi.)	Duration of record	Type of rainagauge
1.1	Panposh	84°50' E 22° 5' N	173	1976 to date	ordinary
1.2	Bonaigarh	84°55' E 21°50' N	142	- do -	- do -
1.3	Chendipida	84°50' E 21° 3' N	158	- do -	- do -
1.4	Pallahara	85°10' E 21°30' N	97	- do -	- do -
1.5	Talcher	85°20' E 20°55' N	57	- do -	- do -
1.6	Kamakhya-nagar	85°20' E 20°57' N	39	- do -	- do -
1.7	Dhenkanal	85°35' E 20°35' N	37	- do -	- do -
1.8	Sukinda	N . A .	N. A .	- do -	- do -
1.9	Deograh	84°40' E 21°35' N	120	- do -	- do -
1.10	Reamal	84°25' E 21°25' N	400	- do -	- do -
1.11	Lohendoge	N . A .	N. A .	- do -	- do -
1.12	Manoharpur	85° 5' E 22°27' N	300	- do -	- do -
1.13	Angul	85° 3' E 20°40' N	70	- do -	- do -

Table 4.2 WATER LEVEL STATION

No.	Name	Location	Altitude of the staff datum(m)	Distance from the river mouth	Duration of record	Type of gauge
2.1	Panposh	84°50' E 22° 5' N	170	306 KM	1969 to date	staff-gauge
2.2	Rengali	85° E 21°10' N	78	490 "	"	"
2.3	Talcher	85°20' E 20°55' N	55	530 "	"	"
2.4	Jenapur Exp. way bridge	86° 5' E 20°55' N	16	692 "	1964 to date	"
2.5	Jenapur railway bridge	86° 5' E 20°55' N	-	690 "	1969 to date	"

Table 4.3 DISCHARGE MEASURING STATION

No.	Name	Location	Distance from the river mouth	Duration of record	Type -float or current meter	Frequence of obs.
3.1	Jenapur	86° 5' E 20°55' N	107 KM	1970 to date	current meter	daily
3.2	Talcher	85°20' E 20°55' N	269 "	"	- do -	- do -
3.3	Panposh	84°50' E 22° 5' N	493 "	"	- do -	- do -

Table 4.4 DATA TRANSMISSION SYSTEM

Station name	Telephone	Telegraph	SSB HZ.	Telemeter HZ.	Other's
Panposh	-	-	SSB	-	-
Batagon	-	-	-	-	Other's
Rengali	-	-	SSB	-	-
Pallahara	-	-	-	-	Other's
Talcher	-	-	SSB	-	-
Samal	Telephone	-	-	-	-
Jenapur	-	-	SSB	-	-

Water level recording stations have been listed in Table 4.2. Discharge measuring stations are listed in Table 4.3.

4.4 Data transmission system:

Mode of data transmission is listed in Table 4.4. It can be seen that there is a great scope of improvement in this field, however, due to the paucity of funds and other priorities it is not possible to update the same.

4.5 Data processing:

The data being received is thoroughly processed manually through visual and arithmetical checks before it is finally used as an input in the forecasting model.

4.6 Forecasting models:

Two types of forecasting models have been developed for forecast formulation on river Brahimini.

A rainfall runoff model has been developed for formulation of forecasts at Talcher using unit hydrograph method. In order to estimate the aerial rainfall, three key raingauge stations namely Kamakhyanagar, Chandipadda and Pallihara have been identified and the unit hydrograph rainfall-runoff model developed. However, due to the non-availability of the rainfall data from these key raingauge stations on real time basis, the model is not in operational use.

A statistical stage correlation model is used for operational purposes in the formulation of forecasts. The model is subdivided into three units. The first unit models the reach between Panposh and Rengali, the second between Rengali and Talcher and the third between Talcher and Jenapur the final forecasting point. The travel time in the three reaches is 24 to 12 hrs., 12 to 6 hrs. and 8 to 6 hrs. respectively. The correlation graphs are shown in Fig. 4.2 to Fig. 4.5. The total travel time available for the formulation of forecast for Jenapur, in the case of highest floods is of the order of 34 hrs. The statistical model is quite satisfactory providing an accuracy within ±15 cms. on 86% of the occasions. However, the travel time available at the time of very high floods is insufficient and calls for utilization of rainfall-runoff model.

4.7 Warning system:

The forecasts for Jenapur are formulated right from the beginning of the monsoon season daily, and are issued to a number of beneficiaries listed in Table 4.5. In case the water level crosses the warning level the forecasts are disseminated to the concerned engineering and civil authorities by the quickest possible means like telephone and special messengers or telegrams and wireless telephony. A schematic diagram shown in Fig. 4.6 is self explanatory.

For the benefit of general public regular flood bulletins are broadcasted from the local transmission station of All India Radio. In addition flood warnings are issued through the local newspapers. The dissemination system is quite satisfactory.

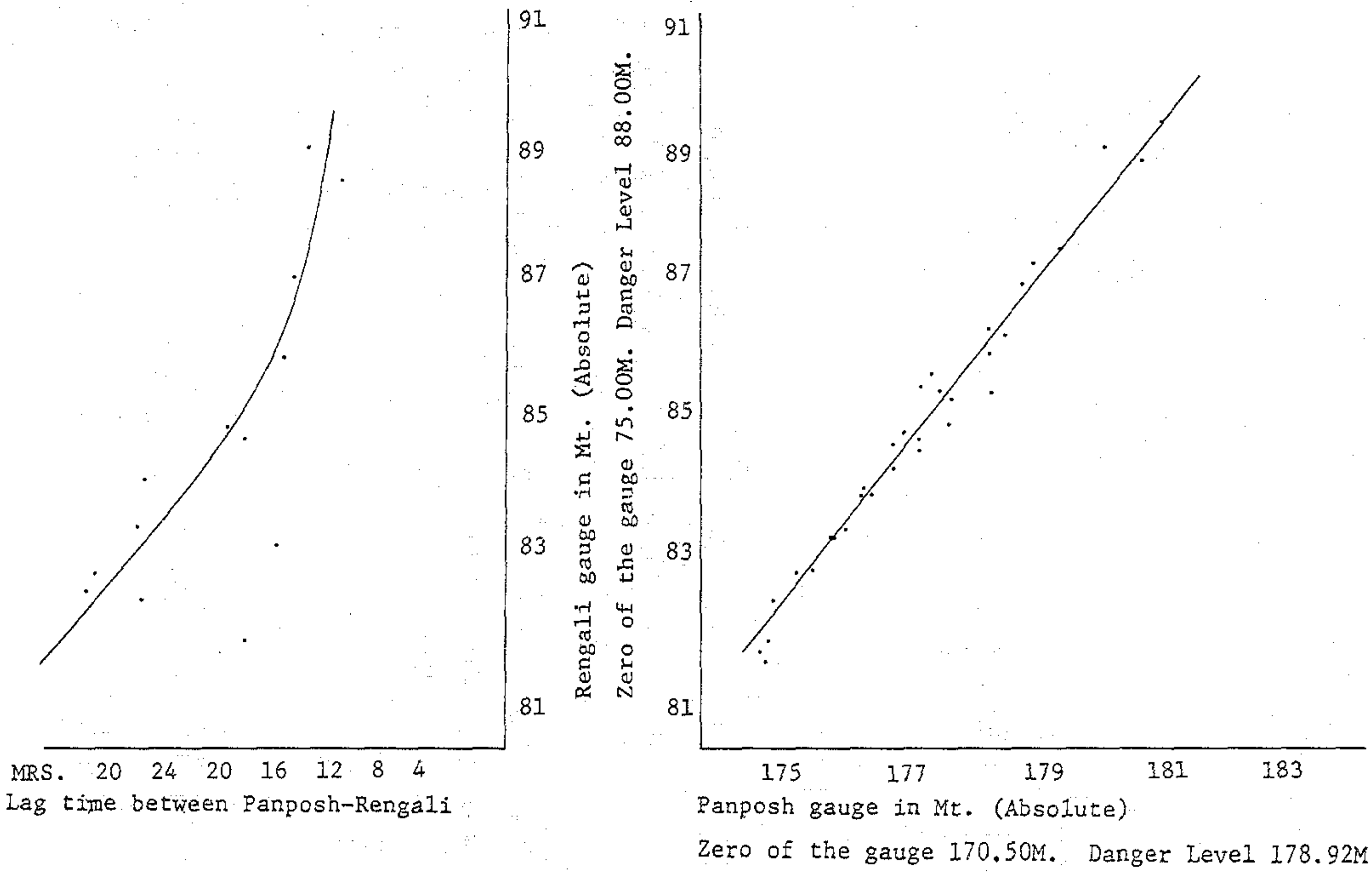


Fig.4.2 Correlation graph of Panposh-Rengali sub model.

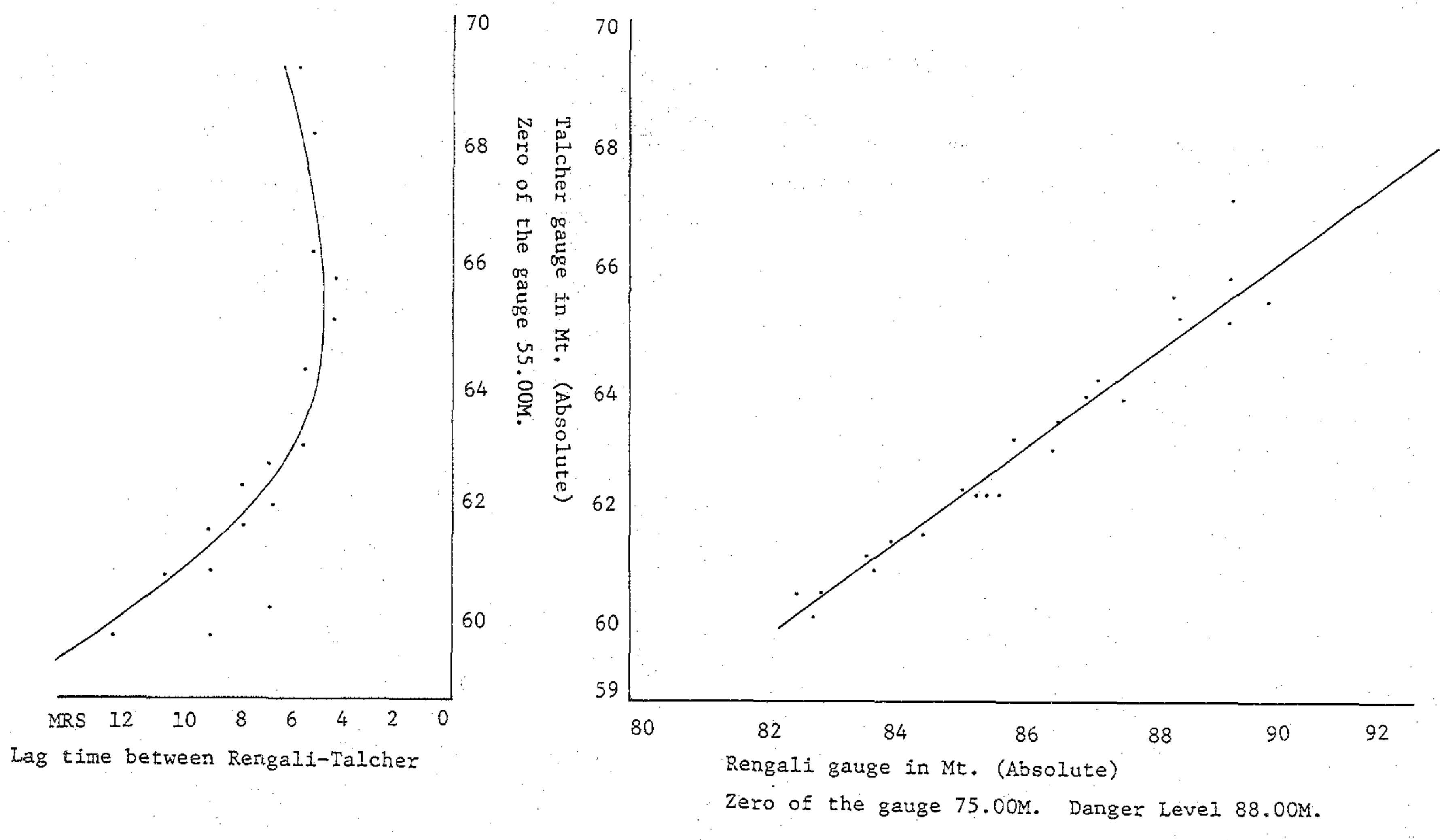


Fig. 4.3 Correlation graph of Rengali-Talcher sub model.

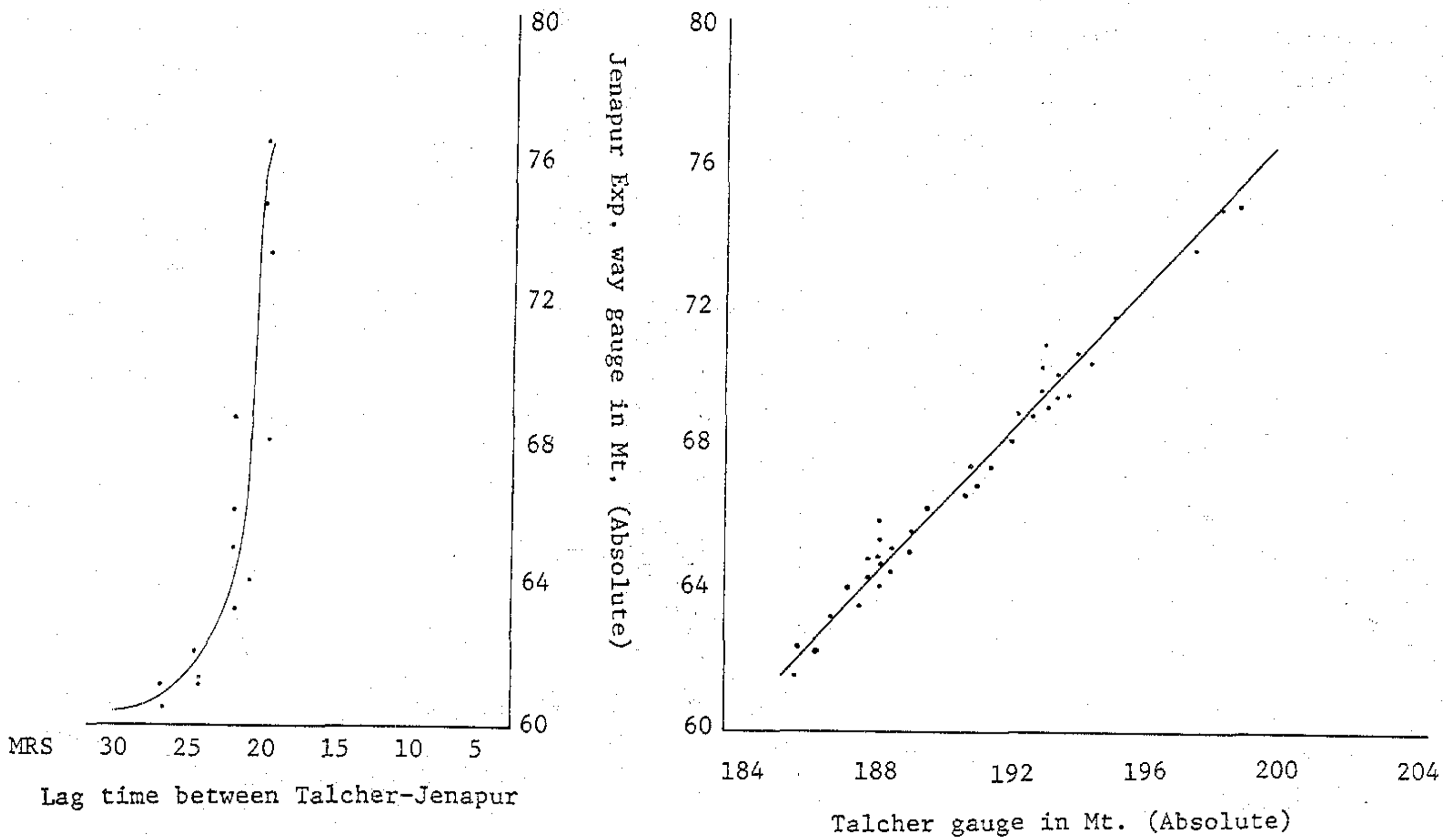


Fig. 4.4 Correlation graph of Talcher-Jenapur sub model.

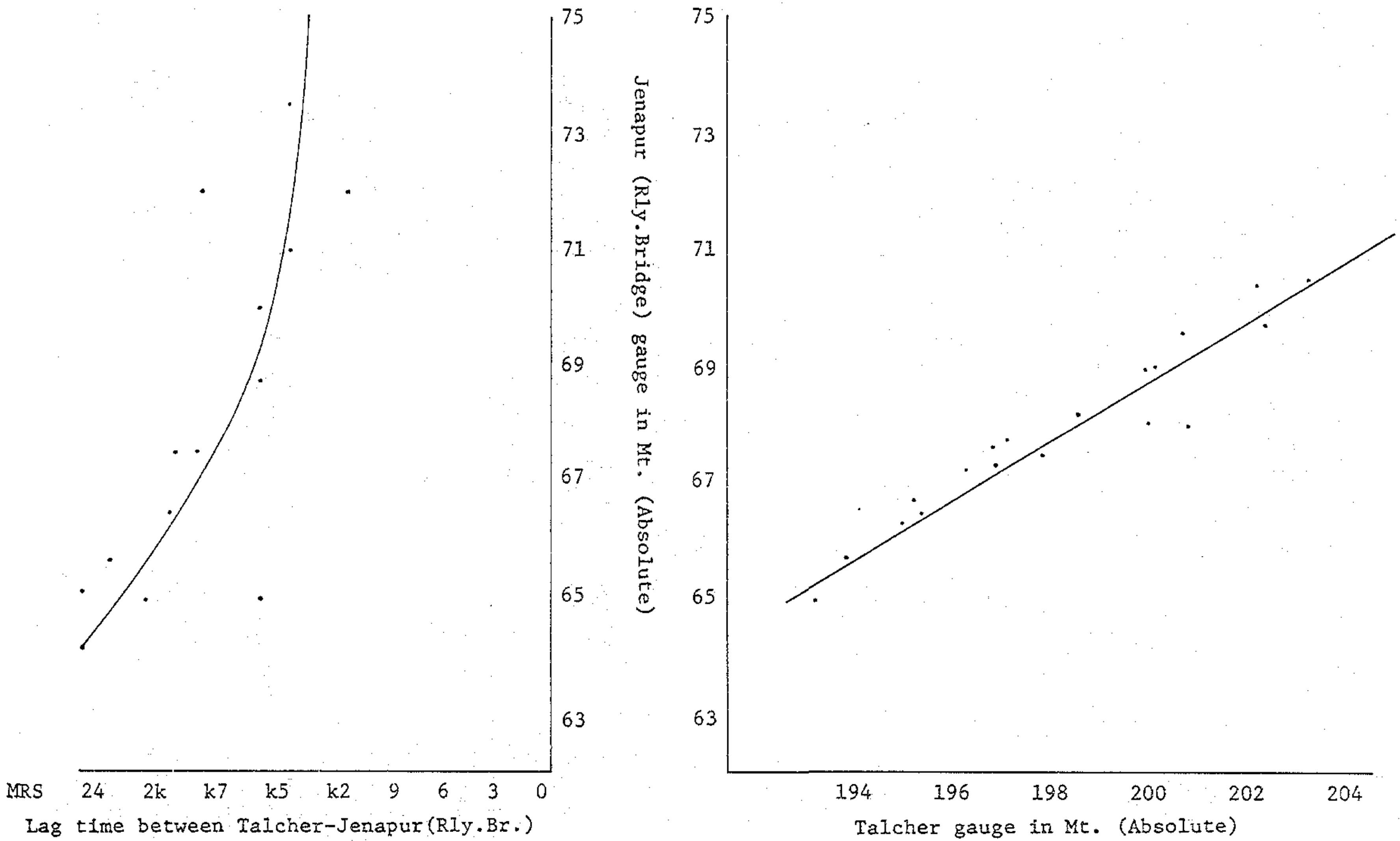


Fig. 4.5 Correlation graph of Talcher-Jenapur (Rly. Bridge) sub model.

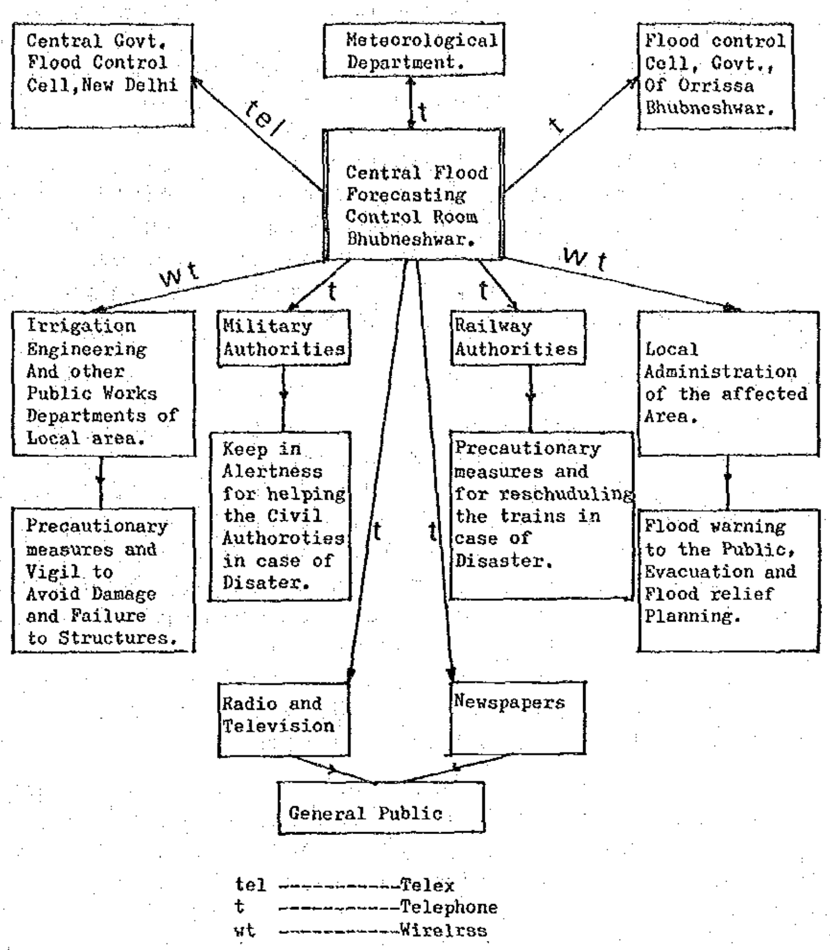


Fig. 4.6 Flood warning dissemination system of river Brahimini.

4.8 Storm surge:

Although the water level of river Brahimini in its lower reaches is effected by the storm surges its effect in formulation of forecast for Jenapur is not considered.

Flood Loss Prevention Measures in the Pilot River:

Comprehensive flood loss prevention measures can be classified into four groups as listed below. Each of the measure attempts either to deal with the flood waters or the activities that would be affected by them.

a) Attempts to modify the floods.
b) Attempts to modify the damage susceptibility.
c) Attempts to modify the loss burden.
d) Bearing the loss.

Each type of the measures can be adopted either independently or in combination. Some adjustments can be adopted by individuals, but most of them require collective action.

Following paragraphs describe these measures in special reference to the Brahimini river basin.

5.1 Modifying the floods:

Modifying the floods is one of the most popular approach to flood problem and has been used to alter the timings and intensity of floods waters. This approach involves i) construction of flood control or protective works; ii) adoption of measures which will retard the run-off from the land; iii) alteration of precipitation patterns through weather modification. First of these adjustments has been widely adopted since long times in Brahimini river basin. The second too has been started recently. However the third adjustment is still in experimental stage all over the world.

5.1.1 Construction of protective works:

The construction of flood control or protective works constitutes "channel phase" of flood management. It involves the construction of control works such as dykes flood walls, dams or reservoirs, channel improvement works or diversion of excess flow to another watershed where it can be accomodated without causing property losses. However this fosters increased flood plain occupancy, not all of which may be rational. Construction of dams, dikes and diversion works tends to develop a false sense of security among flood plain occupants. Therefore, it is imperative that these measures in addition should promote education relating to flood loss damage potential along with warning systems.

This particular approach has been used since long in the Brahimini basin in form of dikes, flood walls and channel improvement works. A multipurpose reservoir at Rengali for modification of the floods is under construction and is expected to modify the floods of 50 years frequency to within safe limits. In addition, the channel improvement works in the lower reaches are also required to be undertaken.

5.1.2 Watershed Management:

Another method of reducing small floods is to retard the runoff in the areas in which the precipitation occurs. It can be accomplished in a variety of ways. In Brahimini basin the measures are to be limited to the conservation practises such as terracing, contour ploughing, strip cropping and planting cover crops.

5.2 Modifying the damage susceptibility:

Second approach to reducing the flood damages is to modifying the susceptibility of property and activities in the flood plain to damages from flood waters. This can be accomplished either by flood plain management or by incorporating certain type of changes in structures and buildings.

5.2.1 Flood plain management:

Flood plain management, such as in land use regulation, attempts to modify losses by discouraging those activities which cannot bear the natural tax exacted by floods for the use of flood plain lands. The main land use in the Brahimini basin being agriculture, it is not possible to modify it. However, the agricultural practices can be modified to suit the flood environment and improvement in techniques sought to prevent crop damages due to long inundations.

5.2.2 Structural changes:

Damage susceptibility can also be reduced by undertaking structural changes. Among the various changes in structures are the construction of houses on stilts. This is being largely adopted by the local inhabitants in the Brahimini basin based on their past experiences with the floods.

5.2.3 Flood proofing:

Flood proofing is essentially a combination of structural change and emergency action. It does not necessarily involve evacuation. Rather it concentrates on the adoption of certain measures that can put into action as soon as flood warning is received.

5.3 Modifying the loss burden:

Another approach to the management of flood losses is to modify the incidence of burden, either by spreading it over a large segment of the community than the immediately effected or by spreading it more evenly over time. Several type of measures can be used, including disaster relief, tax write-off, flood insurance and emergency measures. All these methods are presently being adopted in Brahimini river basin except for flood insurance. Flood insurance measure has still a long way to go before it can be put to use in developing countries like India.

5.4 Bearing the loss:

Bearing the loss is still the major adjustment for large number of flood plain occupants in developing countries as well as in many more developed countries. However, this approach is gradually being abandoned in favour of management of flood plain lands to modify the losses.

6.0 ON FLOOD RISK MAPPING

6.1 A flood risk map contains accurate information on the magnitude of flood and distinct flood hazard area in order to provide information regarding reduction of flood damage. The flood hazard area on a map is usually distinguished by colored area display or contour lines of equal depths of water. It is the most essential tool of a flood manager. It helps him in preparing a comprehensive flood loss prevention management plan. It also allows an assessment of risk of potential flood losses and these risks can be balanced against cost of seeking a safer place or adopting a particular flood loss prevention measure.

6.2 Data outlined in the following paragraphs is required to be compiled in order to prepare a flood risk map.

6.2.1 The first requirement in preparation of a flood risk map is the topographical map of the area, including the contour map and ground levels in the flood plain area.

6.2.2 The historical hydro-meteorological data like rainfall (hyetograph), discharges and water levels (hydrograph) of the past flood events help in checking the correctness of the flood risk map.

6.2.3 Flood inundation maps of the past historical floods with informations regarding the time and depths of inundations in different zones of the flood plains help in evaluating the extent of damages caused by floods and in turn help in identifying the most critical areas requiring immediate attention.

6.2.4 Geomorphological maps and aerial photographs are required for identifying the vulnerable zones requiring more detailed hydrologic-hydraulic analysis.

6.2.5 A detail information regarding the capacities of the reservoirs and other flood control works existing in the basin help in preparation of the proper management plan.

6.3 There are four different approaches to the preparation of the flood risk map.

i) Geomorphological approach,
ii) Historical approach,
iii) Hydrological-hydraulic approach, and
iv) Hydrological-hydraulic-damage susceptibility approach.

All the four approaches have their merits and demerits.

6.3.1 Geomorphological approach:

This approach involves preparation of a flood risk map with the help of a geomorphological map. A geomorphological map indicates different land forms existing in the region and is compiled on the basis of plane shape, genesis, materials and nature.

6.3.2 Hydrological-hydraulic approach:

The process involved in this approach is outlined in the flow diagram shown in Fig. 6.2. Based on the interpretation of aerial photographs and the geomorphological map the basin is subdivided into smaller units of similar hydrologic and hydraulic characteristics. Each sub basin is then taken up individually and a hydrological model developed for it. Hydrological model can be developed by using tank model concept or storage function concept. Each hydrological runoff model is then interlinked together and an inundation model developed with their help. These hydrological runoff models should be checked individually or collectively depending upon the availability of the past records. The inundation model should also be checked with the help of historical flood risk map. After calibration of the models they should be used for calculation of the depths of inundation and extent of inundations for different return period discharges obtained from the past historical data. The depths of inundations for different return period discharges is then marked on the topographical map of the area and the flood risk map evaluated.

This approach is very exhaustive but, at the same time, time consuming and requires a large data. It cannot be used at the outset in the developing countries as there is generally little data availability.

In the absence of the data required for preparation of a flood risk map based on this approach for river Brahimini, the flood risk map of the pilot river could not be compiled. However, study was conducted with the help of available data for Mama river, Japan.

A brief outline of the approach to be followed for the flood risk mapping of Brahimini river basin is shown in Fig. 6.3. The outline is based on the limited information available from historical flood inundation maps and is liable to be modified with the availability of the geomorphological map and aerial photographs. It is felt that units 1 to 11 require only hydrological runoff model whereas units 12 to 19 require hydraulic inundation models. Effect of the surge shall also be taken into account as it is likely to effect the floods in the lower reaches.

6.3.3 Hydrological-hydraulic-damage approach:

This approach is similar to the hydrological-hydraulic approach except for the additional factor of the damages involved which help in identifying the areas of more damage probability and taking up flood protection measures for that area. Due to the economic factors involved in it close co-ordination with flood plain economist is of fundamental importance.

Different steps involved in the preparation of a geomorphological map for the purpose of preparing a flood risk map are:

i) Compilation of the topographical map of the area.
ii) Obtaining aerial photographs of the region.
iii) Interpretation of the aerial photographs to delineate the different landforms.
iv) Compilation of the land condition map.
v) Compilatiion of preliminary geomorphological map.
vi) Field checks in cases of doubt.
vii) Check with the historical data.
viii) Finalisation of the flood risk map on the basis of the above.

The geomorphological approach is simple and best suited in case there are no historical flood data. Also the flood risk map compiled on the basis of this approach is helpful in preparation of more detailed flood risk map on the hydrological-hydraulic and hydrological-hydraulic-damage susceptibility approaches.

6.3.4 Historical approach:

Historical approach is based on the inundation data of the past historical floods. It requires a topographical map followed by an intensive field survey. Historical data is collected from the old records, on the basis of past flood marks and local enquiries from the old residents of the area. Rainfalls and discharges for each flood event are collected and their return period estimated. Thus the inuntion area for any required return period flood can be estimated with the help of the map. Fig. 6.1 shows the schematic diagram of this historical approach. Although simple in procedure, this approach is liable to errors due to a number of human factors involved.

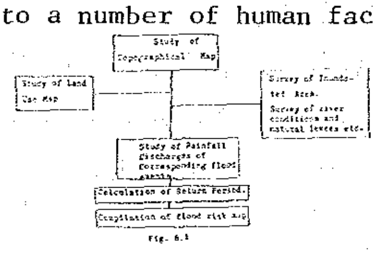


Fig. 6.1

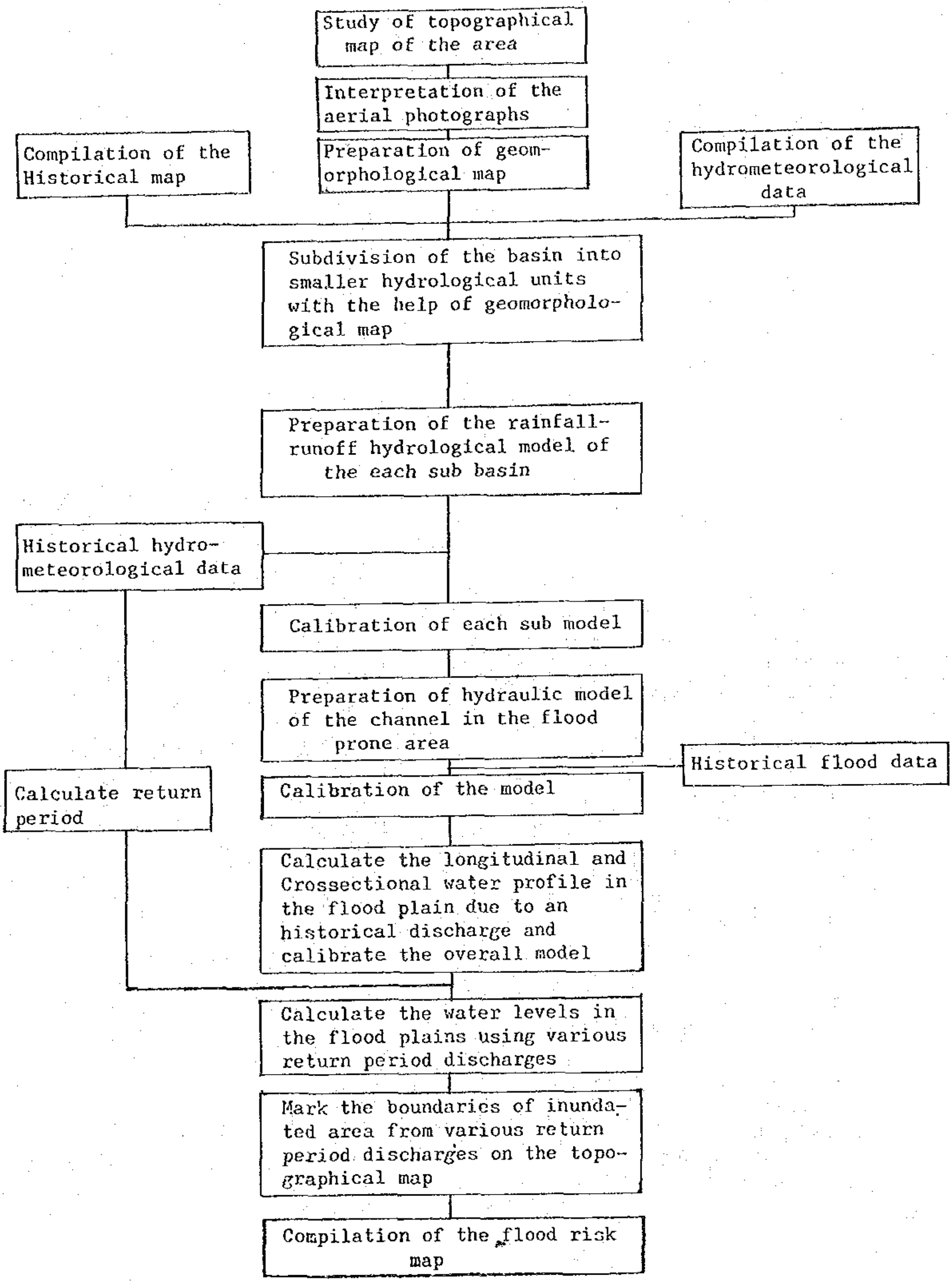


Fig. 6.2 Outline of the hydrological-hydraulic approach.

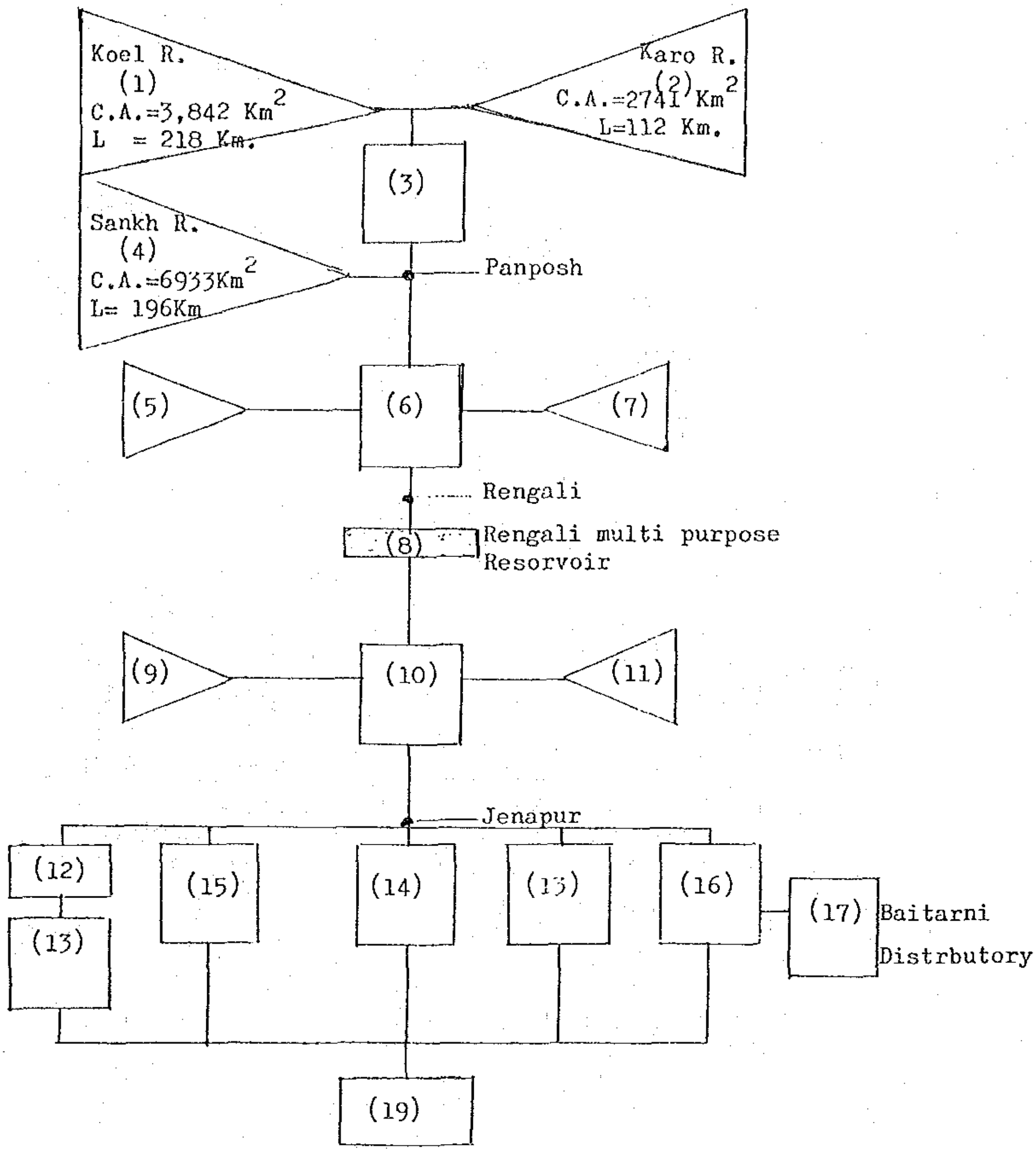


Fig. 6.3 A schematic approach to flood risk mapping in Brahimini basin.

By Ibrahim Bin Jusof
Malaysia

1. COUNTRY: MALAYSIA

2. DESIGNATED RIVER BASIN

From a number of river basins subject to flood problems, two have been selected for presentation during the visit of the Typhoon Committee Advisory Mission, these two are:

(a) *Kelantan River Basin and*

(b) Klang River Basin.

Two river basin were selected as they were difference in land use pattern. The Kelantan River Basin, located in the East Coast of Peninsular Malaysia, represents a large and mainly rural catchment and is vulnerable to the North East Monsoon which often brings in widespread and long duration rainfall. On the other hand, the Klang River Basin represents an urbanised catchment, with fast rate of development, and is vulnerable to a combination of both the monsoon rain as well as the convective thunderstorms.

However for the purpose of this course I had written about the Trengganu River Basin for the initial Country Report. Thus I would like to continue writing about the same River Basin.

2.1 Comparison of catchment area

Name of Basin	Catchment area (km^2)
Trengganu River	4,580
Kelantan River*	12,870
Klang River*	1,200

* Pilot rivers

2.2 Location

Trengganu River Basin
Latitude 4°40' N and 5°25' N.
Longitude 102°25' E and 103°05' E.

2.3 Topographical map of the Basin:

Not available

2.4 Index map:

2.5 General description of the basin:

The Trengganu River with its four tributaries, Nerus River, Telemong River, Tersat River and Brang River drains a total area of 4580 km. More than half the total area of the basin is comprised almost entirely of mountainous forest. The upland areas of the Trengganu River Basin ranging in elevation from 600 m to 1,500 m with its peak over 2,000 m. The lower third of the basin is mostly flat low-lying land with some areas of hills generally running into the foothills of the mountains which comprise the remainder of the basin. The flatter areas comprise most of the existing and potential agricultural lands of the Basin and are subject to flooding from the Trengganu River and its four main tributaries.

The Basin, which has a hurried tropical climate, has an average annual rainfall of between 2,700 mm and 4,000 mm with over 50% of this falling during the months of November, December and January. The basin is characterised by a uniform temperature (25 ° - 35 °C), high relative humidity, abundant but seasonal precipitation. The rainfall during the North-East monsoon (October-January is in the form of continous rainfall, usually heavy. From the end of January to April it is generally dry. From May to September (i.e. the Southwest Monsoon), the rainfall occurs associates with convective thunderstorm activity.

The Trengganu River Basin is not highly urbanised, the two main centres being Kuala Trangganu, the state capital and Kuala Brang, the administrative centre of the Ulu Trengganu District. Bukit Payong which is in between the two centres is this only other significant centre. The population density of the Basin varies from one place to the other in the range 12 - 312 person/km^2. The average population density is about 24 person/km^2.

2.6 Past floods and damages:-

On Records, major floods occurred in 1926, 1967, 1973 and 1979. An analysis of the flood damages shows that the average annual flood damages is about M$170,000.

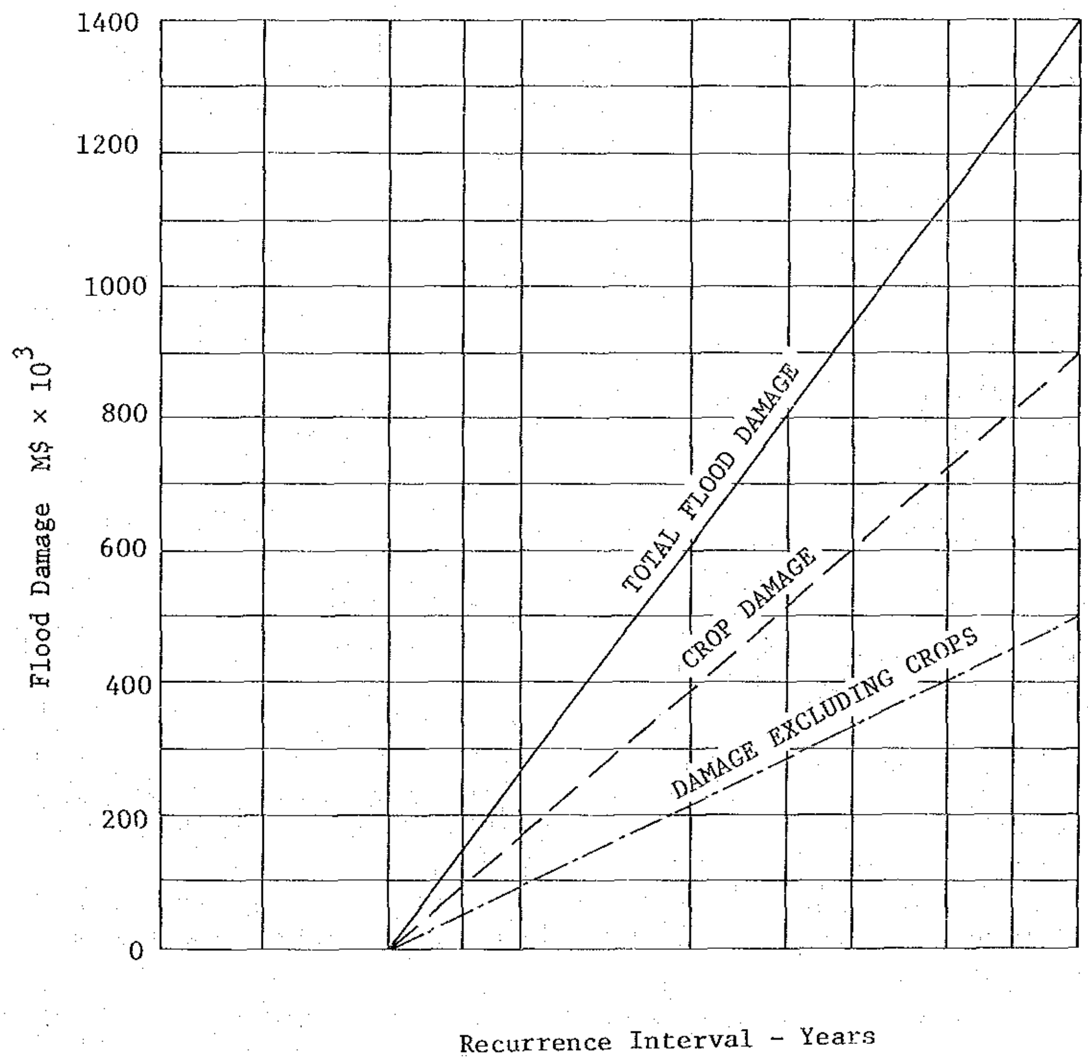
Floods in the Trengganu Basin cause direct losses as a result of the loss of livestock and damage to crops, the irrigation and drainage works, roads, buildings and other structures. There are also cost arising from the destruction of business, the destruction of transport, rescue and relief operations and special flood relief payments. In general the losses are related to the peak flood levels. For some items such as the damage to crops, however, the flood duration is more critical than the peak discharge.

An examination of the data available for the Trengganu River Basin shows that the estimates of flood damages to the irrigation and drainage works, the veterinary losses and the flood relief payments have a reasonable correlation with rank of the peak discharge of the flood. The damage to roads and the agricultural losses do not have any correlation with the peak discharge but the agricultural losses showed some correlation with the Flood Volume.

FLOOD LOSSES M$ × 10^3

Year / Month	1965-66 December	1966-67 January	1970-71 January	1971-72 December	1972-73 December	1973-74 December	1974-75 December	1975-76 November
Flood Peak Return Period	9.2	30	3.8	3.3	17.0	6.1	2.0	4.3
Flood Volume Retern Period Mean of 7 days	4.1	21	9.8	7.5	8.5	17.5	3.5	2.3
Agriculture	1036.2	*	510.6	292.0	175.4	580.3	52.8	Small
Irrigation & Drainage	58.3	151.3	29.5	22.9	120.0	33.0	42.3	26.6
Roads	850.0	790	*	*	91.3	*	0	Small
Veterinary	59.7	*	*	*	38.2	27.1	2.1	Small
Relief Payment		115	*	*	74.5	18.5	20.8	Small

FLOOD DAMAGE FREQUENCY CURVES



3. FLOOD PROTECTION AND RELATED WORKS IN THE BASIN

Since 1973, a telemetring flood forecasting and warning system has been established. The Kenyir Multi purpose dam is now under construction and expected to be completed by 1984. It will have a catchment area of 260,000 ha which is more than half the total area of the Basin and is comprised almost entirely of mountainous forest. It is expected that with-dam condition the flooded areas will be reduced to about 30%.

Steps also have been taken and continously being taken in improving the lower position of road by raising its level above the flood level. The paddy field being protected from the inundation by Drainage and Irrigation system.

4. EXISTING FLOOD FORECASTING AND WARNING SYSTEM

The purpose of the forecasts is to warm residents on the flood plain about the imminence of flooding and to provide them with the maximum time to carry out the necessary precautions to reduce flood damage. Three types of actions are anticipated in response to forecasts:-

(a) the evacuation of people from flood affected areas.

(b) the evacuation of livestock and other assets from flood affected areas and

(c) Construction activities to prevent inundation of flood-prone areas.

Each of the above actions requires a different duration of time for its excution and, therefore, each needs different warning times.

In 1973, the Drainage and Irrigation Department developed a forecasting procedure to predict the flow of the Trengganu River at Tanggol. The gauging station at this location provides the flow from a catchment of 3,340 km^2, which is about 73% of the catchment of the total basin of the Trengganu River.

As for obtaining the real time data for forecasting purposes the following stations and equipments installed at these places.

(i) Terminal Control Centre at state D.I.D. operation room in Kuala Trengganu.

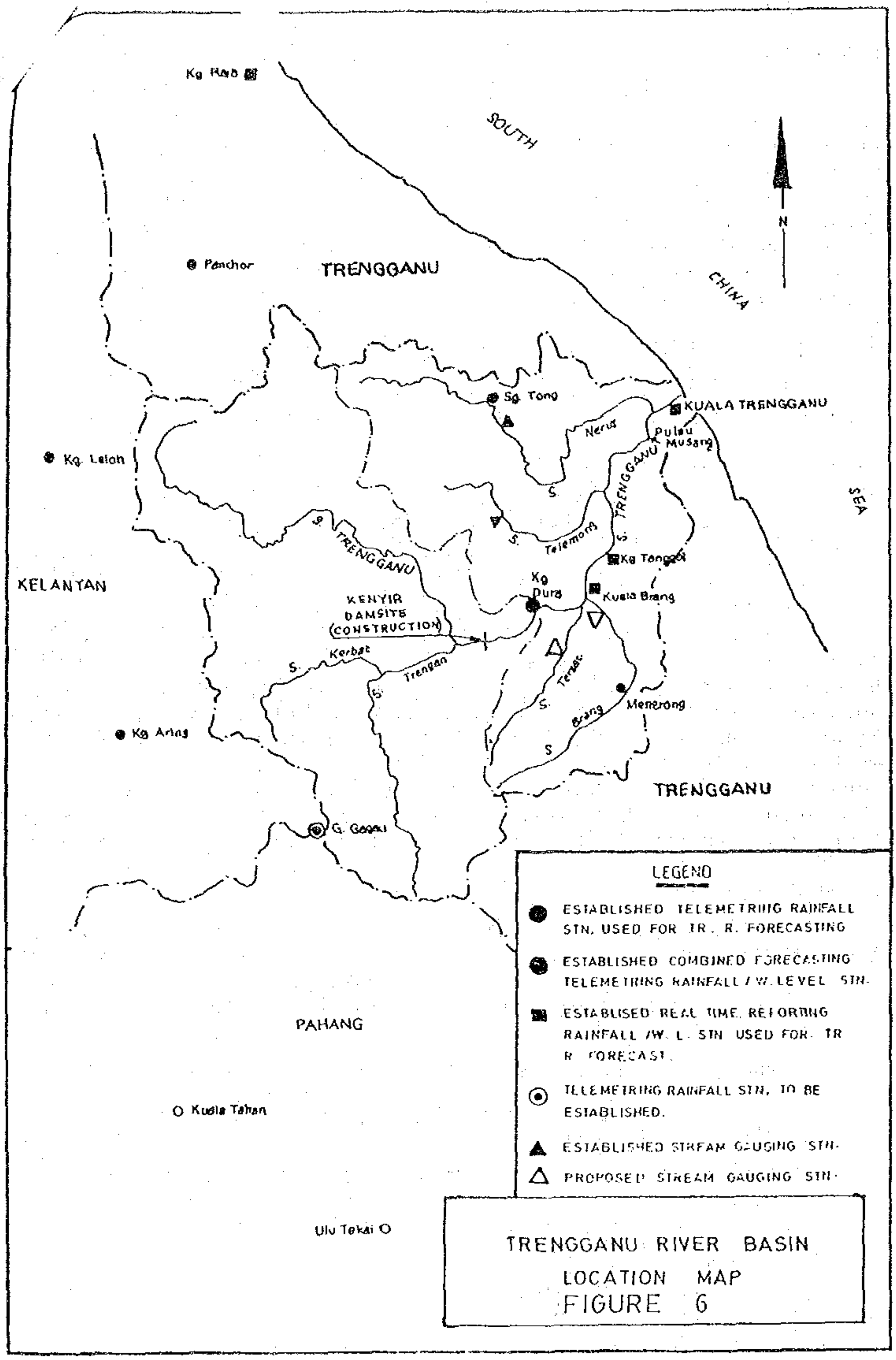
(ii) Rainfall Telemetric outstation at Menerong, Sg. Tong and Panchor.

(iii) Combined Rainfall/Water level Telemetric outstation at Kg. Dura.

(iv) Real time reporting rainfall and water level station at Kuala Brang and

(v) Real time reporting water level station at Kg. Tanggol.

The Sacremento Model has been used to derive the forecasted flows and to adjust the forecasts to the discharges obtained from the telemetered water level records at the Trengganu River at Kg. Dura



TRENGGANU RIVER BASIN
LOCATION MAP
FIGURE 6

(catchment area 2,610 km^2), or obtained from the observed water levels at Tanggol.

FLOOD LOSS PREVENTION PLANNING

Flood is a disaster and I believe to prevent it is better than curing it. What I mean is that comprehensive Flood Loss Prevention and Management (especially by good watershed management, will keep the condition of the river as natural as possible. In most cases this is not always possible as the development needs of a country always overseled the hydrological need of the river. Thus after experiencing losses due to flood, large investments in flood control measures is necessary which have not always resulted in an overall reduction in flood losses.

Flood River Mapping

Flood River Mapping is the most important information for good watershed management as well as for planning the future development. It helps to identify highly vulnerable locations for flood damage. In the later case it also assist in planning the correct structural-measures for certain areas in the watershed.

Zoning Regulations and Land-use Regulations

I think these are the initial step of non-structural measures which will be beneficial if applicable at the beginning or before the development of the basin taking place. For newly developed lands, only open space should be allowed in the zone of highly flood risk. No important structures/buildings such as hospital, schools, police stations, fire stations, etc. should be located in any flood-prone zone. In the occasion when structures must be permitted in the high-risk flood zone, they must be designed such that they could withstand the flood, and could be used during the flood without increasing the floods magnitude somewhere. However there would be some difficulty in the area that is already developed.

Flood Forecast

The purpose of the forecasts is to warm residents on the flood plain about the imminence of flooding and to provide them with the maximum time to carry out the necessary precautions to reduce flood damage. Three types of actions are anticipated in response to forecasts:-

a) the evacuation of people from flood affected areas

b) the evacuation of livestoch and other assets from flood affected areas and

c) construction activities to prevent inundation of flood prone-areas.

Raising Structure:-

The rural population has traditionally built its houses on posts on pilings which elevate the dwelling and its possessions above the flood level. Generally they raised their house 1.5 m - 2 m above the ground level. However this may not always be practical in the urban areas.

Dams and Reservoir:-

This is the beneficial way, as it helps to mitigate flood and on some occasion (Multi-purpose) it could assist in hydroelectric generation, Irrigation and also Domestic water supply. In other words the amount of water could be utilize as well as mitigate the flood.

As the basin area of the river is rural, the constructions of Levees, Dykes Bunds and Flood walls along the river may not be justificiable at present. However bands are usually constructed in irrigation project for paddy field to prevent the crop from being inundated. Various other methods should be implemented especially for the new urban/developing areas in the upper catchment as:-

i) Flood detention. (detention ponds)

ii) Parking lot detention ponds.

iii) Infiltration ponds.