Procedure adopted for Flood Forecasting in Teesta Basin. Strength & weaknesses of present Forecasting System. Tools/data/Program and Infrastructure required to improve the existing forecasting system of Teesta Basin.

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SYNOPSIS: This assignment presents the techniques being operated in CWC to issue forecast of flood in Teesta Basin. A brief on characteristics of Teesta river catchment & how it affects direct surface run off has also been discussed. The data of Teesta river is classified in nature, as Teesta is a trans-country river. Therefore, detailed illustration of current operational flood forecast methodology is made with a set of sample representative data. The significant shortcomings of present forecasting method and ways of improvement, mordenisation and upgradation have also been suggested based on the training modules. Plans to improve the overall network being undertaken in CWC and flood forecast system has also been detailed.

1. Introduction

The flood forecasting activities in Teesta river basin is carried out by the Lower Brahmaputra Division of Central Water Commission since the year 1969. Presently, two level forecast stations on Teesta river one, at Domohani Road Bridge (Jalpaiguri) and other at Mekhilganj (Coochbehar) are being maintained by CWC using most conventional methods of co-axial correlations & Gauge to Gauge correlation. The base stations on river Teesta established at Teesta Bazaar, Coronation Bridge and its tributaries are Chel & Naura. For getting trend the gauge data collected at Sanklang, Khanitar & Mazitar sites are utilized. However, there is no inflow forecast station established by CWC till now though cascade development of power plants happened in teesta river basin

While inflow forecast is provided for assisting in reservoir regulation and monitoring outflow, the stage forecast is one where the water level is predicted well ahead of its occurrence based on observed rainfall and river gauge data of base stations and the trend is confirmed from the ancillary sites.

The simple gauge to gauge relation and multi co-axial correlation for arriving stage prediction are being in operation at these two forecast stations of CWC on Teesta river, the complete flow of activities right from data collection to dissemination of flood forecast under operation at these sites is dealt pari-passu with its strength & weaknesses in later sections.

The local administration, based on the topography, field survey and considering their comfort zone for flood rescue, decides the Danger Level for example at Domohani site Warning Level is 85.65m, Danger level is 89.30m and HFL is 89.30m (observed on 14/10/1968). Warning Level is generally one meter below the Danger Level. Upon completing the prediction of flood stage, CWC disseminates alerts as per Standard Operating Procedure directives issued by National Disaster Management Division, Ministry of Home Affairs;

Category	Descriptions	Bulletin
IV	Low Flood (Water Level between warning Level and Danger Level)	**Yellow**
III	Moderate Flood (Water Level 0.5 m less than HFL and above Danger Level)	**Yellow**
II	High Flood (Water Level less than HFL but still within 0.5m of HFL)	**Orange**
I	Unprecedented Flood (Water level equal and above HFL)	**Red**

2. Characteristics of Teesta river Basin:

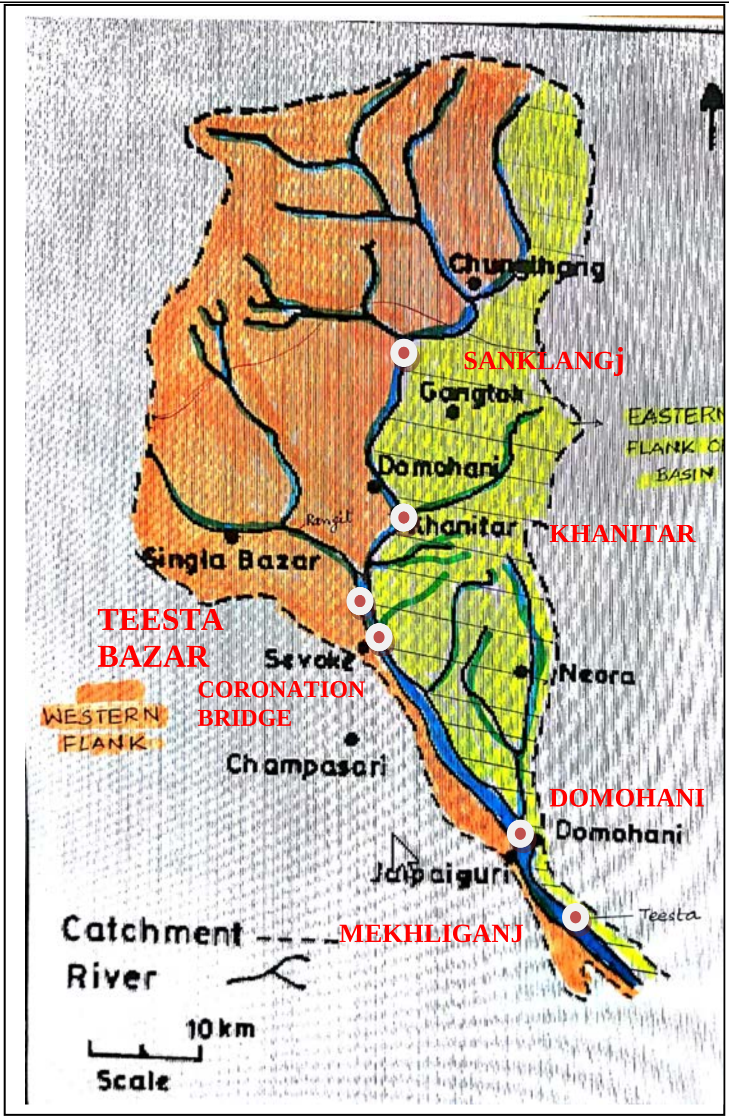
As we learnt in the comet module on Flood Forecasting Case Study, how the watersheds characteristics and local land features relates the run off process. And therefore a brief write-up on Teesta river catchment is made hereunder.

Teesta river originates as chhombu chu from a glacial lake Khangvhung chu at an elevation of about 5280m in the northeastern corner of State of Sikkim. *The tributaries in eastern flank of basin are large in nos. but are shorter in course whereas the major tributary in western flank is river rangit which is much longer & cover larger drainage area consequently contribute much more discharge to Teesta river.*

The soil of Teesta basin in general is loamy sand to silty clay loam with a depth of 30 cm to 100 cm and in some cases even more than 120 cm and mostly over impermeable fresh rock layer. So there is more lake formation and less availability of deep water. It has less water holding capacity and is dry in nature. The western flank has more forest canopy than eastern flank and less steeper therefore, acts as main contributor during non monsoon through base flow.

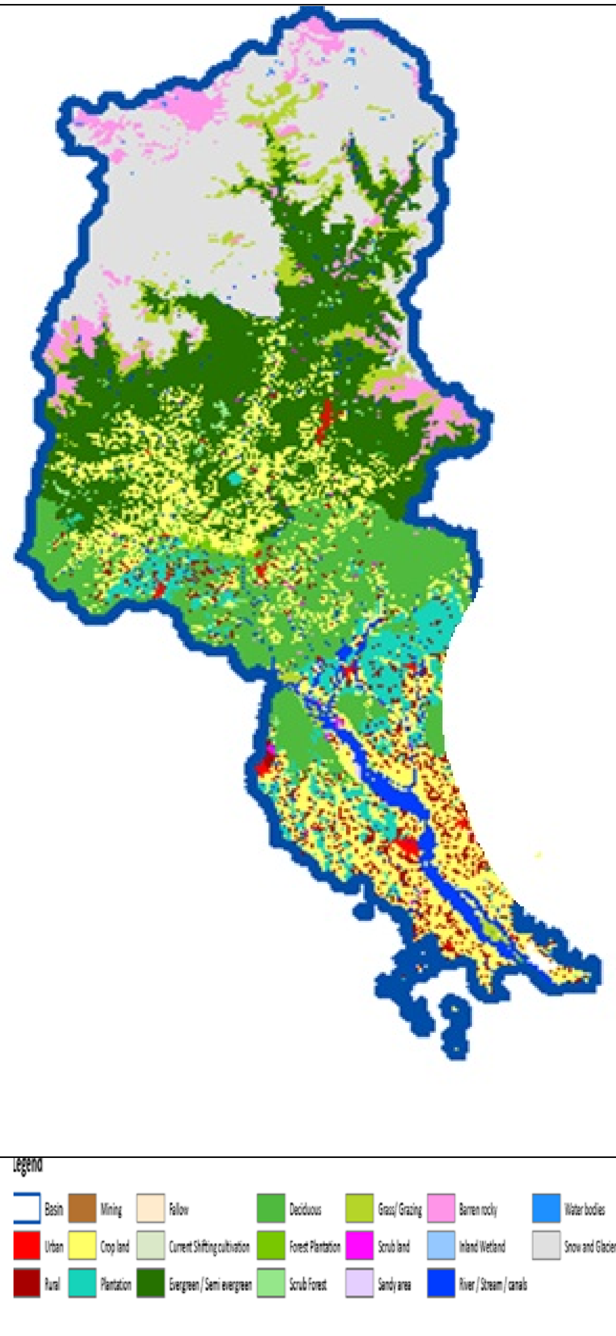
Whereas, the western flank contributes more continuous discharge, the eastern part of basin drain much faster to the river due to steeper slope and soil & rock bed characteristics, thus rainfall in eastern flank contributes effectively in flash floods (See Neora valley in Fig.).

The diagram of basin, land use and land cover, will depict more vividly the basin physiographic:



Eastern Flank is more steeper than Western Flank
1.Domohani Road Bridge 2. Mekhliganj FF Site 3. Teesta Bazar 4. Coronation Bridge 5. Sankalang 6. Khanitar [all shown]

BASIN MAP OF TEESTA RIVER (Fig.-1)



Land use and land cover of Teesta basin (Fig.-2)

3. Description of Flood Forecasting Methodology and its strength & weaknesses

The Lower Brahmaputra Division of CWC has adopted the following conventional methods for making flood forecast on Teesta river;

i) Gauge to Gauge co-relation

ii) Multiple co-axial correlation diagram

Rise and Fall in water level (difference of gauge method)

The above methods are simple to work upon but drop no hint about the shape of likely flood hydrograph at forecast site. Moreover, through this method flood alerts can be issued only with 8hrs to 10 hrs. before occurrence. Whereas, through the hydrological models flood forecast based on rain forecast could be predicated 3 days ahead of its occurrences and gives the local populace more time for rescue. An "ensemble" approach may lead to upto even 15 days ahead forecast. [reference: "The NWA module on Flood Forecasting Technique"]

The set-up for flood forecasting and procedure being adopted are detailed hereunder;

Following primary hydro-meteorological observatories are setup for carrying out flood forecasting of Teesta at Domohani and Mekhilganj stations;

Sl. #	Location (from U/s to D/s	Data observed	Method of observation	Frequency of data observation	Station type
1.	Sanklang	Gauge	Manual	Hourly during Monsoon	Base Station
2.	Khanitar	Gauge & Rainfall	Manual/SRRG	Hourly	Base Station
3.	Teesta Bazaar	Gauge & Discharge	Manual/Float method	Hourly/ daily	Base Station
4.	Coronation Bridge	Gauge	Manual	Hourly	Base Station
5.	Domohani	Gauge & Discharge	Manual/Float method	Hourly/ daily	FF Station
6.	Mekhilganj	Gauge	Manual	Hourly	FF Station

The forecast method presently adopted is dependent on observations at few sites and ignore the effects of drainage from un-gauged area of basin lying between base station and forecast station. In the present case the Neora valley in the eastern flank of teesta basin between base station Teesta bazaar and Domohani. Any rainfall in this area highly affects the flood level at domohani as the travel time is about 6 hrs., only.

3.1 Identification of Forecasting Station and its location:

The location of the flood forecasting stations was selected as per the local populace/ District Administration. The base stations for a flood forecasting stations was selected generally in such a way that the travel time of flood wave from base station to flood forecasting stations shall be approximately equal. The map depicting the location of various sites is shown above at **Fig.-1.**

3.2 Computation of Travel Time:

The hourly gauge observed at base station of same period is plotted with time & date of observation. On same time scale the hourly gauge observed at flood forecasting station are plotted. For example, the hourly stage hydrograph plotted for base station – Coronation Bridge Vs. FF station: Domohani for the period 1st May to 31st October (2016) is shown at **Fig-3.**

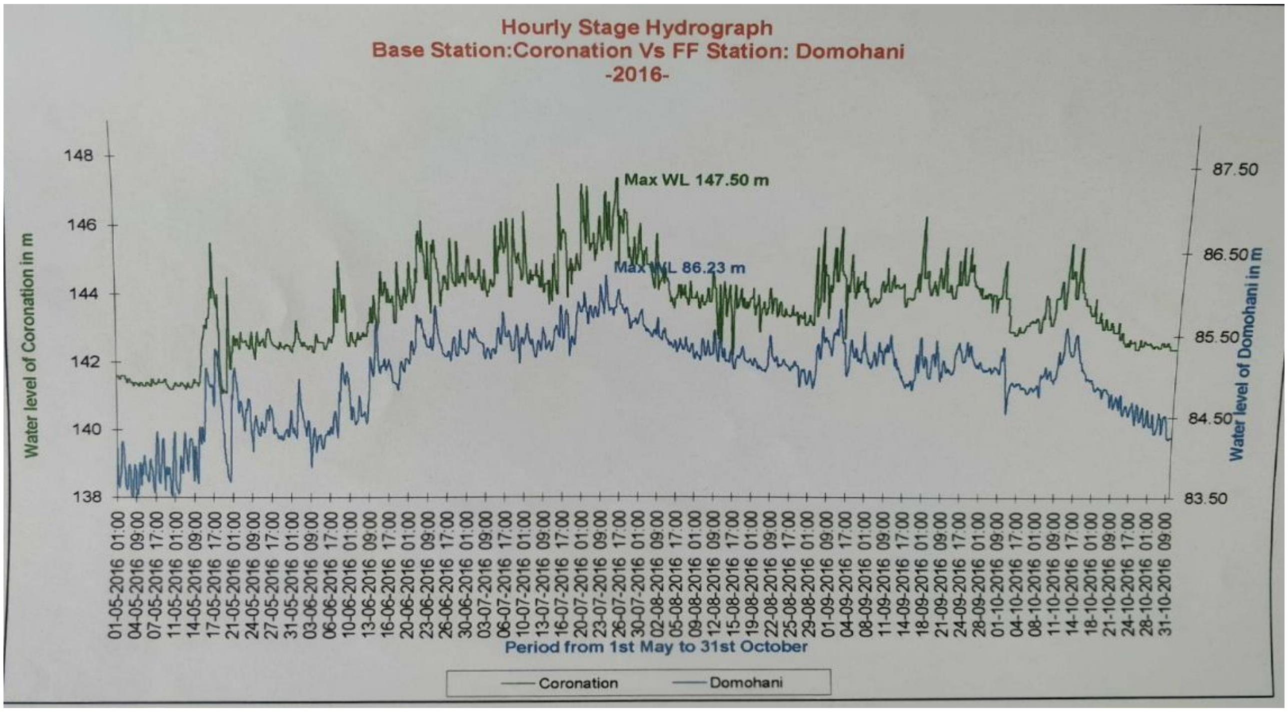


Fig.-3

Similarly, the hourly gauge hydrograph for base station: DomohaniVs. FF Station: Mekhilganj is at **Fig.4.**

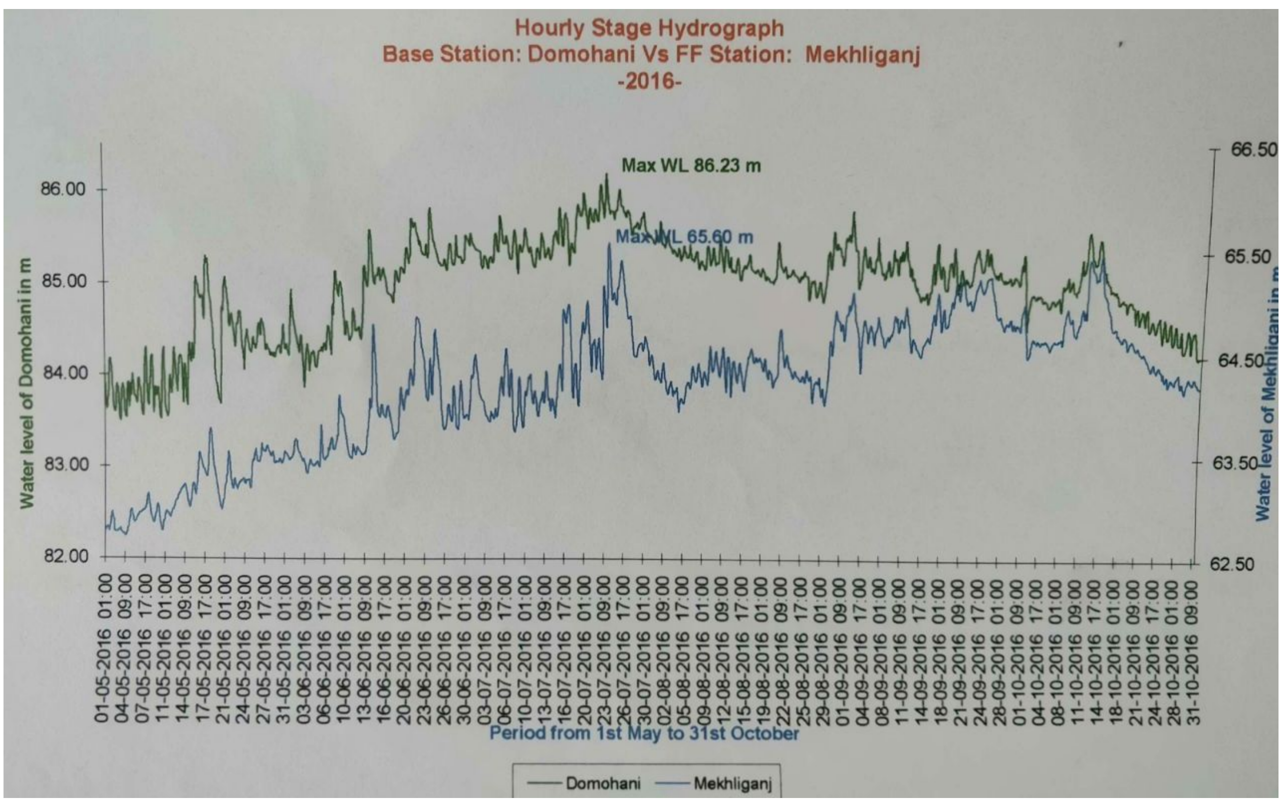
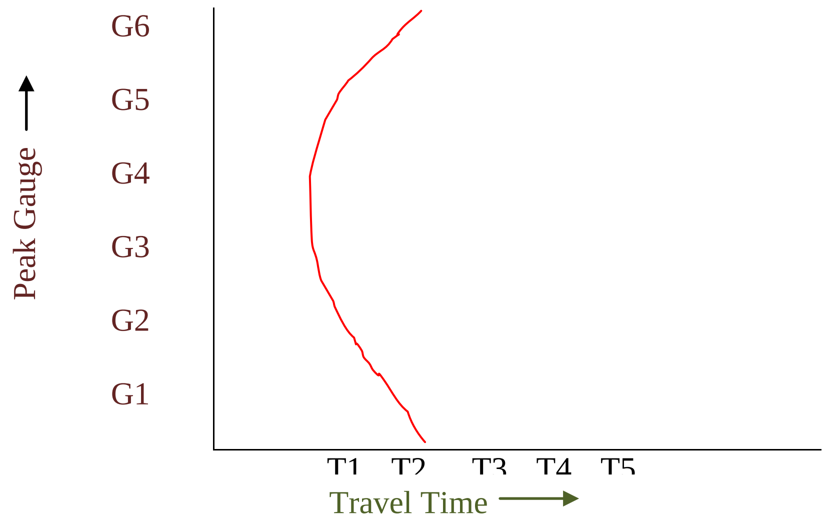


Fig.4

From the hourly gauge hydrograph, the travel times of flood /flow is determined i.e. the difference in time of occurrences between subsequent crests of hourly gauge hydrograph at forecast station and base station. For example suppose the gauge peak of 86.23m (G) is observed at 0900 hrs on 23/07/2016 at Domohani (base station) and the corresponding peak of 65.60 m observed at 1700 hrs on 23/07/2016 at Mekhilganj (FF station), the difference in occurrences of peak in this case works out to be 8 hrs. (T). A graph between the travel times (T) corresponding to different peak gauges observed at base station (G) are plotted to assess the travel time of flood.



The flood forecast of 8hrs can only be predicted based on the location of base station (Travel Time) which is one of the weaknesses of the conventional method.

3.3 (a) Forecast Method using Rise and fall in water level at Teesta Bazaar (Multiple coaxial diagram)

The stepwise formulation of flood forecast utilizing the observed historical data of water levels observed at base station and forecast station is given as under;

a. The average travel time from the data sheet of peak levels say T=8 hrs. in the present case.

b. From the observed data of water level of Nth hrs (say 1600hrs.) and (N-T)th hrs.(0800Hrs) of base station, change in stage i.e. the rise or fall in stage is determined. For example, the water level at 0800 hrs. at Teesta Bazar is 207.50m and at 1600 hrs. it is 207.90m . In this case, there is a rise of stage by 0.40m.

c. The rise in gauge at base station occurred due to a flood will travel to forecast station in a travel time T.

d. Now, the gauge observed at Domohani flood forecasting station at Nth hrs [1600hrs] is now plotted with gauge observed at domohani sites after (N+T)th [2400hrs]. This point corresponds to the rise of water level of 0.40m at base station. Similarly all points are marked and correlation diagram is developed.

e. As per above a correlation between the Nth hour and (N+T)th hour water level of the forecasting station with change in stages at base station during past T hours as parameter is developed as shown in **Fig.5**.

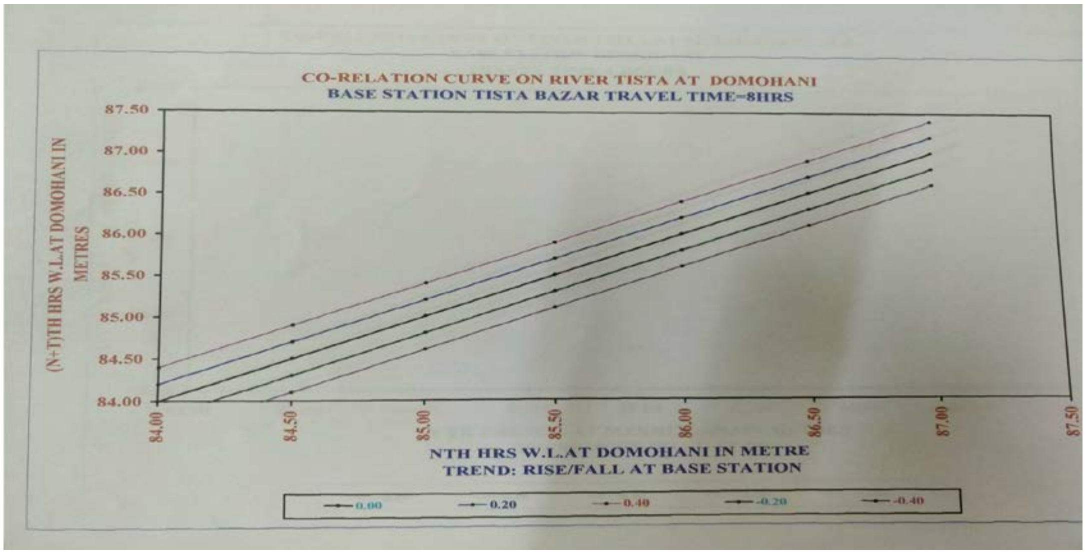


Fig.5

f. Further to incorporate the effect of rainfall of Neora valley, coaxial correlation between Nth hour and (N+T)th hour water level of the forecasting station with average corresponding rainfall in the Neora valley during the past T hours as parameter is developed at **Fig.6**.

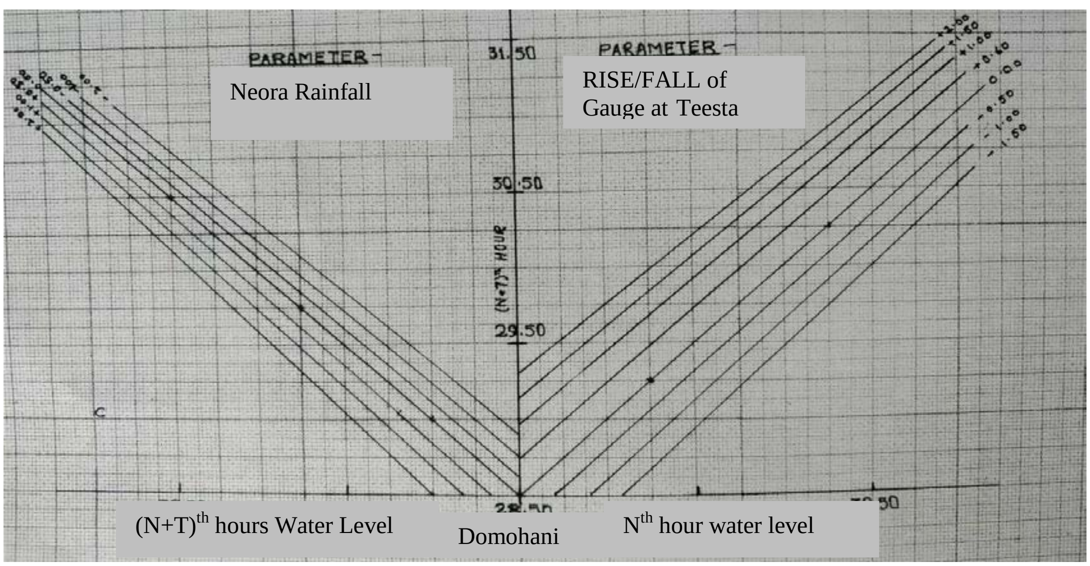


Fig.6

Based on this correlation models the level at flood forecast station is predicted based on the observed rainfall and rise/fall of gauge at base station.

Being a conceptual approach, there is absence of statistical test to measure the strength of correlation. However, such diagrams do not require skilled personnel to operate and proved to be useful in absence of seamless flow of data from remote locations to forecast centre. These charts cannot predict about the shape of likely flood hydrograph at forecast site.

3.3 (b) Simple Gauge to Gauge co-relation hydrograph method of forecast

Simple Gauge to Gauge co-relation between Domohani Base station and Mekhliganj FF station is formulated as there is no tributary in between these stations. The correlation graph is developed considering different peak levels of base station and corresponding peak levels of forecasting stations. Average travel time is obtained from the data sheet of peak levels. The following diagram (**Fig.-7**) depicts the Gauge to Gauge co-relation between Domohani Base station and Mekhliganj FF station.

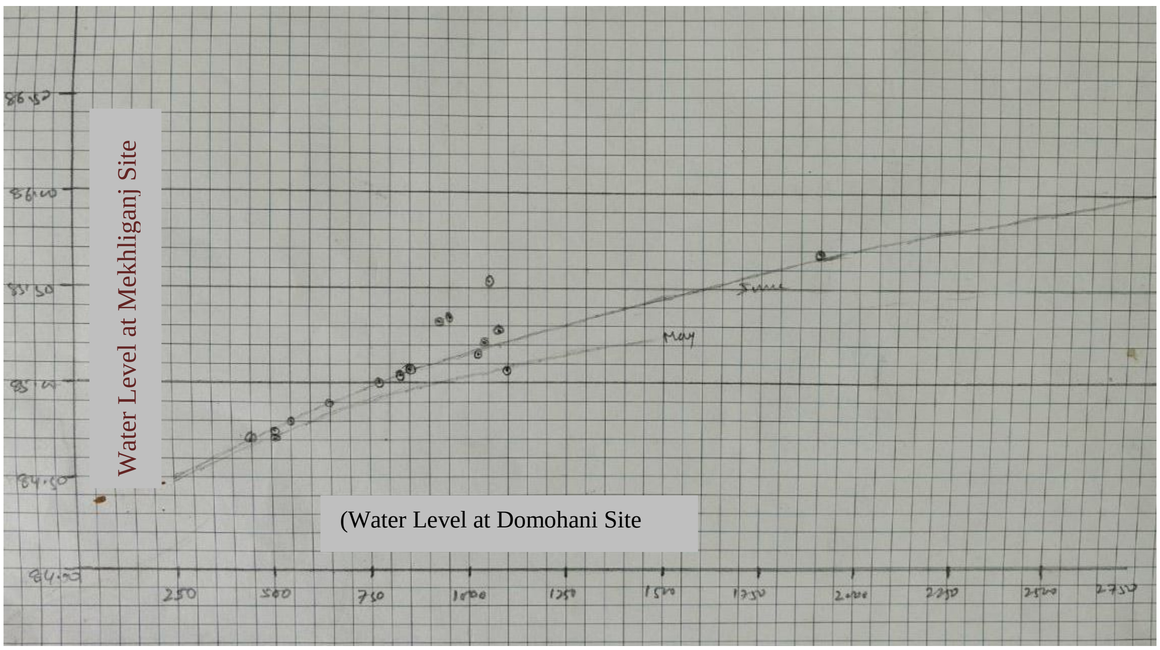


Fig.-7

The Minimum Water Level and HFL at Domohani base station is 82.50m and 89.30 respectively [total variation 5.80m] and that of flood forecasting station at Mekhilganj, it is 62.50m and 66.45m (HFL) [total variation is 3.95m]. Therefore correlation among data is to be made with small range of variation i.e between 5.80m vs. between 3.95m. Due to availability of long historical data such correlation (developed for small range of data variation) has respectable degree of correlation coefficient. Being a mathematical approach, this method gives more reliable forecast predictions.

3.4 Formulation of forecast

The water level, rainfall, discharges etc. data from base station sites are transmitted through wireless or mobile. After receipt of data, forecasts are being formulated at Division level with the help of coaxial diagram/ Gauge to Gauge correlation diagram developed for each sites. Personal judgment may also be considered while formulating forecasts for better accuracy. Thereafter, Daily flood bulletins/Red/Orange bulletins are issued at Division level.

3.5 Outline of Strength & Weaknesses of Forecast Method vis a vis Tools/data/Program and Infrastructure required to improve the existing forecasting system of Teesta Basin.

A. Strength

i) Availability of data for a long period results in a reliable correlation model.
ii) The present method is simple and do not require skilled personnel.
iii) It do not require vast network of data collection sites.

B. Weaknesses of existing Forecast method vis a vis Tools/data/Program and Infrastructure required to improve the existing forecasting system

i) **Lack of Inflow Forecast**: Cascade development of hydroelectric Project results in pooling in river reaches and makes the prediction by present method void. The construction of Teesta Low Dam Stage-III and IV between Teesta Bazar and Coronation Bridge. Dikchu dam between Sanklang site and Khanitar has now raised the need of inflow forecast station and regulation of outflow from reservoir through central nodal agency like CWC rather than project entity.

ii) **Soil characteristics**: This method does not account for soil moisture and other characteristics in forecast.

iii) **Less time of Forecast**: The present forecast technique is most conventional and predicts adverse events typically 24 hrs ahead thus giving very less preparation time for rescue management. Flash floods which are very common in this basin could not be predicted by this method in time.

iv) **Inadequate Hydro-meteorological Network of Site**: Large part of upper reaches of basin is covered with Snow and there is no Exclusive Snow Meteorology (ESM) station in basin. The present method cannot predict the flash floods on account Glacial Lake Outbursts Flow.

v) **Optimization of Network of Hydro-meteorological Sites**: The hydro-meteorological networks presently established are basically for specific need of Hydro-electric Projects (CWC named such sites as Tertiary sites). Presently different State/Centre/PSU/Private agencies have established sites as per their specific need resulting in haphazard network of sites. An optimization of hydro-meteorological network is required for development of hydrologic model for flood forecasting in Teesta basin.

vi) **Automation of data collection**: The data transmission is still made by old system of wireless system, failure of communication may lead erratic forecast. A network of 41 no.Telemetry stations designed for Teesta basin for automation of data collection and transmission in real time domain and generation of flood forecast through flood modeling centre are being established by CWC as per the below diagram (**Fig.-8**)

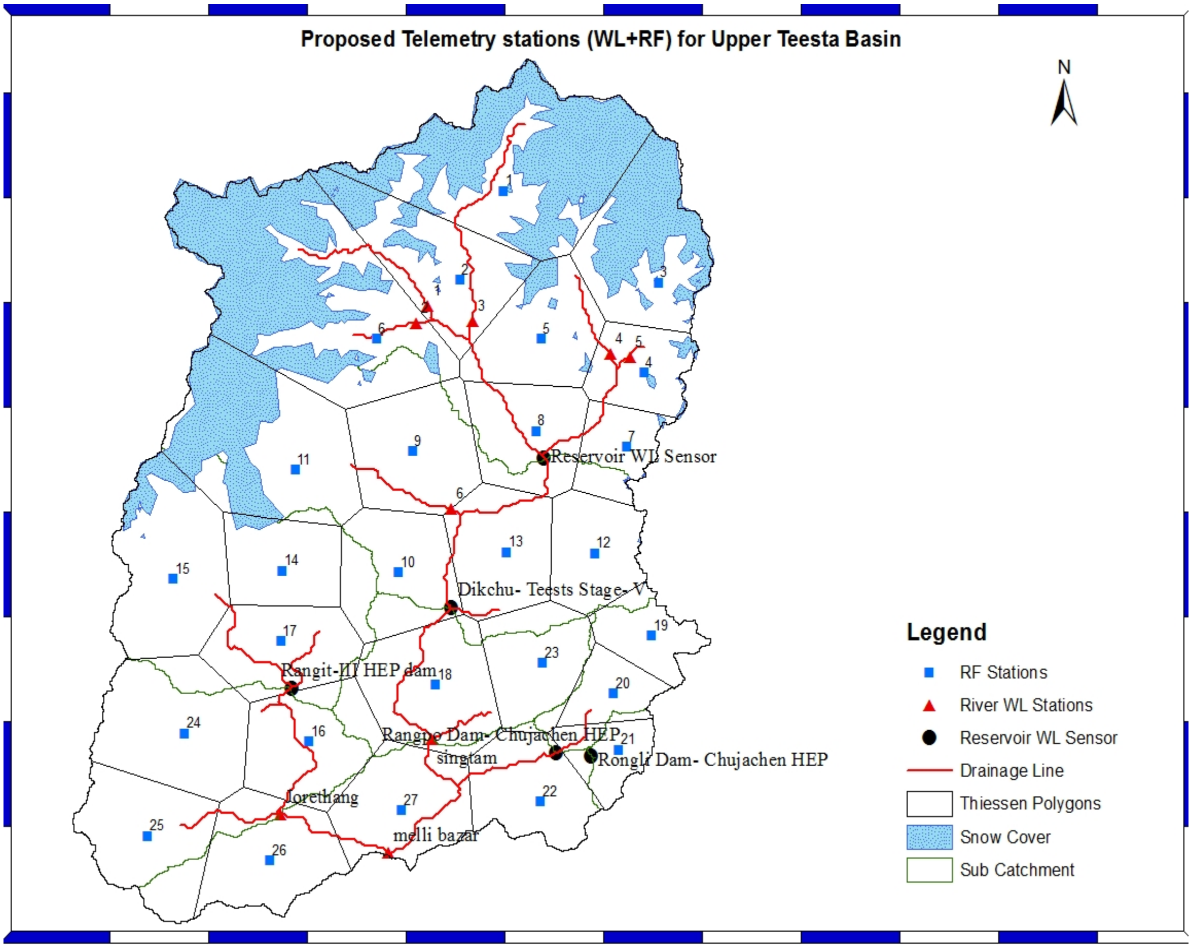


Fig.-8

vii) **Data Transmission** Satellite based real time transmission system to transfer data in real time basis to Earth receiving System.

viii) **VSAT** shall be used for transmission of data in real time basis from Earth Receiving Station to Modelling Centres.

ix) **Introduction of Software** like MIKE-11, MIKE Flood, HEC RAS mathematical models software & Development of specific software appropriate for Flood forecast in Teesta Basin

x) **Digital elevation Maps:** Conversion of level forecasts into inundation maps through Digital elevation Maps which further can be associated with mobile apps for dissemination to local people.

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***References*:**

1. *Comet Module on Flood Forecasting Case Study*
2. *NWA module on Flood Forecasting Techniques*
3. *Water Year Book of B&BBO, CWC.*