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STATEMENT OF THE PROBLEM

OBJECTIVES

HYPOTHESES

RESEARCH METHODOLOGY

RESULTS & DISCUSSION

FINDINGS

RECOMMENDATIONS/SUGGESTIONS

CONCLUSIONS

SCOPE FOR FURTHER RESEARCH

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BOOKS

- Bowersox, Donald J., Closs, David J., (1996), "Logistical Management." Tata McGraw, Hill, New Delhi.
- Hunker, H.L. and A.J. Wright (1963), "Factors of Industrial Location in Ohio" Ohio State University, Nigeria.

CONTRIBUTIONS TO BOOKS

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

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- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

CONFERENCE PAPERS

- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–22 June.

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- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

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WEBSITES

- Garg, Bhavet (2011): Towards a New Natural Gas Policy, Political Weekly, Viewed on January 01, 2012 http://epw.in/user/viewabstract.jsp

ASSESSMENT AND MANAGEMENT OF FLOOD HAZARD, DIGARU RIVER CATCHMENT ARUNACHAL PRADESH

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ABSTRACT

Floods is one of the common unavoidable problems which have been causing problems and threatning to the people of Digaru and its adjoining areas from time to time. Flood hazards are one of the alarming phenomena in the region. During every rainy season the river overtops its bank and inundates the adjoining areas. Though Digaru and its catchment experiences flood almost every year, flood management policies are not adequate or mostly based on structural options including flood walls, dykes, embankments etc. Natural disasters have their greatest impact at local level especially on the lives of ordinary people. Current disasters are becoming more complex and the damages caused by the natural disaster at community level in Digaru catchment has increased exponentially in the past 20 years, despite the great efforts that the Government, NGO's and Local Communities have put into many disaster prevention programes. The objective of this paper is to assess flood hazard in Digaru and its catchment areas for the historical flood events using GIS approach and comprehend flood hazard management strategies for landuse planning. The database & methodology are Base mapping, topographic mapping and post-disaster verification of mapped floodplain extents and depths by DEM model using analogue maps through GIS approach. All possible combination of flood hazard maps are prepared using landcover, geomorphology and elevation heights for flood affected frequency and flood water depth of different flood seasons. The study related to natural hazards is a very new research in Arunachal Pradesh context that's too in the district of Lohit. The study area falls under a very strategic location i.e. Tidding thrust in the northern side and Mishmi thrust in the south-eastern side that makes the region geologically very fragile. This research work is a humble beginning where as researcher i will try to comprehend flood hazard management strategies for landuse planning decision proposed for the efficient management of future flood disasters.

KEYWORDS
Inundate, disaster, exponentially, strategic.

INTRODUCTION

The word flood comes from the Old English '***flod***', a word common to Tentonic languages, compare German ***'flut'***, Dutch ***'vloed'*** from the ame root as is seen in '***flow***', ***'float'***. When rivers overflow their banks they cause damage to property and crops. Floods are common and costly natural disasters (http://en.wikipedia.org/wiki/flood2007).

It is among the most destructive natural hazards causing extensive damage to the built up and natural environment, and devastating to human settlements. Economic losses due to the effects of damaging floods have increased significantly around the world (ADPC, 2005).

Very large floods happen very seldom: the size or magnitude of a flood is described by a term called 'recurrence interval'. By studying a long period of flow records for a stream, it is possible to estimate the size of a flood that would for example, have a 5 year recurrence interval (called a 5 year flood). A 5-year flood is one that would occur, on the average, once every 5 years. Although a 100 year flood is expected to happen only once in a century, there is a 1 percent chance that a flood of that size could happen during any year.

Flooding can be also defined as the overflowing of water from sources such as rivers, reserviors, estuaries and ponds caused by prolonged seasonal rains, typhoon rains, and intrusion of seawater on the land or during tides surges (Regant.P.M.2005).

It occurs when an area of land, usually low-lying is covered with water. The worst floods usually occur when a river overflows its banks followed by breaching. Floods happen when soil and vegetation cannot absorb all the water. The water then runs off the land in quantities that cannot be carried in stream channels or kept in natural ponds or man-made reserviors (http://en.wikipedia.org/wiki/Flood2007).

Floods are often deadly, damaging and devastating. They kill numbers of people, damage houses and crops, and cause extensive destruction. It became hazard when it causes colossal loss to human lives and property. At present, almost every part of the world is affected by the flood due to increase in population. People started top inhabit the flood plains which is highly vulnerable to flood for example Ganga and its major tributaries flood plains (India), the Mississippi and the Missouri (USA), the Yangtze, the Yellow (China), the Irrawaddy (Myanmar), the Indus (Pakistan), the Niger (Nigeria), the Po (Italy) etc.

Though, flood creates a big problem to the whole environment set up of a region, it creates fertile flood plain on which most of the world's leading agriculture was practiced. That is the reason why inspite of so many destructive event, human still prefer to live with flood.

STATEMENT OF PROBLEM

Lohit District, situated at the foothills of the Mishmi hills, is the most vulnerable place for flash floods and landslides in the state. Flash floods are common features in this district therefore it is felt that some of the flood prone villages are really needed to rehabilitate and resettle in a safer place for the safety of life and property. In fact there is not even single safe place in the district where one can confidantly say that floods will not occur (DEC, Lohit).

The Digaru River is an alluvial river which originates from the south-eastern slope of the Mishmi hills of Lohit district at a height of 3785m above MSL (Mean Sea Level) and flows over the unstable formation of the hilly tract with dynamic systems that is drained by numbers of intermontane river system with potential to bring about rapid changes in the landscapes. The region is extreamely vulnerable to natural disasters due to both geographical and meteorological conditions. The major hazards related to this region are flood, landslides, bank-erosion and channel course shifting. Some of which are frequently recurrent and some are continuous.

Rivers flowing in the district has no definite natural channel. In fact all the rivers change their courses every now and then. Normally all the rivers and nallah are surging abnormally during the summer. Most of the rivers and nallahs are snow-fed as well as rain fed. Due to lack of awareness as well as scarcity of clean drinking water villages often consume contaminated floodwater and practice unhygienic way of life, which inturn results in outbreak of water born diseases such as epidemic, dysentery etc. Lift water supply and water tankers are used during the flood situation to meet the requirements of the district, which is inadequate meet the needs of the people hence the locals are forced to consume rainwater and contaiminated floodwater.

The climatic conditions of the district are very suitable for cultivators. Moreover this district has got large area under cultivation. The soil is very fertile but loose in nature. Soil erosion is a common phenomenon especially during the rainy season. Since maximum area of the district is plain, water logging and stagnation is another problem, which creates havoc in the form of various water borne diseases.

Due to the temporary nature of river channel and regular change of river courses, road communication is often disrupted. The major obstacle in the development of this district is lack of proper roads, which have been destroyed by frequent floods and landslides. The irregularity in the course of the river channels makes it difficult to build permanent bridges for proper connectivity. Till date country boats and engine boats are used for transshipment of man and materials within the district as well as with the rest of the country. While doing so every year few boats get drowned by forceful water currents which claim not only materials but human life too.

The district receives the heaviest rain in the state. The problem becomes worse when the rainwater from the highlands of Anjaw District reaches foothills. It carries sediments and other debris and within no time all the river and nallah of the district get over flooded, which disrupts not only surface communication but also other essentials supplies such as electricity, telephone, mobile networks, water supply, POL supply, LPG Gas supply, ration items etc.

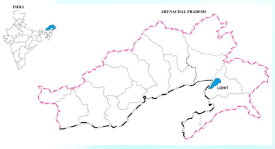
Like many other provinces of Lohit district, the Digaru catchment is no exception to disaster vulnerability. In fact, it is considered among the most disaster prone areas of Lohit district. The region has varied geography- including forested mountains and hills, heterogenity of the basic rocks and sedimentary formation of soils, there is great variation in the nature and composition of the soils and also the loose and fragile surface matter, undulating topography, steep valley slopes, river terraces, juvenile river systems, and is located in the humid tropical and sub-tropical climate zone. The region lies in the Vth seismic zone and reported techtonically very active. All the above mentioned characteristics designate the region as of geo-environmentally having a unique set up (Resource Atlas by Savindra Singh, 1999).

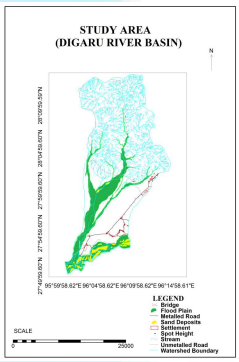
These scenarios are very common and are frequently and almost yearly occuring phenomenon in the area, posing a serious threat to the general ecology and environment of the region. During every rainy season crops, infrastructure and the inhabitants of this region suffer huge losses due to disastrous annual floods. Loss and damage to rpoperty coupled with insecurity to human lives keep many households trapped in a cycle of poverty. In this regard we can talk about some of the most destructive events of the study area in a chronological manner to highlight the importance of the study. The 1988 flood in the Digaru and its nearby areas, which was due to the continuous rain, wherein the whole region was inundated by the flood water of the Digaru and its intermontane streams causing damages to the anthropogenic factors of the region. The 2004 flash flood of Tebang Nallah, which was originally known as Sukha Nallah was a small gully, collecting rain water from the nearby catchment area of upper Loiliang village but during the flash flood of 2004, the course of Tebang Nallah (one of the tributary stream of Digaru river) has got diverted into it and thereby causing flood hazard to Danglat village. The 2012 flood, which is most recent devastating flood, reflects the continuous environmental impacts on the inhabitants of the region which was also due to the continuous rain and thereby causing the shifting of the course of the channel, posing serious threat to the ecological balance of the region.

In this present study, an attempt would be made to carry out the geo-environmental assessment of fluvial hazard selecting a small watershed, since the study area is currently facing vulnerability risk of inundation (almost every year), soil loss, bank erosion and landslide. And no such work had been done earlier; therefore geomorphological investigation of the Digaru river basin, which is one of the main tributary streams of Lohit River, assumes great importance and claim priority.

STUDY AREA

The proposed study lies in Lohit district, of Arunachal Pradesh which is situated between the 27° 50′ 05″ N & 28° 13′ 10″ N Latitudes and 96° 00′ 20″ E & 96° 15′ 40″ E Longitudes, with an areal extension of about 529.22 Km². The total length of the river from its source to the mouth is 50.8 Km. Though the Digaru basin covers a small area in context of the whole district i.e 11,402 km² (according to Census report 2011), it is characterised by complex and intricate drainage system. The typical features exhibited are believed to have been produces by the interactions of the underlying folded structures, varied geomorphological processes specially the rock of Mishmi groups are exposed over large part of the district in the eastern Himalaya and all the litho units are trending NW-SE and dipping towards NE, according to the source (Singh and Choudhary, 1990).





The district is populated by 77,315 (male) and 66213 (female) with a total population of about 1, 45,538 persons contributing 13 persons per km² to the total density of the country (according to 2011 census report). The sex ratio i.e number of females per thousand males is 856 and literacy rate 56.05 percent. The populatiopn is almost rural, inhabiting some 524 villages, with major tribes like Mishmi (Kaman, Taraon and Idu), Khampti and other indigenous groups like Meyors/Zakhring, Singphos, and Padams. In recent past the Tibetian, Chakma and Hazong refugees have been settled here. There are various other group of people who also live and are engaged with government services, constructional work and in business.

OBJECTIVES OF THE STUDY

Fluvial hazards attract broad interest and media coverage. Despite the massive risk reduction efforts and billions invested in flood defences worldwide, floods continue to be an acute problem causing increasing material damage and high death tolls. Therefore, the main aim of the present study is to attempt depth study regarding flood and effect and management aspects of the sellected study area. Further the specific objectives are as follows-

I. To study the effect of flood in the study area.
II. To identify the role of administration in the flood mitigation.
III. To assess the role of disaster management to relief programe during flood event.

METHODOLOGY & DATABASE

The present study shall purely base on the field observation and practical experiment using both the primary and secondary data.

I. **PRIMARY DATA BASE**
   1. Field observations of the area, taking photographs of the important affected area.
   2. Questionnaires were being prepared to know the people's perception on the flood issues.

II. **SECONDARY DATA BASE**
   1. Topographical map (published by Survey of India) bearing no. 92 A/1, A/5, 91 D/4, D/8 with the scale 1:50,000.
   2. Hydrological and climatic data compiled by CWC, RWD, Brahmaputra Board Office, Tezu would be use.
   3. Flood data has been collected from the Disaster Management Department, Itanagar Aruachal Prqadesh.
   4. Geological and soil map prepared by earlier worker would be use.
   5. Census of India Report.
   6. Available literature in the form of research articles, relevent books, Ph.D work, etc.

GIS (Geographical Information System) based software ILWIS have been used for the preparation of final output map.

RESULT & DISCUSSION

Flood is one of the common and most frequently occuring phenomenon in the study area, infact it can be called as regular occuring feature of every monsoon period. From the present study it has been found that the main reason behind this disasterous natural event is largely due to the prevailing hydro-meteorological, geomorphic and topographical characteristics of the study area. The high seismicity and geological fragility of the region supplimented by high annual rainfall lead to disasters like soil erosions, landslides and heavy siltation culminating into devastating floods (Department of Disaster Management, Itanagar). Heavy rainfall and heavy siltation because of erosion by the rivers, leads to an adverse synergistic effect, creating havoc in the foothills by over flooding the embankments and deposition of silt along the valley floors. The consequent blockade of main courses of the rivers and sub-streams cause diversion of flow, which inturn engulf big chunks of fertile land between consecutive loops.

From the prepared DEM map below the topographical characteristics of the region can be traced out:

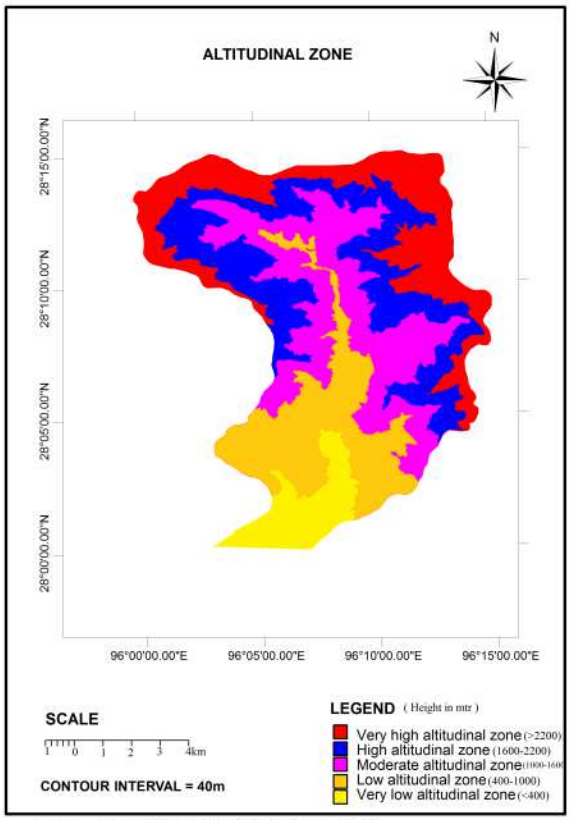


Fig. 3.4: ALTITUDINAL ZONE MAP OF DIGARU RIVER BASIN

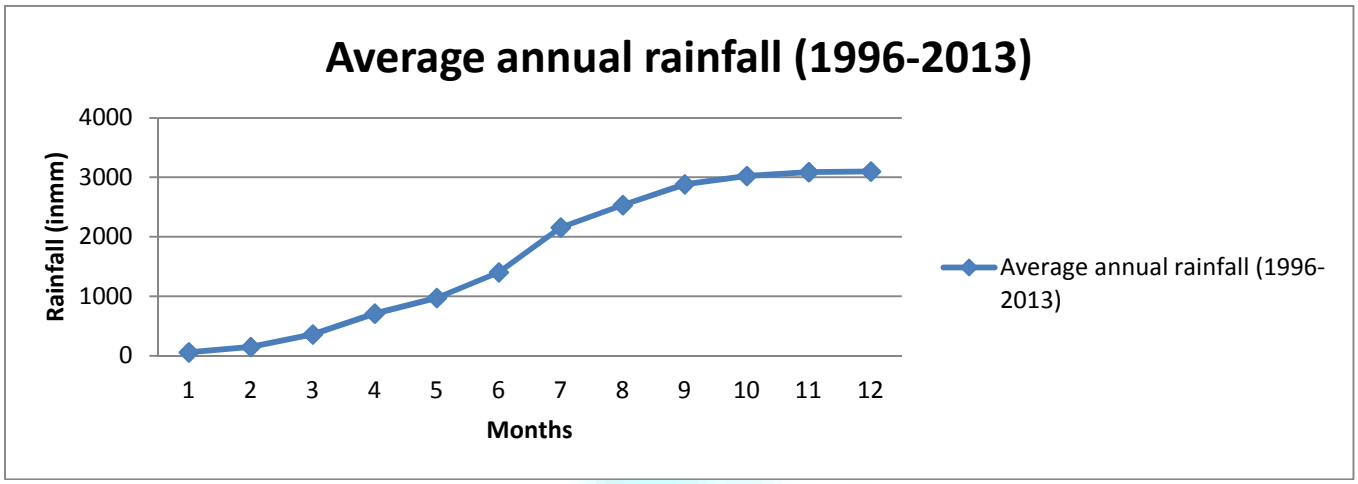
Source: Prepared by self using GIS based software ILWIS

Based on the prepared altitudinal map, it is found that the region between <400-1000 meter (low and very low altitudinal zone) are more vulnerable to flood effect then the medium and high altitudinal zone. On the other hand landslide dominates between the height 1000-1600 meter durng every monsoon season.

The district receives heaviest rainfall in the state. It receives heaviest rainfall of about 80-160cm during monsoon season. Heavy rainfalll in the upper catchment causes sudden increase in the volume of water in the downstream. This causes overtoping of river bank by enormous volume of water and consequent inundation and flooding of the plain areas. The rainfall records of the study area varies from one year to another say for example in 2010 the total annual rainfall was 6224.91mm whereas in the year 2011 it was 4108.78mm. Below the rainfall variation is shown in tabular form as follows-

TABLE 1: MONTHLY AVERAGE RAINFALL DATA OF DIGARU RIVER CATCHMENT (1996-2013)

Months	Average Rainfall (mm)
January	58.67143
February	147.7667
March	359.5667
April	710.1867
May	973.4
June	1404.688
July	2157.871
August	2534.444
September	2884.775
October	3023.713
November	3089.377
December	3099.7



Source: WRD, Tezu.

During high discharge period river brings heavy silt and debris from the upper catchment, this raised up the river bed and flattened, causing severe flood in the lower plain areas. Thus heavy monsoon shower brings immense miseries for the people who have already lost their kin, livestock, houses and fields. Apart from damages to basic amenities and other infrastructure, the colossal damage during flood is caused to the agriculture fields, every year. Annual flood discharge of river Digaru from the year 1991-2012 are presented in a tubular form below-

TABLE 2: ANNUAL FLOOD DISCHARGE IN DIGARU RIVER, 1991-2012

Sl.No.	Year	Annual Maximum Flood Discharge (in Cumec)
1	2000	182
2	2001	165
3	2002	185
4	2003	181
5	2004	280
6	2005	320
7	2006	382
8	2007	364
9	2008	310
10	2009	280
11	2010	292
12	2011	362
13	2012	450

Source: WRD, Tezu.

Flood hazard has become a common problem in the study area because it affect the region every now and then during monsoon season. Though river gets flood very year, but it becomes hazard when it enters the human settlement areas. The damages caused due to 2004-2005 flood in the whole district is presented in the table below:

TABLE 3: DAMAGE/LOSS INCURED DURING 2004-2005 FLOOD IN LOHIT DISTRICT

Sl.No.	Details of Damage	2004	2005	Total
1	No. of villages affected	172	85	257
2	No. of households affected	3043	1200	4243
3	No. of households completely affected	83	25	108
4	No. of households partially affected	2960	1175	4135
5	No. of families affected	9726	1200	10926
6	No. of population affected	42089	30000	72089
7	No. of population threatened by floods	85000	55000	140000
8	No. of relief camps setup	37	2	39
9	No. of victims evacuated to relief camp	16960	350	17310
10	No. of casualities by flood	1	-	1
11	No. of cultivable land/crops (agri & horti) affected	9150.45	3340	12490.5
12	No. of Bridges damaged	55	10	65
13	No. of culverts damaged	44	15	59
14	No. of embankment damaged	89	18	107

Source: District Relief & Rehabilitation Department, Tezu.

The frequency of flood has been increased in Digaru catchment and it has become a big trouble for the people residing there. It has caused immense damage of life, property, crops of the region. During every rainy season, the river not only filled up with water, but excess amount of water also spill over the banks innundating the adjoining regions. Due to its inadequate channel capacity and soil erosion, every year a vast fertile land standing crops and temporary huts of the people use to be damaged by these flood.

CONCLUSION AND SUMMARY

Flood are natural phenomena, one cannot entirely get rid of it but their impacts can be minimise by managing it using man's technical skill, better warning systems and positive human response to flood warnings and various controll measures adopted by the governments. There no any prime flood protection measures has been taken up since 2004-2005 except some petty temporary works on the following major and minor rivers like Lohit river, Tabang Nallah, Ziri Nallah (Department of Disaster Management, Itanagar). Though, after the flood of 2004-2005, some preventive measures has been taken by the government like construction of boulder bunds, spurs, plugginh structure, giude walls. But were damaged and washed away by later floods (Department of Disaster Management, Itanagar).

Based on the present study it is found that floods occur frequently in the study area, so there is a need to adopt proper flood controll measures which should be taken by the government as well as citizen to minimise its impacts. Though one cannot totally overcome the problem of flood but atleast can minimise their impacts, here some controlling measures and steps one should adopt during flood are-

i) Construction of embankments, dikes, flood walls on the bank of the river, so that the flood water can be confined within the channel. This will include the building of artificial levees of earthen materials, stones or concrete walls.
ii) Construction of dams and reserviors in the upper ridge to controll the volume of water. Such structure will also be usefull for irrigation purpose.
iii) To check the soil erosion and siltation problem, one should adopt aforestation in the catchment and avoid deforestation.
iv) Construction of raised platforms near the settlement for taking temporary shelter for both man and animal during flood.
v) Creating awareness among the people about the cause and consequences of the flood and encourage them how to mitigate from the yearly occuring deadly natural phenomena.

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