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Flood Hazard Zonation Of Imphal River, Manipur, India,Using Aws Data

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Abstract: Humans have been enduring a variety of natural disasters since time immemorial. Out of the several natural disasters, flood is one of the greatest and most common forms of natural disaster. Flood plains are generally thickly populated because of their economic significance. It is, therefore, essential to properly understand, utilize and manage floods for taking up preventive measures and mitigation works to minimize the risk of flood and its ill effects, such as, damage to lives, properties, infrastructure and crops. Flood considering as an agent of hazard pose a serious threat to the inhabitants of the flood plains and so it deemed necessary to focus on the mitigation and hazard management. A flood hazard map highlights the areas which are affected by or are vulnerable to flood. Such mapping is done with main emphasis being given on the management and reduction of impacts of hazard. In the present study, to prepare Flood hazard zone maps Remote Sensing (RS) and Geographic Information System (GIS) tools are employed on sub-catchment of the Imphal River basin in Manipur State, India. Present study is limited to factors such as rainfall distribution, drainage density, land use, soil type, and slope to prepare Flood hazard risk zone map. The thematic maps of these factors are prepared using ArcGIS, ArcSWAT and HEC-RAS tools. By giving ranks and weights to these thematic maps, the weightage maps are created. In this study Weighted Overlay Analysis method is adopted to prepare the Flood hazard risk zone map. The hazard map thus prepared shows the total areas subjected to the hazards, as very low, low, moderate, high and very high risk zones. Flood hazard assessment results so obtained may be utilized by land development planners as a part of an integrated approach to improve flood preparedness. The study area having experiences repeated flash flood in recent years, has been selected and aims to improve future land developments and raise community awareness of the area.

Index:AWS data,Flood Hazard, Overlay technique, RS&GIS

I. INTRODUCTION

Flood is one of the most common natural calamities causing havoc to various vulnerable elements including living and non-living assets in a region."Flooding is a general temporary condition of partial or complete inundation of normally dry areas from overflow of inland or tidal waters or from unusual and rapid accumulation of runoff" [5] It is caused when rivers overflow their banks, damaging lives, property, infrastructure and crops. Floods usually occurs suddenly and sometimes with little or no warning and they may be of short period. They usually are caused by intense storms that produce more runoff than an area can store or a stream can carry within its normal channel.

Floods cannot be prevented totally but preventive measures and mitigation works can be taken up to minimize the risk of flood. As per the Flood Directive [3], flood risk is defined as the product of 'hazard' and the "vulnerability".In order to minimize flood hazards, it is necessary to focus on the mitigation and risk management with emphasis on hazard analysis, management and risk assessment so as to come up with effective mitigation in the areas of interest. The comprehensive analysis and assessment of flood hazard is an essential part of the whole hazard management concept [6]. Flood hazards may increase due to human activity and may be decreased by appropriate flood management and planning [8]. Flood hazardassessmentresults can be utilized by land use and development planners as part of an integrative approach to improve flood preparedness. Also, it can be used to improve future land developments and raise community awareness.

The primary causes of flood in Manipur Valley are heavy runoff and less infiltration in degraded watersheds in the upper reaches of the river during rainy seasons in the valley. Recently, Manipur has faced multiple events of flood (five times in the year 2017). It has greatly affected the socio-economic condition to vast majority of farmers as agriculture being a major occupation of inhabitants of Manipur.

The Imphal River is one of the major rivers of Manipur. During the south-west monsoon season (June-September, IMD classification) frequent flood occurs, which affects the agriculture, livestock and inhabitants in the catchment. The management and mitigation of such flood events is essential so as to reduce and overcome the hazards of floods. In order to develop a comprehensive flood mitigation plan, flood hazard zonation is of primary requirement. Geospatial techniques are used to assess and discuss the flood hazard zonation. Hydro-meteorological data from Automated Weather Station(AWS) installed in different parts of the catchment are used.

II. METHODOLOGY

The simulated result of geospatial technology might enhance the ability for preparing flood hazard map and forecasting. Prior knowledge of Geoinformatics, hardware and software requirements, are few of the restraints that may encounter during such study.

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Natural resources and hazard mapping comprises vital component for appropriate land use planning in disaster prone areas, thus hazard mapping is considered significant. It creates easily read, rapidly accessible charts and maps which facilitates the stakeholders to identify areas of risk and prioritize their mitigation or response efforts. An efficient methodology is used to accurately delineate the decision making areas in the Imphal river basin.

The study is based on the employment of satellite remote sensing imageries, which requires various levels of corrections and rectification (radiometric correction). The accurate topographical features extraction is the significant part of this study.

The whole methodology of this study is classified as follows:

A. Pre-processing

B. Post- processing (Hazard zonation Mapping)

i. Prepare a flood hazard zonation map, using remote sensing and GIS technique.

ii. To identify and assess the effects of flood hazard to various land use class and inhabitants of the catchment.

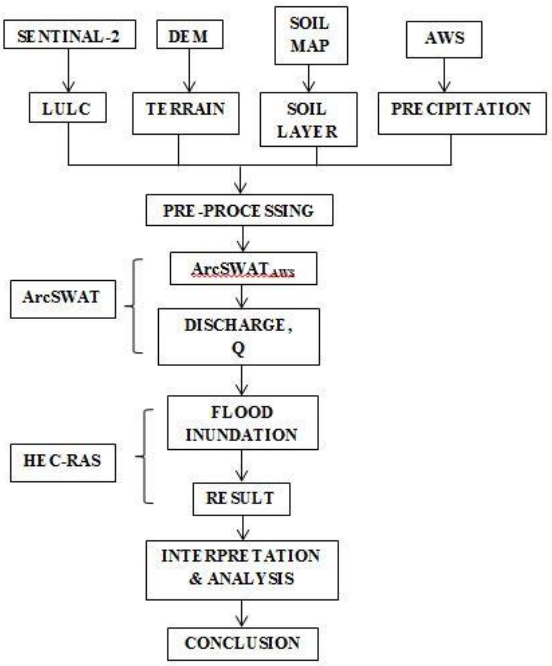

Fig 1.Methodological flow-chart of the study

A. Pre-processing

Pre-processing comprises of corrections of the acquired data and prepares it for the input in the processing of the model. This includes the corrections of satellite remote sensing data, tabulations of the hydro-meteorological data, and generations of various input layers. The layers include Terrain Layers, Land use-Land cover (LULC), Soil Layers, and conversionof hydro-meteorological data from tabular format to GIS raster formats (Using Stations Geo-Coordinate). All the input layers are resampled to 10m spatial resolution (10m per pixel) so as to have spatial homogeneity in operating the model.

Advanced Land Observatory Satellite - Phased Array type L-band Synthetic Aperture Radar (ALOS-PALSAR) Digital Elevation Model (10m spatial resolution, resampled from 12.5m) of Alaska Satellite facility is used for the generation of elevation surface, slope, delineation of catchment and to facilitate simulations in the study.

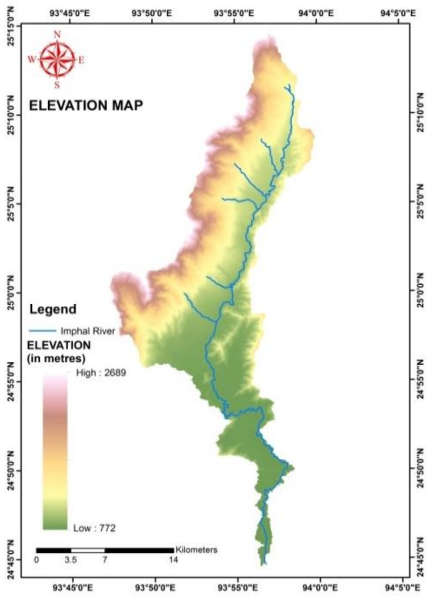

Fig 2. Elevation map of the catchment area

The Sentinel-2 (10m spatial resolution**)** Earth observatory data, multispectral satellite imagery is acquired from the European Space Agency (ESA), Copernicus land monitoring services. The imageryis used for the generation of land used land cover layer by image classification based on maximum likelihood classification (shown in fig. 3).The geographical information on land usedclass is based on National Remote Sensing Centre, India classification.

For the analysis,the gauged (AWS) precipitation data, acquired from Indian Council of Agricultural Research, Lamphelpat, Imphal west, Manipur and Directorate of Environment, Porompat, Imphal East Govt. of Manipur, are tabulated along with the geo-coordinates of the AWS's. Using the co-ordinates, the data are interpolated and resampled to 10m raster layer.

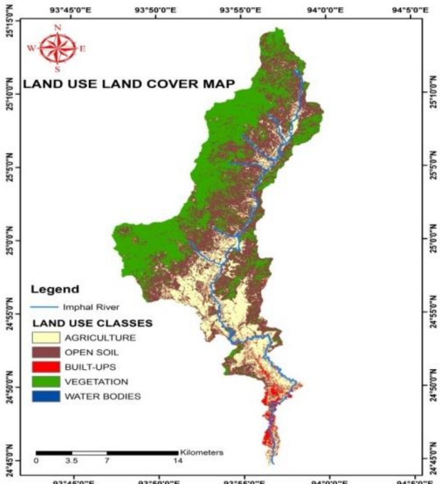

Fig 3. Land use land cover map of catchment

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Soil map of Manipur prepared by National Bureau of Soil Survey and Land Use Planning (ICAR), Nagpur, is retrieved from European Soil Data Centre (ESDAC) [7]. The map is geometrically corrected and digitized and converted to raster format as shown in figure4 and the taxonomy for different soil types are classified according to the mapping units along with the area coverage in sq. km.

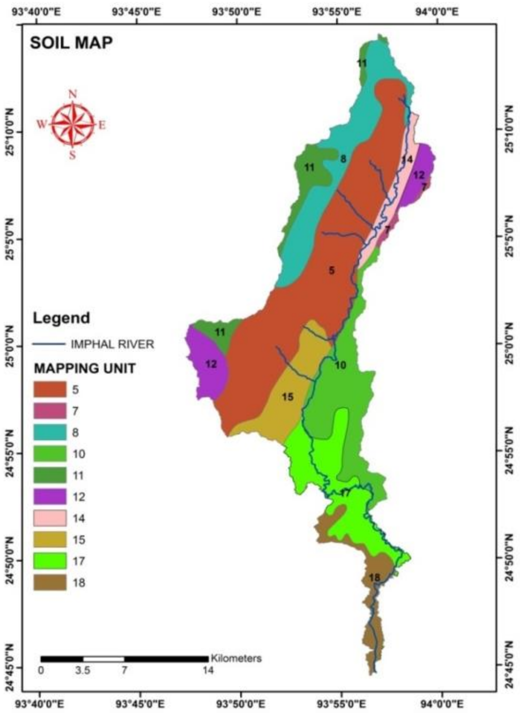

Fig 4. Soil Map of the catchment

B. Post-processing

The layers generated are used as variables in the ArcSWAT (Soil & Water Assessment Tool) to estimate the discharge at outlets of sub-catchment of the whole study area. Land use land cover map, digital elevation model, soil map and precipitation data from various AWSs are applied in ArcSWAT to generate discharge data. The discharge estimated by ArcSWAT is employed as input in Hydrological Engineering Centre - River Analysis System (HEC-RAS) to generate the flood inundated region within the study area.

The HEC-RASis used to generate critical flow profiles. The basic requirements to run HEC-RAS arethe geometry data and flow data.The geometry data consisted of description of the size, shape, and connectivity of stream cross-sections, the flow data contained discharge rates. The flood scenariosare developed for various levels of river discharge.The HEC-GeoRAS facilitated data exchange between ArcGIS and HEC-RAS as the pre-processed or post-processed result between ArcGIS and HEC-RAS cannot be interchanged directly.

III. INTERPRETATION AND ANALYSIS

The main outlet of the catchment is considered at Lilong Bridge, of the Imphal river basin. Defined assessment is conducted using the precipitation data from AWS. The total area of the study area is 386.035 sq. km. It comprises of six small sub-catchments and area covered by each sub-catchment is calculated and its corresponding areas are defined in the figure 5.

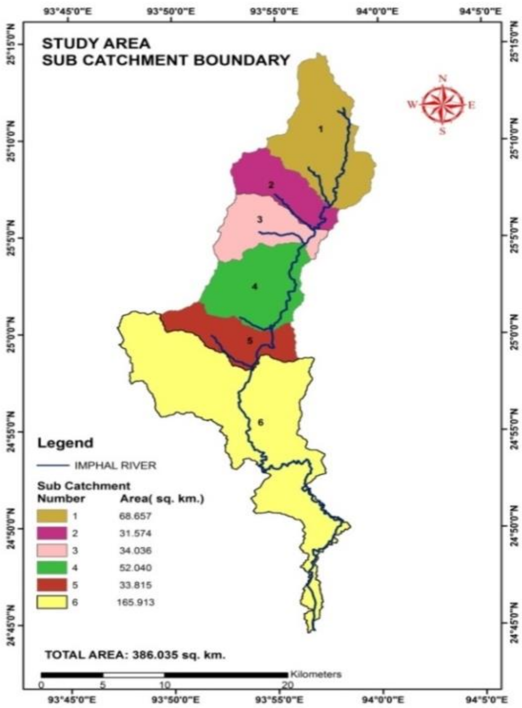

Fig 5.Study area Sub-catchment

IV. RESULT

A. Inundation Map using AWS data

The inundation map is obtained from the analysis using AWS data. The inundation depth ranges from 0-3.689m., and it is classified into five hazard classes based on Natural Breaks (Jenks) as shown in table 1 and figure6.

Table 1. Natural Break (Jenks) classification of Flood Hazard Intensity

HAZARD INTENSITY	DEPTH (m)	AREA (sq. km.)
VERY LOW	0-0.564	16.652
LOW	0.564-1.186	11.584
MODERATE	1.186-1.837	6.876
HIGH	1.837-2.619	3.959
VERY HIGH	2.619-3.689	1.364

B. Flood Inundation-LULC Intersection Map

The flood inundation map is overlay (intersection operation) with land used land cover map and AWS data. From this operation, the inundated areas of various land use land classes are obtained. Detailed of the inundated LULC areas are given in table 2.

Table 2. LULC class-wise Inundated area (sq. km.)

CLASS	LULC Area	Inundated Area (AWS)
AGRICULTURE	77.519	24.645
OPEN SOIL	160.895	9.07
BUILT UPS	13.048	6.534

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VEGETATION	134.509	0.151
WATER BODIES	0.064	0.034
Total Area	386.035	40.434

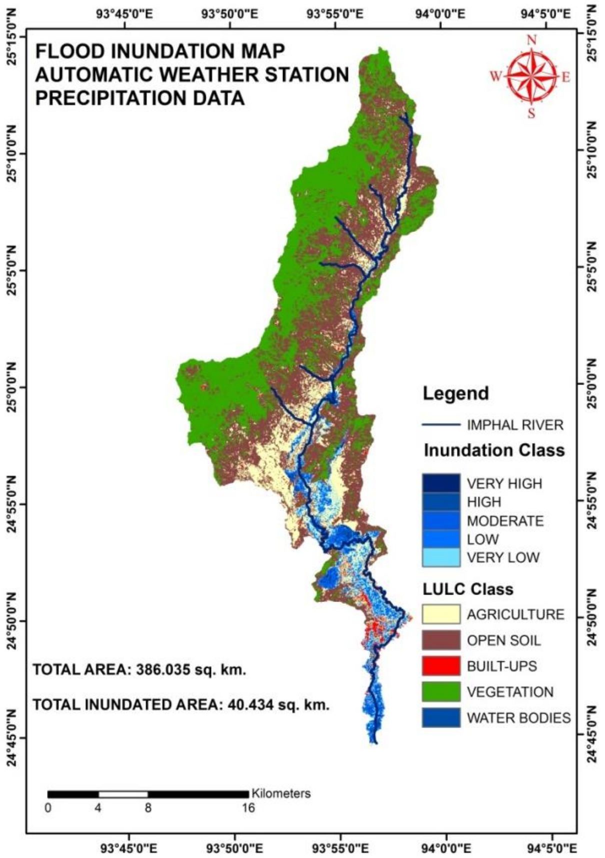

Fig 6. Inundation map using AWS

The relationship between the inundated area and land used is classified as in Figure7. In this case, the most affected area by flood is the agricultural area followed by settlement area and least affected is the water bodies.

It is observed that the most affected class is found to be the agricultural class.

The spatial extent of the inundation affected areas estimated using the automatic weather station data, for different land use classes are classified as mentioned earlier. The total area of the agricultural class inundated is 24.645 sq. km. out of the 77.519 sq. km. under agricultural cover of the catchment.

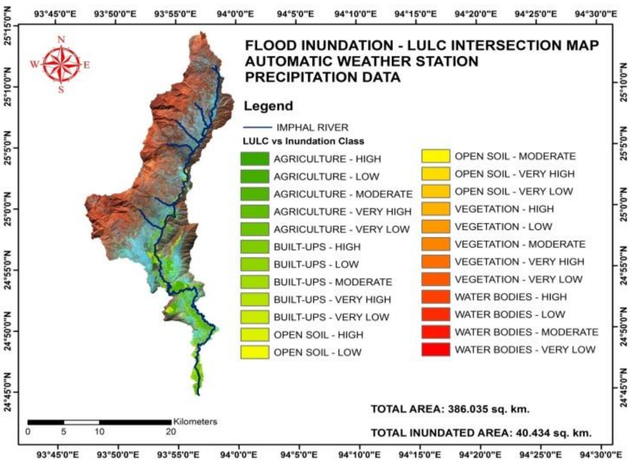

Fig 7.Flood inundation- LULC interception map

V. DISCUSSION

In this study, it is observed thatareas lying along the flood plain are most affected by flood. The total inundated area is found to be 40.434 sq. km. of which 60.95% is found to be agricultural land the build ups which affect about 16.16%. These inundated regionsare mainly focused at the plain area of the catchment having low elevation.

From table 2, the area covered by Agriculture class is 77.51 sq. km. and the inundated area of the same class resulted from the analysis is found to be 24.645 sq. km. of the total geographic area of the catchment. And Built-ups class covered about 13.048 sq. km. of which 6.534 sq. km. are inundated.

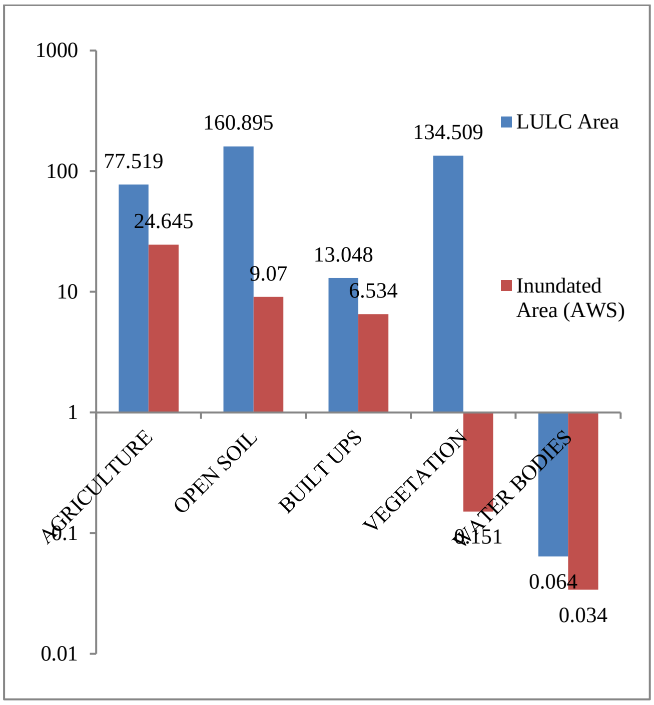

Fig 8.Comparison between the land used class vs inundated land used (in sq. km.)

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VI. CONCLUSION

The flood inundation map is generated using 10m spatial resolution of various input layers such as DEM as terrain parameter, LULC layer and AWS precipitation data. The total inundated area generated using the AWS data is observed to be 40.434 sq. km which is 10.47% of the total geographic area. The inundation depth is classified into five hazard classes and the inundated areais dominant in Very Low followed by Low, Moderate, High and Very High (as shown in Table 1).

Most of the cultivatedareas are situated in low lying flood plain as the Imphal River is the main source of irrigation. Hence, the cultivated areas are most prone to be inundated. Such hazardous events may resulted to the decreased in agricultural yield and hence ultimately affect the socio-economic condition of the state. From the result of this study,it is expected to help policy and decision makers to take up necessary preventive, mitigation and management measures.

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