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Flood geoenvironmental disaster preventive measures in water sheds area of Ambasamuthiram town by using GIS and multicriteria technique

In this fast technically developing world it has been difficult to avoid disasters which are occurring periodically despite the scientific reasoning and technical supports. Recent events have fostered the selfish and irresponsible human activities for seasonal floods in India Ambasamuthiram Taluk, Tirunelveli District, Tamilnadu. Flood is a natural disaster almost occurs in every part of the world. India has longest rivers passing from high population density area. During monsoon season, cyclone floods are usually happen in India. Many conditions can result in a flood: hurricanes, overtopped levees, outdated or clogged drainage systems and rapid accumulation of rainfall. The recent flood in Ambasamuthiram was unexpected and not triggered by the above factors.

Sometimes floods occur when the watershed size is considerably small which leads to the over flow of water inland. Temporarily used backwater effects in sewers and blocks in local drainage channels and creation of unsanitary conditions may cause flooding. Ambasamuthiram flood was basically claimed to occur due to improper drainage system and underlying strata which was found to be landfill over the ponds and lakes.

People floods are the most common natural disasters; their frequency, magnitude and the cost of damage are on the rise all over the world. "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 or runoff" (Jeb and Aggarwal, 2008). According to European Commission (2007), a flood can be defined as "a natural phenomenon that results in the temporary submerging with water of a land that does not occur under normal conditions". They are the naturally occurring event and hence cannot be prevented and they can have serious consequences such as displacement of and damage to the environment (IFRC, 2001; Adeoye et al., 2009; Nmeribeh, 2011). Floods can also be caused by anthropogenic activities and human interventions in the natural processes such as increase in settlement areas, population growth and economic assets over low lying plains prone to flooding leading to alterations in the natural drainage and river basin patterns, deforestation and climate change (EC, 2007; Balabanova, 2008; Kwak, 2008; Kondoh, 2008; and Vassilev, 2010). Floods cause about one third of all deaths, one third of all injuries and one third of all damage from natural disasters (Askew, 1999). During a World Conference on Natural Disaster Reduction organized by the United Nations in Yokohama in May 1994, one of the 10 "principles" of the Yokohama Strategy is that "risk assessment is a required step for the adoption of adequate and successful disaster reduction policies and measures". The terms "floods", "flood hazard", and "flood risk" cover a broad range of phenomena. The terms such as "flood risk" and "flood losses" are essentially our interpretation of the negative economic losses and social consequences of natural events. Flood risk may increase due to human activity and may decrease by appropriate flood management and planning (Simonovic, 2009).

A morphometric analysis was carried out to describe the topography and drainage characteristics of Papanasam and Manimuthar watersheds. These watersheds are part of Western Ghats, which is an ecologically sensitive region. The drainage areas of Papanasam and Manimuthar watersheds are 163 and 211 km^2 respectively and they show patterns of dendritic to sub-dendritic drainage. The slope of both watersheds varied from 0° to 59° and 0° to 55° respectively. Moreover, the slope variation is chiefly controlled by the local geology and erosion cycles. Each watershed was classified as a fifth-order drainage basin. The stream order of the basin was predominantly controlled by physiographically and structurally matures geomorphic

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stage. The development of stream segments is affected by rainfall and local lithology of the watershed conditions.

Keywords: *Analytic hierarchy process (AHP), Geographical Information System (GIS), multi-criteria decision making (MCDA)*

1.0. Introduction

A river is a natural water course, usually freshwater, flowing towards an ocean, a lake, a sea or another river. In a few cases, a river simply flows into the ground or dries up completely at the end of its course, and does not reach another body of water (Probhat Kotoky, 2012). Small rivers may be called by several other names, including stream, creek, brook, rivulet, and rill. Rivers are part of the hydrologic cycle. Water generally collects in a river from precipitation through a drainage basin from surface runoff and other sources such as groundwater recharge, spring and the release of stored water in natural ice and snow packs (e.g. from glaciers. Rivers have formed over a long time and continue to evolve because of their dynamic nature. Human activities accelerate and redirect these processes of change in many different ways, indirectly through anthropogenic stressors such as global warming or directly by interfering in the physical, geo-morphological characteristics of a river. Reducing the length of the channel by substituting straight cuts for a winding course is the only way in which the (effective) fall can be increased. This involves some loss of capacity in the channel as a whole, and in the case of a large river with a considerable flow it is very difficult to maintain a straight cut owing to the tendency of the current to erode the banks and form again a sinuous channel. Even if the cut is preserved by protecting the banks, it is liable to produce changes shoals and raise the flood-level in the channel just below its termination (Dewidar, KH. M, 2004). Nevertheless, where the available fall is exceptionally small, as in land originally reclaimed from the sea, such as the English Fenlands, and where, in consequence, the drainage is in a great measure artificial, straight channels have been formed for the rivers. Because of the perceived value in protecting these fertile, low-lying lands from inundation, additional straight channels have also been provided for the discharge of rainfall, known as drains in the fens. Even extensive modification of the course of a river combined with an enlargement of its channel often produces only a limited reduction in flood damage. Consequently, such flood works are only commensurate with the expenditure involved where significant assets (such as a town) are under threat.

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1.1 Data source

Flood risk concept

An attempt by the risk experts in late1970’s to come up with the standard definition of risk concluded that a common definition is perhaps unachievable, and authors should continue to define the risk in their own way. As a result, the numerous definitions of risk can be found from vague and conceptual to rigid and quantitative. At conceptual level, we define risk as (i) a significant potential unwelcome effect of system performance, or (ii) the predicted or expected likelihood that a set of circumstances over some time frame will produce some harm that matters, or (iii) future issues that can be avoided or mitigated, rather than present problems that must be immediately addressed (Simonovic, 2009). Singh et al. (2007) classified risk into three categories: (i) risk for which statistics of the identified causalities are available; (ii) risk for which there may be some evidences, but where the connection between suspected cause and damage cannot be established; and (iii) estimates of the probabilities of the events that have not been occurred. Additionally, there are risks that are unforeseen.

In the last decades, methods for risk assessment have been developed in different fields, e.g. in the insurance sector and in the fields of environmental or technological risks (Molak, 1997). Here, risk is defined as the probability of suffering, harm or loss, and risk analysis is a body of knowledge that evaluates and derives the probability of the adverse effects of a natural process, technology, industrial process or an agent (chemical, physical etc).

The term 'risk' has different meanings, and therefore, it is necessary to define it and to give indicators, which allow to quantitatively describe and to map flood risks. Flood risk analysis of the German Research Network on Natural Disasters (DFNK) investigated the complete flood disaster chain from the triggering event to its consequences: "hydrological load – flood routing – potential failure of flood protection structures – inundation – property damage".

Commonly, there are three components to determine flood risk:

- Hazard: the threatening natural event including its probability/magnitude of occurrence
- Exposure: the values/humans that are present at the location involved
- Vulnerability: the lack (or loose) of resistance to damaging/destructive forces.

This means that within an identified flood hazard area there may be the same exposure or risk of flooding, but a wide range of vulnerability to the hazard (Federal Emergency Management Agency/Emergency Management Institute).

As per the Flood Directive (2007), "flood risk "is the definition of risk as the product of "hazard", i.e., the physical and statistical aspects of the actual flooding (e.g. return period of the flood, extent and depth of inundation), and the "vulnerability", i.e., the exposure of people and assets to floods and the susceptibility of the elements at risk to suffer from flood damage.

Forster et al. (2007) defined flood risk as a combination of potential damage and probability of flooding. More precisely, risk is considered as the product of hazard and vulnerability of a region. Risk is an integral part of life. Indeed, the Chinese word for risk "weji-ji" combines the characters meaning "opportunity/chance" and "danger" to imply that uncertainty always involved some balance between profit and loss (Smith, 1996). Since risk cannot be completely eliminated, the only option is to manage it. Risk assessment is the first step in risk management.

Risk assessment generally comprises three distinct steps (Kates and Kasprson 1983):

I. An identification of hazards likely to result in disasters e.g. what hazards events may recur?

II. An estimation of the risks of such event e.g. what is the possibility of such event?

III. An evaluation of the social consequences of the derived risk e.g. what is the loss created by each event?

However, for sound risk management to occur there should be a fourth (d) step which addresses post-audit of all risk assessment exercises. When risk analysis is undertaken, risk (P) is taken as some product of probability (P) and loss (L)

$$R = P \times L \qquad \dots\ 1$$

Flood risk assessment involves estimation of both statistical probability of an event occurring and the scale of the potential consequences (Smith, 1996). All development of land within the floodplain of a watercourse is at some risk of flooding, however, small. The degree of flood risk is calculated from historical data and expressed in terms of the expected frequency 10 year, 50 year or 100 year flood. Flood risk is a combination of flood occurring (the hazard) and of the potential adverse consequences of the flood for the human health, the environment, the cultural heritage, and the economic activity (the vulnerability) (Ologunorisa, 2001; FRM 2009).

A real flood risk level therefore requires a certain level of hazard, and for the same location, a certain level of vulnerability. A situation of risk is due to the incompatibility between hazard and vulnerability levels on the same land plot. The United Nations Commission for Human Settlements (Unchs– Habitat, 1981) has defined the hazard and vulnerability as follows:

Hazard: It is the probability that in a given period in a given area, extreme potentially damaging natural phenomena occurs that induce air, earth movements, which affect a given zone. The magnitude of the phenomenon, the probability of its occurrence and the extent of its impact can vary and, in some cases, be determined. Table 1 shows hazard categories based on The Commonwealth Scientific and Industrial Research Organization (CSIRO, 2000).

1.2 Annual rainfall

The Fig.3 refers the satellite-view over the south-eastern India during the 2015 flood.

Ambasamuthiram town receives the average annual

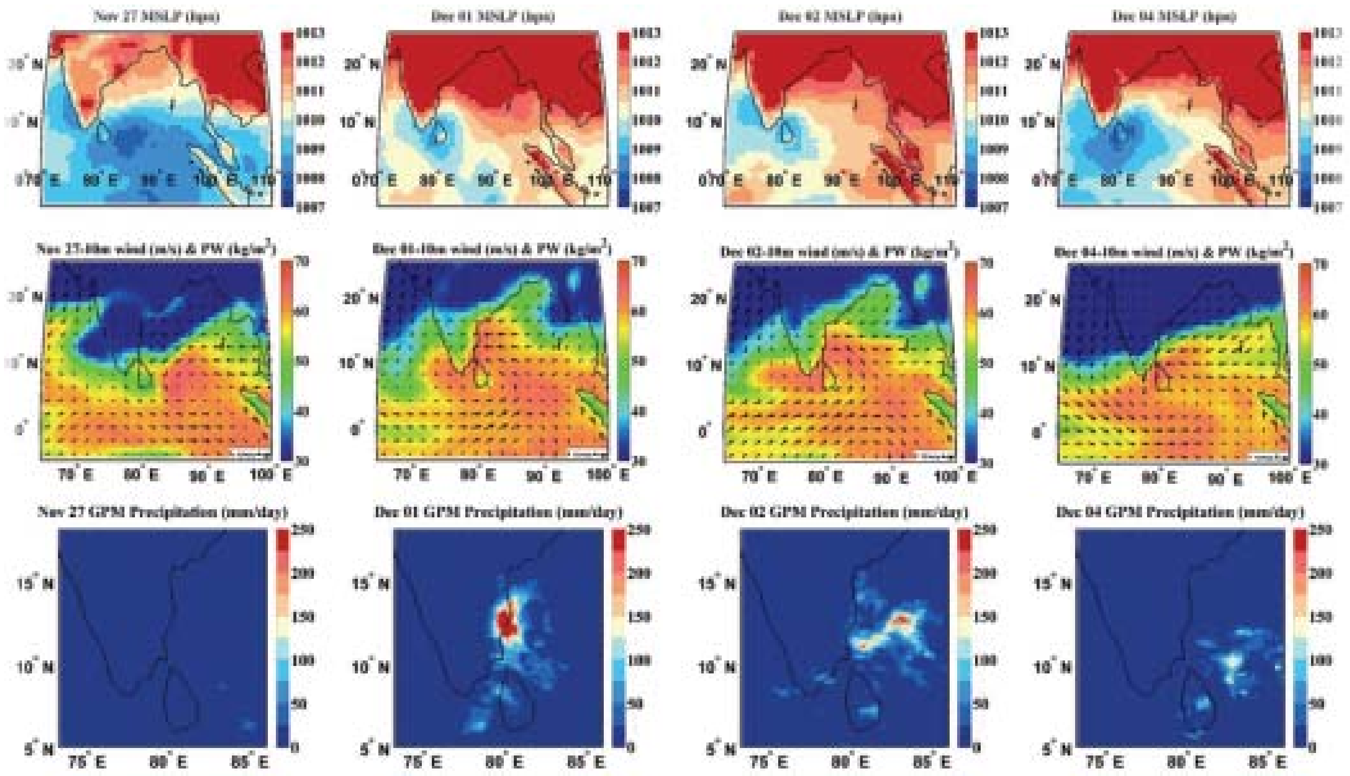

Fig.1 Distribution of mean sea level pressure (panel 1), perceptible water (PW with colour map) and surface wind (with arrows) (panel 2) and satellite-observed precipitation (panel 3) during the extreme event over southern India and Bay of Bengal.

TABLE 1 MONTHLY RAINFALL DATA IN MM – TIRUNELVELI DISTRICT

Year/Month	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
2007	24.10	3.52	7.44	131.61	10.97	87.78	46.49	33.11	79.70	187.03	181.90	126.16	920.54
2008	9.28	83.3	377.19	103.4	4.94	10.32	35.22	72.00	20.63	345.6	183.1	94.78	1339.76
2009	8.89	0.0	31.64	72.01	24.07	21.38	59.94	25.97	30.56	126.59	431.59	153.29	985.93
2010	37.16	0.08	4.48	36.91	39.40	29.67	60.56	18.43	77.53	107.56	293.38	168.53	873.69
2011	25.26	46.37	40.00	65.00	4.25	63.31	22.08	23.43	14.93	311.84	275.70	79.52	971.69
2012	40.54	29.03	35.95	65.12	9.82	2.31	15.68	12.66	8.35	304.41	144.80	100.20	768.87
2013	2.19	98.50	142.14	24.94	25.72	103.92	46.58	28.35	41.05	57.01	256.66	86.80	913.86
2014	57.20	9.24	60.30	36.28	206.55	7.88	12.98	52.52	38.45	391.66	316.91	150.89	1340.86
2015	4.75	13.48	71.80	133.36	93.09	56.32	13.15	10.55	71.62	317.8	312.8	102.2	1200.92
2016	5.1	43.5	1.53	163.6	41.03	10.2	78.2	122.3	69.6	265.6	420.7	67.2	1288.56

rainfall of about 140cm (55 in). Starting from mid-October to mid-December the town receives the heaviest rainfall from the northeast monsoon winds. Sporadically the city experiences cyclones formed in the Bay of Bengal. The highest annual rainfall recorded is 257cm (101 in) in 2005.The highest rainfall of 72.4mm was recorded in Tiruvelveli-Tamil Nadu. However, Tamil Nadu received an average annual rainfall of 1304.1 mm during the year 2005-06. The rainfall was excess in 26 districts and normal in 4 districts as shown by the rainfall records during 2005 and 2006 as compared to the normal annual rainfall. However, the highest recorded rainfall of 2005-06 in Ambasamuthiram had been beaten by the recent rains in 2015.

GIS system navigated by the NASA was used to view over the south-eastern part of India, Ambasamuthiram. The record of three consecutive days has been shown. According to the record, continuing from Tuesday till Wednesday more quantity of moisture started to accumulate over the region of Ambasamuthiram. These have a reason for heavy precipitation and high chances of flood.

In our work an automated procedure was used to identify the floodplain extent and to determine its depths. But this automated procedure is different from that mentioned above in the way that water levels are obtained. We do not create a

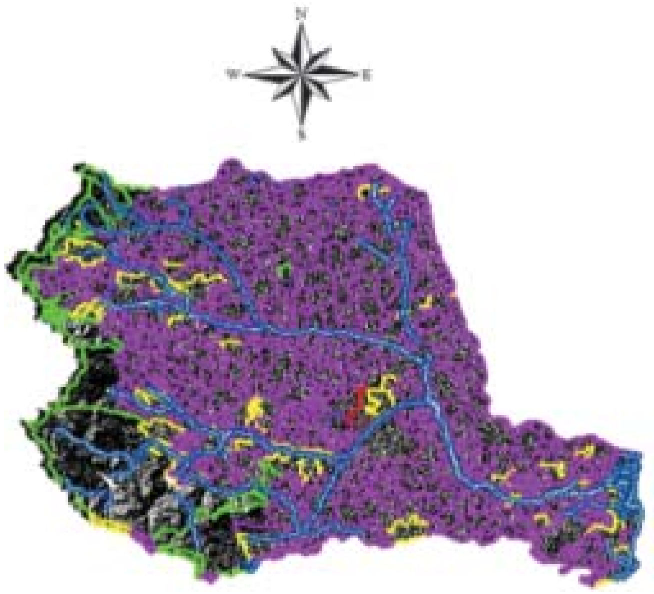

Fig.2 Satellite-view over the south-eastern India during the 2015 flood

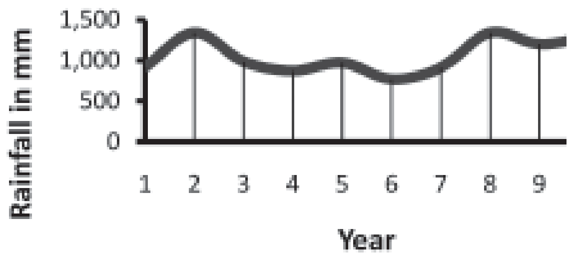

Fig.3 Fluctuation of rainfall data for the period of 2007 – 2016

water surface level in a raster format and then compare that water surface level with the DTM to delineate floodplains. Rather, the floodplains are directly delineated from the high-resolution DTM (in this study, LIDAR 20-ft DEMs) using a simplified, but practical approach, which was developed based on the actual mechanism of flooding. The Fig.4. shows the drainage system of Ambasamuthiram town.

1.2.1 Drainage system and wetland

As the water level crossed the normal limits in residential areas of Ambasamuthiram and Tiruvallur districts, the drainage system miserably failed to flush the water. The drainage system was blocked due to excessive dumping of garbage and as well as the failure of administration to ensure periodic desalting. Hence water could not find a way to flow. The failure of drainage system in many parts of Tamil Nadu, especially Ambasamuthiram and Tiruvallur, made the situation worst. Besides that, encroachment was seen on Cooum river, Adyar river and Buckingham canal, which serve as the main source of drainage in the city. These encroachments were not slum dwellings but concrete structures blocking up the flow of water in the canal.

In addition to that, lack of wetland, which acts as a sponge, soaking of rainwater, played vital role in the devastating effect of floods. According to a report of a leading daily, over 5500 hectares of wetlands in those two districts have been into commercial lands and as a result only 10 percent of the original wetlands remained. Hence, rainwater runoff has nowhere to go and settles instead along the road, causing flooding. This severe flood disaster was caused due to mismanagement and violation of protocols during urban planning and unplanned sprawl of urban development.

1.2.2 Types of soils

Soils of Ambasamuthiram are mostly clay, sandstone and shale. Areas found along the coasts and the river banks are sandy in nature and in these areas, run water percolates quickly though the soil. And a few parts of Ambasamuthiram comprise hard rock surface. The groundwater table in Ambasamuthiram is 4-5 m below the ground level.

Among many soil tests through apparatus, a few have been employed to test the soil in Ambasamuthiram, especially two methods have been employed for the soil test: visual method where the soil sample is collected and examined in the laboratory while titrimetric test is used to determine the concentration of a substance in a sample solution.

1.2.3 Slope and size of watershed

There are a number of watersheds in Ambasamuthiram alone. Some of the well-known water sheds are at Ambasamuthiram, Papanasam and a few canals. Watersheds range from 10.5 km to 50.99 km and it bears a slope of 1 in 20 which indicates that if the volume of water rises suddenly in the river basin then there will be high chances of flood occurrence due to overflow. The Fig.4 watershed boundaries of different rivers in Ambasamuthiram town river basin.

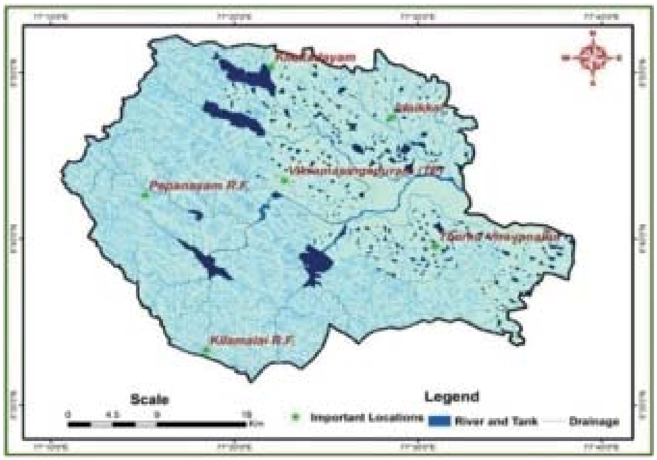

Fig.4 Watershed boundaries of different rivers in Ambasamuthiram town river basin

2.0 Multi-criteria analysis

Applied and integrated with the spatial data, the causative factors of a phenomenon under concern of multi-criteria

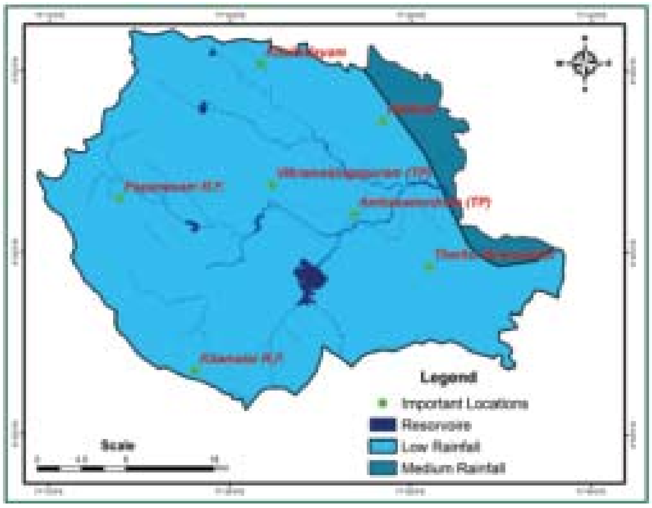

Fig.5 Map showing flood validation

analysis, are described. In this study, the risky areas were first produced by numerically overlaying soil, drainage network, slope, rainfall layers and size of the watershed. The selection of these criteria was based on the expert's opinion and avaibility of data. Boolean overlay was employed to carry out this overlay. Logical operators such as intersection and union combined all criteria for analysis.

In the second phase, ranking method was used, where every criterion under consideration was ranked in the order of the decision maker's preference. Each factor was weighed according to the estimated significance for causing flooding. Factor of rank 1 is the least important and factor of rank 8 is of the most importance. In the third phase, determination of the weight of each criterion was done by pair wise comparison method which was developed by Saaty. General procedure used to create flood risk map for the study area is illustrated in figure.

2.1 Spatial Analysis

Rainfall is a continuous phenomenon that affects the whole region, not just the locations of the weather stations. Based on the observed rainfall at the monitoring stations and their locations, we can interpolate and deduce the approximate rainfall across the whole region. We use the interpolate points tool from the GIS's spatial analysis service for this. The Fig.5 show the flood validation.

3.0 Pair-wise comparison method for Ambasamuthiram flood

This method is generally used for the comparison of two criteria at a time. Conversion of subjective assessments of relative importance into linear sets of weights is taken into consideration in this method. In this case study, this method estimates the weight of the following criteria:

C1= Slope of the basin;

C2= Rainfall (precipitation);

C3= Drainage network;

C4= Soil type.

The square pair-wise comparison matrix is presented in Table 2. Each factor was given weightage according to the estimated significance for the flood potential project which was to generate the criterion values for each evaluation unit. Table 3 shows the normalized matrix. At the same time, the individually observed record, this never agreed perfectly with the degree of consistency achieved in the ratings which were randomly generated. The random indices for the matrices are listed in Table 4. According to the rule of the thumb, CR less than or equal to 0.1 indicates an acceptable reciprocal matrix, whereas a ratio over 0.1 symbolises that the matrix should be revised.

Calcutaion based on pair-wese method

Calculating consistency ratio (CR) CR = CI/RI

Where, CI = (ζ max – n)/(n – 1); RI= Random consistency index

Table 2: Pair wise comparison matrix for flood risk parameters

	C1	C2	C3	C4
C1	1.1	2.3	2.1	2.5
C2	0.5	1	2.3	0.5
C3	0.5	0.5	1	0.5
C4	0.5	2	2.1	1.7
Total	2.6	5.8	7.5	5.2

Table 3: Normalize matrix

	C1	C2	C3	C4	C5
C1	0.4	O.36	0.29	0.5	0.387337662
C2	0.2	0.18	0.29	0.125	0.198133117
C3	0.2	0.09	0.14	0.125	0.139691558
C4	0.2	0.36	0.29	0.25	0.274837662
Total	1	1	1	1	1

Table 4: Random indices for matrices of various sizes (n).

N	R1
1	0.00
2	0.00
3	0.59
4	0.97
5	1.13
6	1.25
7	1.34
8	1.41
9	1.20
10	1.50
11	1.53
12	1.49
13	1.57
14	1.60
15	1.65

n = Number of Criteria

max is the priority vector multiplied by each column total;

max = 4.13526786CI= 0.04508929

CR = 0.0500992

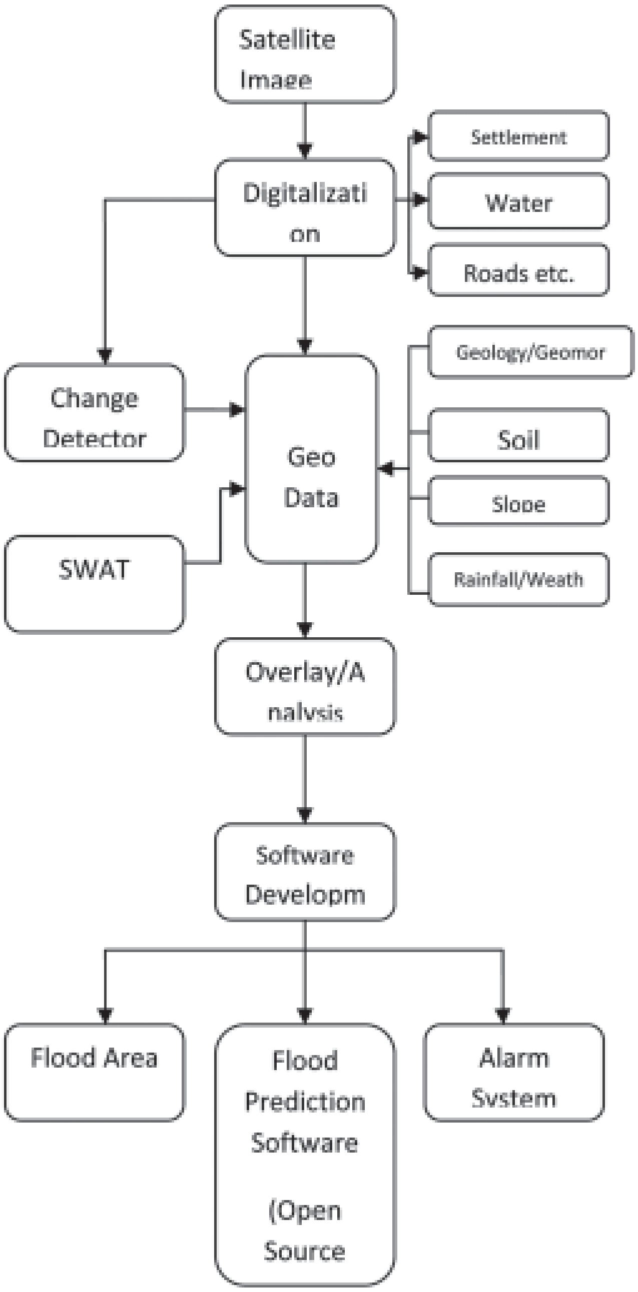

Fig.6 i.e Flowchart showing multi-criteria analysis satellite image

4.0 Result and discussion

4.1 Flood Risk Map

The Tamiraparani originates from the peak of the Periya Pothigai hills of the Western Ghats above Papanasam in the Ambasamudram taluk. The great river like the Cauvery, but unlike most of the other Indian rivers, is fed by both the monsoons – the south west and the north-eastern and is seen in full spate twice a year if the monsoons do not fail. Prior to the bifurcation of the Tirunelveli district, the Tamiraparani was the only major river in Tamil Nadu which had its source and end in the same district. After bifurcation, the river traverses the two districts of Tirunelveli and Tuticorin before joining the Gulf of Mannar of the Bay of Bengal at Punnaikayal in Tiruchendur taluk of Tuticorin district. Thamirabarani river is 130 km in length and the Thamirabarani basin is situated between latitudes 8.21ºN and 9.13ºN and between 77.10ºE longitudes. The forty meters deep Vanatheertham waterfalls are located near the origin of the Thamirabarani river. The river is feed by its tributaries as well as by monsoons. The Thamirabarani has several tributaries, which join at different points during its course. The tributaries Peyar, Ullar, Karamaniar and Pamba join near the Papanasam reservoir. A major tributary of Thamirabarani is the Servalar river, which joins at a distance of 22 km from its origin. The Manimuthar river, which originates in the Agathimalai Ranges and joins Thamirabarani near Ambasamudram. Gadana river joins at a distance of 43 km from its origin. The Pachaiyar river joins near Gopalasamudram. Chittar river flows for seventy-three km before joining this River. The river flows for 125 km out of which 75 km are in the Tirunelveli district. The Vaigai is a river in Madurai, Tamil Nadu state of southern India. The major tributaries of the river Vaigai are, Suruliyaru, Mullaiyaaru, Varaganadi, Manajalaru and Kridhumaal. Vaippar is a river in the state of Tamil Nadu. It originates from the hills bordering the state of Kerala and runs through Teni and Virudhunagar districts before entering the Gulf of Mannar. Gunnar is a river flowing in the Virudhunagar and Tirunelveli districts of the state of Tamil Nadu. The sanctuary area is within the 15 m (49 ft.) high embankments of the

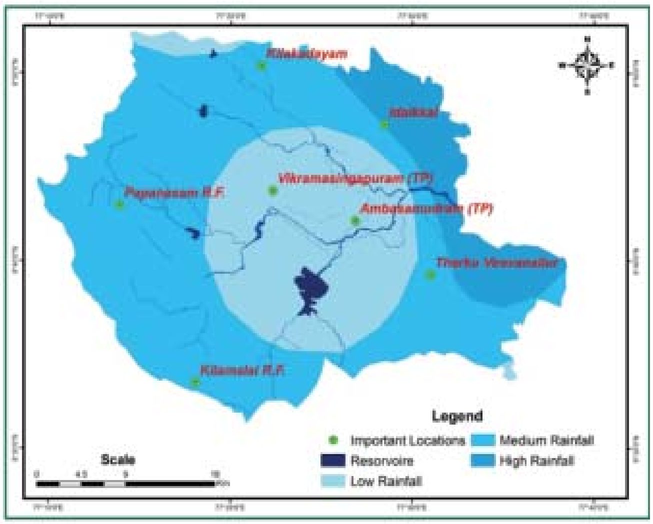

Fig.7 Rainfall winter spatial distribution map period of 2007-2016

community irrigation tank. The total length of the embankment is 4.010 km.

Evaluation of each unit based on ranking method was generated using the criterion maps combined by logical operations and criterion values. Fig.6 shows the floodrisk map created based on GIS and multi-criteria method. Using pair-wise comparison the normalized criterion weights were calculated as 0.198, 0.387, 0.275 and 0.14 respectively for basin slope, annual rainfall, drainage network of the river basin and soil type. The study carried out based on this method showed a consistency ratio (CR) value of 0.0, which fell much below the threshold value of 0.1 which indicates a high level of consistency. Therefore, the weights are acceptable (Fig.8).

4.2 Flood map validation

The flood potential map which resulted from multi-criteria analysis was compared to the original flood map of 2005/2006 obtained from DID in Ambasamuthiram for the purpose of validation. The original flood potential map is shown in Fig.7 which was classified based on flood vulnerability:

(a) 4 for the most prone to flooding;

(b) 3 for the moderately prone to flooding;

(c) 2 for the least prone to flooding;

(d) 1 for no flooding area.

All the features which had been designed in grid code values of feature map from the raster pixel values are shown in the map. Correspondingly individual polygon has one grid value (i.e., 1, 2, 3 and 4) based on the cell value at the same location in the raster. This step helped to design four polygon features with each polygon having different flood suitability level. The flood classes which were obtained were converted into external shale file (*.shp) and the external image was compared with the original flood map.

The final extracted flood map which contained the data and features of original and potential flood maps had been analysed and it was noticed that the non-flooding area (class 1) did not exist in the original flood map. Table 5 summarises the overlaid result for the other classes (class 2-4). The total area of original flood map was 66.742 sq km which means around 90% of the original flood area was covered by class 4 and 3. The above respective two classes indicate the high flood potential area and moderate flood potential area. The remaining areas were covered in class 2

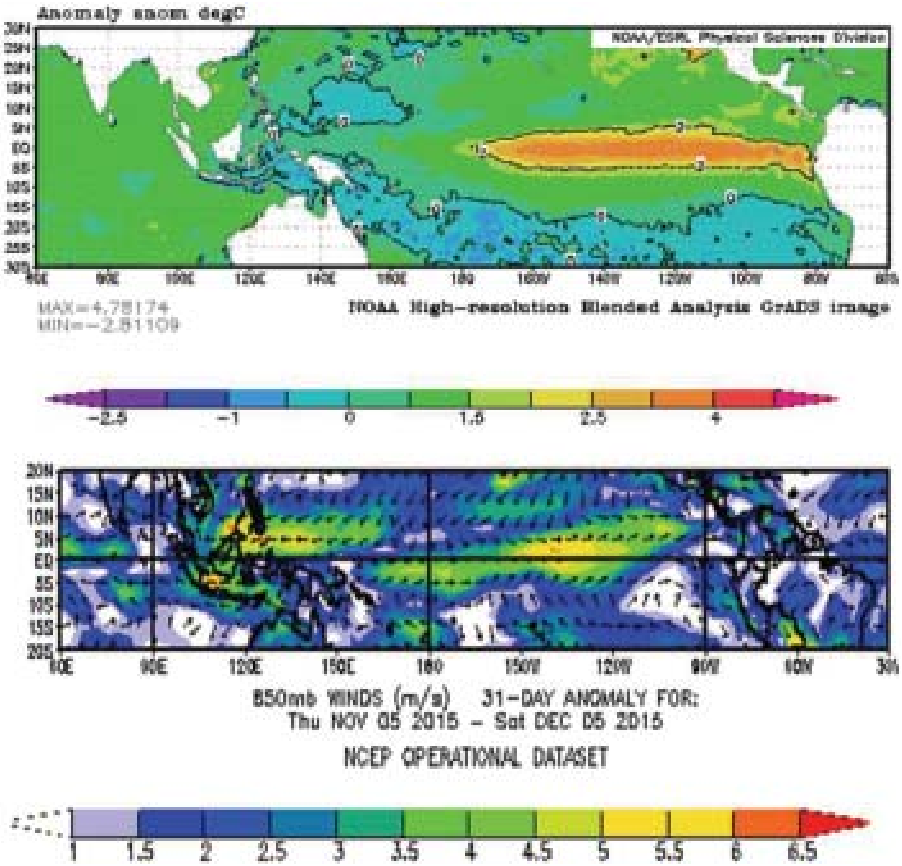

Fig.8 Distribution of SST (During October-December 2015) anomalies and wind speed at 850 mb (05 November- 05 December) based on NCEP/NCAR reanalysis as plotted with the tool

Table 5: Most affected zones/places in Ambasamuthiram town

	Affected places /zones	Affected flood area in %
1	Phavanasam	14.5
2	Manimutharu	17.2
3	Kadayam	18.8
4	Ambasamuthiram	15.5
5	Mukoodal	12.4
6	Srivaigundam	11.2
7	Tirunelveli	10.4

as shown in Fig.8.

4.3 Strong El-Nino of 2015 and the Possible Connection

The El-Nino of 2015 was one of the strongest reported, which started developing in 2014. El-Ninos are reported to have impacts on North East monsoon (Zubair and Ropelewski, 2006) by modestly intensifying it. A possible hypothesis would be that a stronger El-Nino led to a strong easterly during Nov-Dec 2015 (Fig.7) which probably brought moisture to the East coast of India over Ambasamuthiram with a much intensified rainfall. However, the scientific question remains if the easterlies (possibly) generated by El-Nino are the only reason or some other factors/drivers have caused heavy precipitation over Ambasamuthiram. This hypothesis needs climate model based verification. The Fig. 8 shows the distribution of SST (During Oct- Dec 2015) anomalies and wind speed at 850 mb (05 November - 05 December) based on NCEP/NCAR reanalysis as plotted with the tool.

5.0 Recommendatioins

After the flood the sense of fear had entered into the mind of people. This forced the experts and scientists to reason out the causes and factors of the flood. After that the suitable and valid remedies should be fetched. Some of them are recommended below:

(a) Better understanding of the weather

It is always better to understand the weather conditions in advance and the data collected should be of great accuracy so that there will not be any havoc created afterwards. By doing so, people can act on the disastrous management action easily.

(b) Water wiring of cities

Every small water body should be taken into consideration along with the large and well known rivers, reservoirs and canals. Only by doing so we would not miss out any small bit of information and thus we could edify the problems.

(c) Maintenance of watershed and drainage systems

Watersheds should be maintained very well. Although it seems to less important, a watershed plays a vital role in controlling the overflow of water. Similarly, drainage system should be checked and kept clear of obstacles. All the channels of drains should be connected properly and the outlet should be properly maintained.

(d) Improvements of civil infrastructure and wetlands

Most of the underlying ground soil of Ambasamuthiram is the refill of ponds and lakes. These soils act as a poor filter for the rain water. Thus, all the rain water gets collected on the surface which causes floods. This can be avoided by improving the soil permeability and building proper civil infrastructure will allow the water to pass through proper channels.

(e) Human activities

One of the factors which contributes to flood or any other natural disasters is human's selfish activities. Burning of harmful gases and fuels, raising the number of industries, clearing the forest cover for construction purposes etc., have dramatically changed the climatic conditions over the decades. Therefore, human beeing need to reduce their wants and try to live in harmony using the nature wisely.

6.0 Conclusion

The study area (presented with the darkest area as shown in Fig.7) is the high potential area for flood. However, the potentiality of flood decreased as the underlying surface was hard rock or sandy. Further validation was done to ensure the result. This result could be a valuable tool for assessing flood risk. The study also reviewed the role of GIS in decision-making and then outlined the evaluation approach for many criteria in decision process.

There have been many small patches of water bodies like ponds, lakes, rivers which were turned into artificial dry lands without proper care and recommendations from the government. This was considered as one of the main factors which caused flood in Ambasamuthiram. The study showed the number factors which contributed to Ambasamuthiram flood. They are: continuous precipitation, cyclones, physical land terrain, improper civil infrastructure, drainage system, watershed and wetlands.

According to the study, the flood was the most disastrous facts which hit Ambasamuthiram leaving millions of people homeless. There has been economic crisis due to the damages caused to the domestic properties and agricultural products which were cut off completely. This has basically caused loss to four economic bodies. The summary of estimated economic loss in four various bodies are: Ambasamuthiram real estate faced the loss of Rs 30,000 cores, small and medium industrial units bore the loss of Rs 14,000 cores, insurance companies and street vendors faced the loss of Rs 4,800 and Rs 225 crores respectively.

Meanwhile, many people lose their lives. A few became homeless and millions were afraid of the flood. This posed a great threat to human lives both mentally and physically. So it became necessary to detect the cause and avoid such disastrous flood in future. For reasons many experts are working to resolve this series issue.

7.0 Reference

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