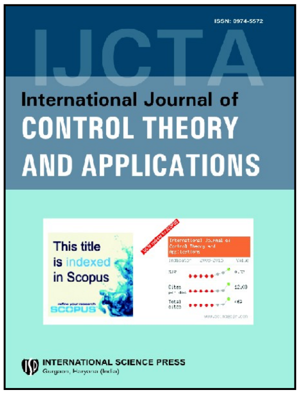

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Assessment of Quantitative Index, Depicting the Vulnerability of Avulsion for Decision Support System in Madhubani District of North Bihar – India, by Employing Global Land Data Assimilation

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Abstract: Flood plain is the area where a variety of river landforms are built by sediments which are derived from upper reaches of the drainage basin and deposited further downstream. Increasing human intervention in watersheds and extensive deforestation has resulted in a deficiency in these constituents in recent floodplain deposits. In addition, an increase in the relative proportion near river side as the river side fertile soil is suitable for farming is one of the major causes of damaging of flood plains. Population pressure has led to repeated reclamation of these areas for farming, location of industries, housing and transport network. The resulting pollution of water bodies has adversely affected aquatic life and the overall ecosystem. There is an urgent need, to make balance in such man made disaster invitation activities.

In this study a methodology to compute a quantitative index depicting the vulnerability of flood, based on indicators, is developed, that can be used as a tool for decision making to direct investments at the most needed region. Its implementation could guide policy makers to analyse actions towards better dealing with floods. Three main components of a system are recognized which are affected by flooding: social, economical and environmental The interaction between vulnerability factors and the components serves as the base of the proposed methodology. The methodology has been applied in various temporal scales (Monthly from January 1979 to August 2015), which resulted in interesting observations on how vulnerability can be reflected by quantifiable indicators. Implementation of this study will support in decision making and policy formation towards better dealing with flood in Madhubani.

Keywords: Decision support system, Flood Vulnerability Index, Avulsion detection, Quantitative index method of avulsion forecasting, Global Land Data Assimilation.

PROBLEM STATEMENT AND ITS CAUSES

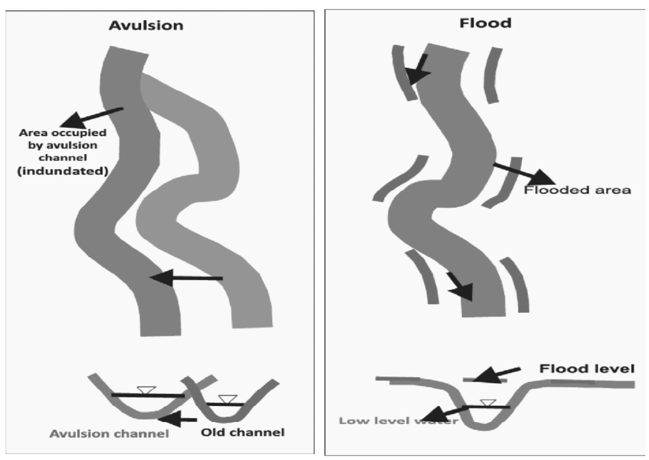
- Floods according to common perception occur; due to heavy rainfall in monsoon season and may arise from abnormal precipitation, dam failure, rapid snow melts, and river blockage or even burst water mains, channels carry heavy sediment load, reducing their capacity to carry water, indiscriminate construction and encroachment in river beds narrows the channels.

- Heavy monsoon rains and poor maintenance caused a breach in the Kosi embankment almost every rainy season in Madhubani.
- Occurrence of Avulsion in Madhubani is due to sudden change in the course of a river. Avulsion can occur even during a minor increase in discharge. Its causes due to following reasons.
- Role of Precipitation: A flood occurs when the Geomorphic Equilibrium in the river system is disturbed because of intrinsic or extrinsic factors . As an example large flux of sediments may reduce the depth of channel to such an extent that the river overflows its banks. A similar situation can arise because of heavy rainfall when the discharge exceeds the carrying capacity of the river.
- **Dam:** It's a Man Made creation against the ecology phenomenon.
- **Discharge of water from curved stream flows:** Discharge of a stream is the amount of water passing any point in a given time.

Q = A x V

Discharge = Cross-sectionalArea (width x average depth) x Average Velocity

(m3/sec) = (m2) x (m/sec)



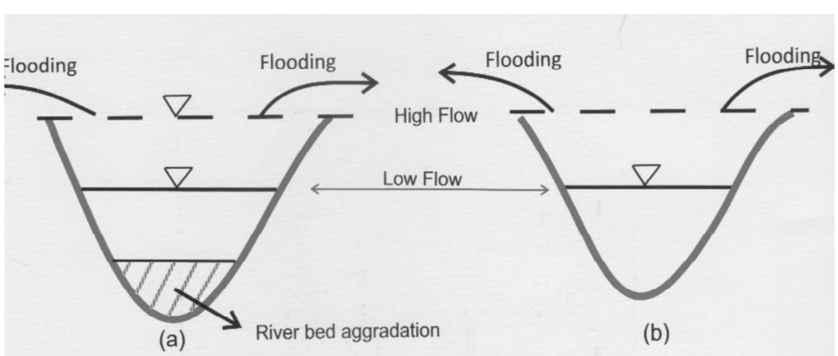


Figure: Illustration that, In Turbulent Flow, river flows healthy as of ample number of Flood Plains that reduces the breach or overflow of permissible banks

Stream Load: A The rock particles and dissolved ions carried by the stream are called the stream's load. Stream load is divided into three parts:

Suspended Load: particles that are carried along with the water in the main part of the stream. The size of these particles depends on their density and the velocity of the stream.

Bed Load: denser particles that remain on the bed of the stream most of the time but move by a process of saltation(jumping).

Dissolved Load: ions that have been introduced into the water by chemical weathering of rocks. Dissolved load consists mostly of HCO-3 (bicarbonate ions), Ca+2, SO4-2, Cl-, Na+, Mg+2, and K+. These ions are eventually carried to the oceans and give the oceans their salty character.

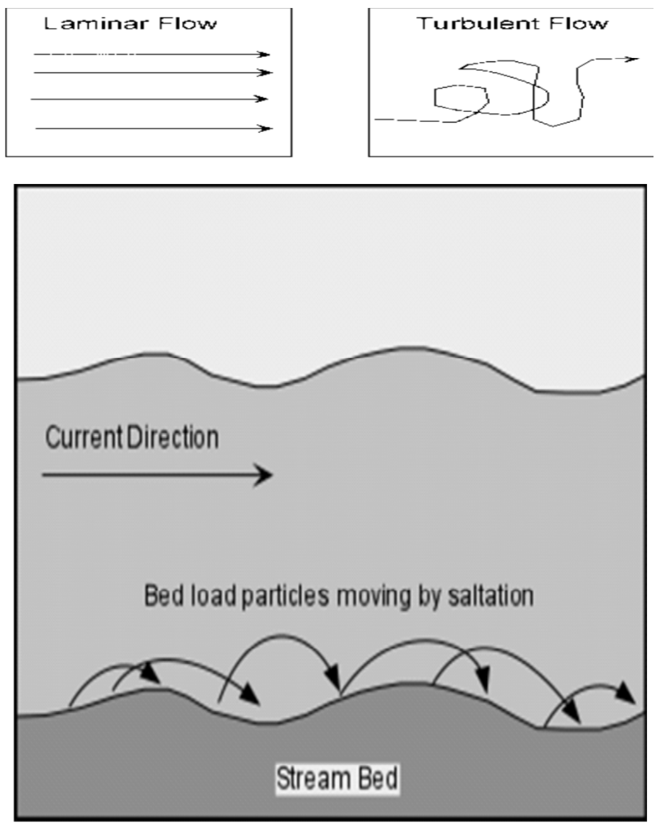


Figure: Stream Load

It encounters an enormous amount of human and animal causalities, public property damage, annihilate social living of society….. every year and huge expenditure comes to surmount this pre-known natural disaster

RESEARCH OBJECTIVE

The basic purpose of this research is to utilize technological innovation through software simulation, to help, design and do make an optimal decision that can contribute to the welfare of the country and its people. The disaster risk (of a region, a family, or a person) is therefore made up of two elements: hazard and vulnerability. Under the sponsorship of the International Strategy for Disaster Reduction (ISDR) an updated glossary was issued in May, 2001, which marks a major step forward in standardizing terms in disaster risk management.

Disaster Risk = Hazard × Vulnerability (susceptible to being wounded or hurt**)**

Occurrence of hazard is natural and common ecological event, so variable Hazard considered as constant; that converts the following expression

Disaster Risk ∝ Vulnerability

In this case, the objective of study is to reduce vulnerability factor with the aid of technology by generating early warning system and its intensity, before the occurrence of disaster and it will automatically reduce the disaster risk.

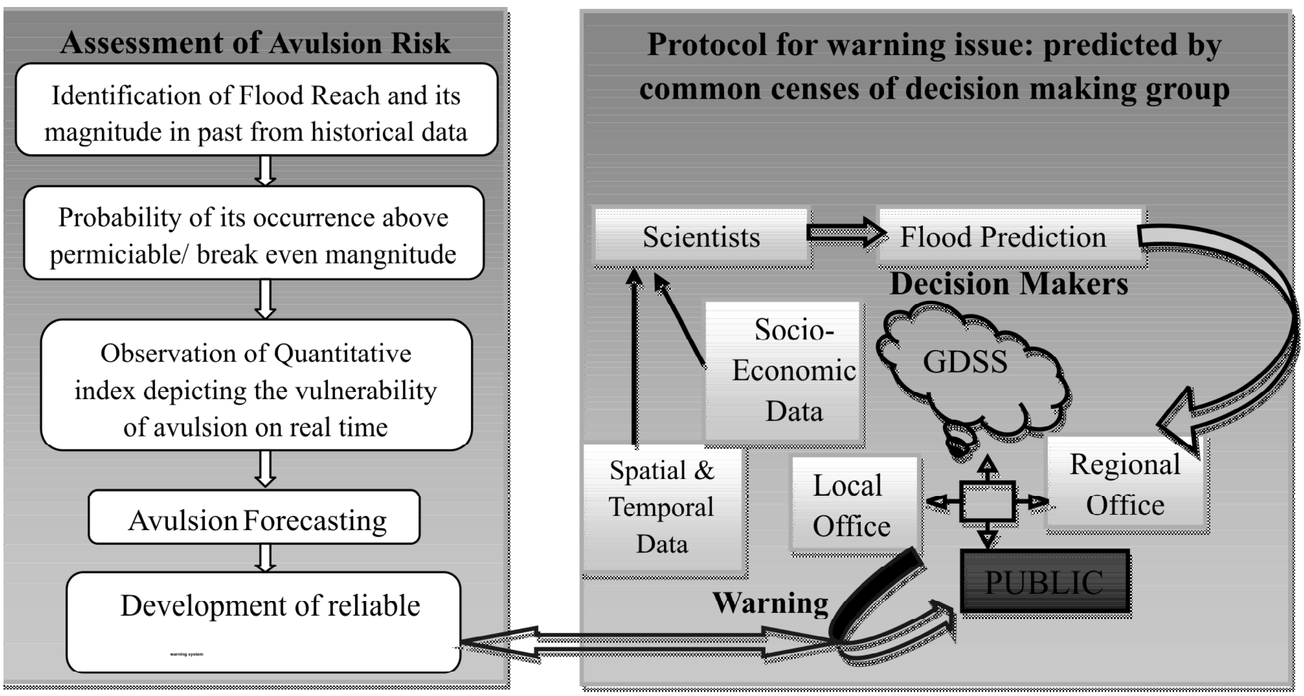


Figure: Prediction of Avulsion and computation of Early warning system to Reduce vulnerability

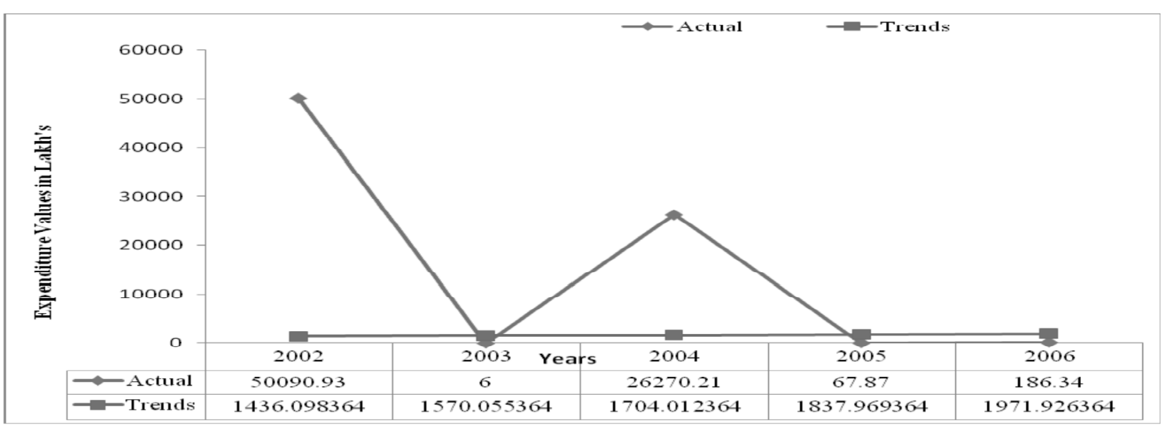
To validate region where flood affects almost every year, a time series- Quantitative forecasting method is used for long range forecast on the basic of following facts:

- Past information about the variable being forecast; is available (from year 1991 to 2001).
- Available information is quantitative (in terms of, amount in rupees)
- A reasonable assumption is that the pattern of past will continue into the future.

	Value of Damaged Crops (Rs Lakh)	*Value of Damaged Residential Buildings (Rs. Lakh)*	*Damage Value of Public Property (Rs. Lakhs)*	*Cash Dole Compensation distributed (Rs. Lakhs)*	*Total Amount (Rs. Lakhs)*	
1991	8.13	2.64	0.5	0	11.27	
1992	0	0	0	0	0	
1993	34	184.55	210.76	0.03	429.34	
1994	0	0	0	0	0	
1995	689.76	212.54	127.2	19.01	1048.51	
1996	448.8	0.5	0	0.03	449.33	
1997	1.57	0	0	0.11	1.68	
1998	302.24	47.45	0	130.81	480.5	
1999	1619.36	309.17	845.5	0.58	2774.61	
2000	172.58	760.4	2	26.78	961.76	
2001	320.82	328.24	107	42.86	798.92	
					6955.92	Trend
2002	13330.6	31180.43	5311.01	268.89	50090.93	1436.098
2003	6	0	0	0	6	1570.055
2004	5500	6192.73	13771.7	805.78	26270.21	1704.012
2005	67.47	0.4	0	0	67.87	1837.969
2006	180.34	6	0	0	186.34	1971.926
					76621.35	8520.062

	Actual	*Trends*	
2002	50090.93	1436.098	-48654.8
2003	6	1570.055	1564.055
2004	26270.21	1704.012	-24566.2
2005	67.87	1837.969	1770.099
2006	186.34	1971.926	1785.586
	13939.88	**5973.865**	

In figure five year actual and linear **trend analysis advocates that Madhubani is a flood affected districts** in north Bihar- India.



RESEARCH METHODOLOGY

Research Design	Exploratory Research Design.
Data Type	Secondary Data.
Data Source	• For statistical forecasting data - Bihar Secretariat (Govt. of Bihar), • Data for Simulation - Official Website of NASA – NIC/Census data of Govt. of India
Sampling Used	Area Sampling and Judgmental Sampling
Sample Size	Madhubani is one, among five heavily flood affected districts of North Bihar (that had been the main focus area of United Nations Development Program (UNDP) during year 2002- 2006)

RESEARCH HYPOTHESIS

Null Hypothesis (H0) **(A):** There will be minimum occurrence of flood during the month of May to November every year.

(B): There will be no relationship between intensity of flood and Flood Vulnerability Index [F.V.I.], for mitigation to flood affected areas.

Hypothesis Testing If numerical weight of Climate and Hydrogeological Factors is greater than 1 then there will not be any "Flood" else there will be "Flood".

COLLECTING THE DATA

To analyse following dominant land and surface factors

(1) Forcing (such as surface meteorology and radiation)

(2) State (such as soil moisture and temperature)

(3) Flux (such as evaporation and sensible heat flux)

Within LandClimateHydrogeological (function used in following algorithm) conditions; monthly data (starting from January-1979 to August-2014) is fetched using file transfer protocol from official website of NASA, and stored in CPU for farther execution on it.

Specific lat long scale used for this data mining is as under:

Table: Lat Long Scale for Spatial Data-Mining

District Name	*Latitude Longitude Pointer Location (as Under)(scale: 2mi=2kms)*			
	North	*East*	*West*	*South*
Madhubani	26.376338	86.097766	86.049529	26.316036

DATA ANALYSIS

Total 27 factors considered for analysing the impact of LandClimateHydrogeological (function used in following algorithm) components, on occurrence of flood, seven are of different dimensions and near surface specific humidity is dimension less.

So researcher can not determine the quantitative relationship among such variables. Such type of data is termed as 'non-metric' data.

As correlation and regression techniques are not applicable for non-metric data, so in these circumstances researcher is applying 'Linear Discriminant Analysis' that enables the researcher to predict the quantitative relation among mutually exclusive data elements (such as non-metric data).

Discriminant analysis promotes a scoring system, on the basis of which it classifies individual data elements in the most likely classes. In mathematical equations of LDA; not only the values of the Discriminant coefficient but also the positive or negative sings of these coefficients are equally relevant. Positive or negative sign of data item in Mathematical equation elaborates that individual data component belong to that category or not and the numeric value before sing emphasis the magnitude of support.

To obtain desired results LDA gives following algorithm that processing mathematical formulation (on total 428 months, monthly data) for assessment of Land, Climate and Hydrogeological Components over study area:

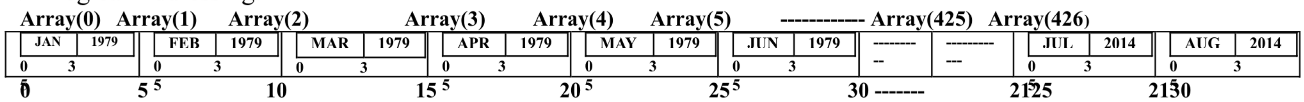
Algorithm for Flood Vulnerability Index [F.V.I.] computation for Madhubani

```
Void MADHUBANI()
{
Begin
Int :i,j,k,m;
/*scope of data types declared within the MADHUBANI() function, same data may be initialised beyond the scope of MADHUBANI() */
    long double : value1, value2; FVI=0,FVI_m;
        struct
          {
        char month[3];
        int year [4];
          } Array[428]; // there are total 428 records in Array(k); starting from JAN1979 to AUG2015 for (k=0; k<427;k++)
          {
              write ("enter the 'month' and 'year' starting from JAN1979 onwards");
              read("%s, %d", Array[k].month, &Array[k].year);        //initialization of array
          }

              write("enter the 'starting' month and year for flood Vulnerability Index [FVI]
              estimation "); read("%s, %d", Array[i].month, &Array[i].year);
                  //starting record (in month & Year) is initialized as i^th logicallocation of Array

              write("enter the 'ending' month and year for flood Vulnerability Index [FVI]
              estimation "); read("%s, %d", Array[j].month, &Array[j].year);
                  //ending record (in month & Year) is initialized as j^th logical location of Array
```

/* Logical Addressing: --




```
physical addressing:*/
if (j<i)
        exit(1);    //if logical value of ending month & Year (i.e.'j') is smaller than
                    the logical value of starting month & Year (i.e.'i'), then exit
        else
                    for (m= logical location of Arra[i]; m<= logical location of Array[j]; m++)
                    Begin
                          value1=LandClimateHydrogeologicalData(G1, H1,I1,J1,k,l,m);
                          value2=PopulationSocioEconomicData();
                          FVI=((value1+value2)/2);
                          write(" Flood Vulnerability Index= %Lf", &FVI);
                          FVI_m=FVI;
                    End
                    Write("Resultant Flood Vulnerability Index (FVI) for selected time duration will be =
                          %Lf",&median(FVI_m));
End                                                    //END OF MADHUBANI() function

              LandClimateHydrogeologicalData(G1, H1,I1,J1,k,l,m)
              Begin
                    long double : k,l,m,G1,H1,I1,J1,F_1=0;
                    write("Enter the values of :Near surface specific humidity, Near surface wind Magnitude,
                          Surface Pressure");
                    read (" %Lf, %Lf, %Lf",&k,&l,&m);
                    G1=g();
                    H1=h();
                    I1=I();
                    J1=j( );
                    F_1 = ((0.419715293355205*G1) - (0.651954320654439*H1)+(0.590733231443679*I1) +
                          (0.463044940899173*J1) + (0.646230576231404*k) - (0.24032055380742*l)
                          - (0.0712375692868146*m));
                    return(F_1);
        End         //end of function LandClimateHydrogeologicalData(g( ), h( ),i( ),j ( ),k,l,m);

        PopulationSocioEconomicData();         // global function call
        g ( )
        Begin
                    long double : g_1,g_2,g_3,g_4,g_5,g_6,g_7,G=0;
                    write ("Enter the values of: Average layer (0-10 cm) soil temperature, Average layer (10-40
                    cm) soil temperature, Average layer (40-100 cm) soil temperature, Average layer (100-200
```

```
        cm) soil temperature, Deep soil temperature,Average surface temperature, Near surface
        air temperature");
            read (" %Lf, %Lf, %Lf, %Lf, %Lf, %Lf,%Lf",&g1,&g2,&g3,&g4,&g5,&g6,&g7);

        G=  ((0.204674835404771* g1)+ (0.276170783309992* g2)+ (0.402765331464704* g3)+
            (0.673082256593763* g4)+( 0.281762184228599* g5)+ (0.190510066427232*g6)+
            (0.2316553492387* g7));
        return(G);
End                         //end of function g();

h( )
Begin
      long double : h1,h2,h3,h4,h5,h6,h7,H=0;
      write ("Enter the values of: Ground heat flux, Latent heat flux, Net longwave radiation, Net
        shortwave radiation,Sensible heat flux, Surface incident longwave radiation, Surface
            incident shortwave radiation");
      read(" %Lf, %Lf, %Lf, %Lf, %Lf, %Lf,%Lf",&h1,&h2,&h3,&h4,&h5,&h6,&h7);

      H=      ((0.116485544423381*h1) - ( 0.495034455183463*h2) - ( 0.406890003084864*h3)+
              (0.141302145545916*h4 )+( 0.125878006823456*h5) - ( 0.362373234711186* h6)+
              (0.142754695925954*h7));
        return(H);
End                         //end of function h();

i( )
Begin
      long double : i1,i2,i3,i4,i5,i6, I=0;
      write ("Enter the values of: Average layer 1 (0-10 cm) soil moisture, Average layer 2 (10-40
        cm) soil moisture, Average layer 3 (40-100 cm) soil moisture, Average layer 4 (100-
        200 cm) soil moisture, Average layer 5 (200-350 cm) soil moisture, Total canopy water
        storage");
      read(" %Lf, %Lf, %Lf, %Lf, %Lf, %Lf",&i1,&i2,&i3,&i4,&i5,&i6);
      I = ((0.8829818418279*i1)+(0.802950461318506*i2)+( 0.58274745204613*i3)+
        (0.497668899202336*i4)+( 0.592927132581172*i5)+( 0.506033081724651*i6));
      return(I);
End                         //end of function i();

j( )
Begin
        long double : j1,j2,j3,j4, J=0;
        write ("Enter the values of: Rainfall rate, Surface runoff, Subsurface runoff, Total
            evapotranspiration");
```

```
read(" %Lf, %Lf, %Lf, %Lf ",&j1,&j2,&j3,&j4);

                J = ((0.652*j1)+( 0.43* j2)+( 0.534*j3)+( 0.89*j4));
                return(J);
    End                     //end of function j();
}
PopulationSocioEconomicData()
    Begin
    Int: p;
    float :f20,f21,f22,f19,f23,f24,f18,f25,f26,f17,f27,f28,f16,f29,f210,f15,f211,f212,f14,f213,f214,
    f215,f13, f216,f217, f218,f219, f220, f221,f222;
        long double :
    w1,w2,w3,w4,w5,w6,w7,w8,w9,w10,w11,w12,w13,w14,w15,w16,w17,w18,w19,w20,w21,w22, F2;
write("Total Population Person,Total Population Male, Total Population Female, Literates Population Person, Literates Population Male, Literates Population Female, Illiterate Persons, Illiterate Male, Illiterate Female, Total Worker Population Person, Total Worker Population Male, Total Worker Population Female, Total Non Working Population Person, Non Working Population Male, Non Working Population Female, Total Population of infants (0-6years), Population of infants (0-6years) Male, Population of infants (0-6years) Female, Total Number of Households, House Type Permanent, House Type Semi- Permanent, House Type Temporary, Total inhabited villages, Drinking water facility, Electricity availability, Educational institutes, Medical centres, Road connectivity, communication services, Transport services");

read("%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f,%f",
&f20,&f21,&f22,&f19,&f23,&f24,&f18,&f25,&f26,&f17,&f27,&f28,&f16,&f29,&f210,&f15,&f211,&f212,
&f14,&f213,&f214,&f215,&f13,& f216,& f217,& f218,&f219,& f220,& f221,& f222);

//(Relative weight of Total Population Male)//                          w1  = (f21/f20);
//(Relative weight of Total Population Female)//                        w2  = (f22/f20);
//(Relative weight of Literates Population Male)//                      w3  = (f23 /f19);
//(Relative weight of Literates Population Female)//                    w4  = (f24/f19);
//(Relative weight of Illiterate Male)//                                w5  = (f25/f18);
//(Relative weight of Illiterate Female)//                              w6  = (f26/f18);
//(Relative weight of Total Worker Population Male)//                   w7  = (f27/f17);
//(Relative weight of Total Worker Population Female)//                 w8  = (f28/f17);
//(Relative weight of Non Working Population Male)//                    w9  = (f29/f16);
//(Relative weight of Non Working Population Female)//                  w10 = (f210/f16);
//(Relative weight of Population of infants (0-6years) Male)//          w11 = (f211/f15);
//(Relative weight of Population of infants (0-6years) Female)//        w12 = (f212/f15);
//(Relative weight of House Type Permanent)//                           w13 = (f213/f14);
//(Relative weight of House Type Semi- Permanent)//                     w14 = (f214/f14);
//(Relative weight of House Type Temporary)//                           w15 = (f215/f14);
//(Relative weight of Drinking water facility)//                        w16 = (f216/f13);
```

```
//(Relative weight of Electricity availability)//          w17 = (f217/f13);
//(Relative weight of Educational institutes)//            w18 = (f218/f13);
//(Relative weight of Medical centers)//                   w19 = (f219/f13);
//(Relative weight of Road connectivity)//                 w20 = (f220/f13);
//(Relative weight of communication services)//            w21 = (f221/f13);
//(Relative weight of Transport services)//                w22 = (f222/f13);
for (p=1; p<23;p++)
Value2=sum (wp);
return(Value2);
End                                 //end of PopulationSocioEconomicData()
```

TESTING OF RESULTS

Madhubani district has been found that among 428 months study (starting from January 1979 to August 2015) the actual results obtained support hypothesis in 367 months, so it gives 85.74766355% favours or advocates tautness of hypothesis and expresses that forecast is 'True'.

District Name	*support hypothesis level (in%) for correctness of forecast, based on 428 months study*	*If we alter our hypothesis that flood will occur only in June to October every year (instead of flood occurs only from May to November) then support hypothesis level (in%) for correctness of forecast, based on 428 months study*
Madhubani	85.74766355%	92.7570093457944%

FINDINGS

Kosi river in north Bihar plains shows extreme variability in terms of flood magnitude and frequency (both spatially and temporally). During study it was found that only hydrological data is not enough for the assessment of Flood Vulnerability Index [FVI] as vulnerability depends on multi-dimensional factors. So, hydrogeological data can be meaningfully integrated with population and socioeconomic data to create Flood Vulnerability Index [FVI] database on monthly basis for a time interval starting from January 1979 to August 2015.

FVI has been calculated using Land, Climate and Hydrogeological Components as well as Population and Socio Economic Data. Such efforts are a part of non-structural measures of flood management to reduce short term and long term damages. **Analysis of 'FVI'is valuable and powerful tool for policy and decision makers along with and insurers**. **It helps to prioritize investments and makes the decision making process more transparent. Identifying areas with high flood vulnerability may guide the decision making process towards preparedness to mitigate the impact of flood.**

The disaster awareness programme has to be structured on the following lines mentioned here under:

1. The state Disaster Management Policy is being prepared which will facilitate in effective disaster anagement at various levels.
2. Large scale awareness generation among various stakeholders including government officials, Panchayati Raj representatives and common mass is being carried out at various levels through

state level exhibition like 'Chetna', rally among school students, slogans and wall paintings in buildings on various Do's and Don'ts on Disasters, slides in Cinema halls, and competitions among school children in various schools are being conducted.

3. Various Capacity Building training Programmes are being conducted on role of various agencies in Pre, During and Post Disaster situations.

CONCLUSIONS

1. FVI provides a method to systematically express the vulnerability of a river system to disruption factors, such as floods.
2. Vulnerability can be reflected by three factors: exposure, susceptibility and resilience (i.e. flexibility).
3. The river and urban systems can be damaged regarding four different components: social, economical, environmental and physical. Floods can be a cause of these damages.
4. The FVI is applicable in three different spatial scales: river basin, sub catchment and urban area scales;
5. FVI is a powerful tool for policy and decision-makers to prioritize investments and makes the decision making process more transparent. Identifying areas with a high flood vulnerability may guide the decision making process towards a better way of dealing with floods by societies.
6. FVI offers easy to understand results, with the use of a single value to characterize high or low vulnerability. This also allows continuous data interpretation for more in-depth analysis and it is suitable to policy-makers.
7. Finally, the proposed methodology to calculate a FVI provides an approach to quantify how much floods are affecting, or can affect, the livelihood of a spatial scale: in all the aspects that make a society function properly.
8. A FVI is calculated by Area clustering within region for heavily flood affected Madhubani district of north Bihar; depicts the most disasters area that numerically grade on one to five in decreasing order of vulnerability index.
9. PM's DIGITAL INDIA may aid to obtaining real-time online data, administration can instantaneously measure Flood Vulnerability Index for individual area with in district and then forecast comparative most vulnerable area within Madhubani; where flood impact is going to be serious. It helps in decision making using GDSS (Group Decision Support System) for optimal resource allocation for rehabilitation to reduce the overall impact of flood.

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