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An Analysis of the Unevenness of Intra-Regional Development of Urban Space and Associated Vulnerabilities: A Study on Nabadwip Municipality in Nadia District, West Bengal, India

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Abstract: The regional development of any urban area is depended on some physical and infrastructural conditions. Theoretically, urban-regional development means the process adjoining with formulation and clarification of socio-anthropogenic objectives in the order of activities in urban-regional space. In some cases the unevenness of spatial development effects on the livelihood of the city-dwellers negatively which may be caused by some physical hazardous conditions or some socio-cultural distress situations. Thus, The present study signifies the hypothesis with fulfilling some specific objectives through selected methodologies that regional development of a particular urban area noted as Nabadwip Municipality, the birth place of Sri Chaitanya situated in Nadia District, West Bengal is uneven and highlights the impact of physiography as a controlling factor of the resultant vulnerabilities such as from 1991 to 2011 and onwards the flood affects most of the central business districts of this urban area rather than its less developed fringes.

Keywords:uneven development, centrality, vulnerabilities, physiographic dilemma

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I. INTRODUCTION

The regional development of any urban area is depended on some physical and infrastructural conditions. Theoretically urban-regional development means, "…the process of formulating and clarifying social objectives in the ordering of activities in supra-urban space" (Friedmann, 1964). The unevenness of inter-ward situation is revealed by some of the disparity of socio-cultural impact factors of urban-municipal area. This type of disparity is measured through the analysis of some of the important indicators and its spatial variations in the, micro-level situations of the municipal area. In some cases the unevenness of spatial development effects on the livelihood of the city-dwellers negatively which may be caused by some physic hazardous conditions or some socio-cultural distress situations. The process of regional development through the changing globalized situation in 21st century establish some of the greater relationship in between the indicators of development and as per as the development goes the negative feedback of it severely falls upon on the urban-ecological structure and function of any area. Next, it has been focused that the vulnerability of the urban-regional unevenness calls not only the infrastructural and live-dealing dispute in an municipal area at the present situation , but also it creates some emphasis on the physical vulnerabilities on the river sided city. Depended on this account flood hazard is a significant output of the developmental unevenness of the development of flood prone basin area consists city-morphology.

The present study signifies the unevenness of regional development, basically inter-ward disparity of the study area which can be determined by some criteria of development that are availability of socio-economic variables per thousand population, number of variables per square kilometer and distance of all the centers of municipal wards from the significant sites. The flood conditions are also be determined with establishing the relationship with the intra-urban disparity and unevenness of regional development which ultimately reveals the relevance of the study with establishing a relationship between the impact of the elevation as a significant factor on flood water level and status of regional development. Besides, the objectives which are related to unevenness of intra-regional development and associated vulnerabilities are principally justified with the suggestive hypothesis and also the data are analyzed with the selective methodologies related with mainly secondary databases, descriptive statistics, other statistical and cartographic analysis and remote sensing and GIS applications.

II. REVIEW OF LITERATURES

The predominated literatures shows those type of relationship with the continuation of the urban-regional study.Berdegue, Bebbington, and Escobal(2015) conceptualized that the structures, institutions and coalitions of spatial diversity impact on the rural development of Latin America.Sapawi, Said and Mohamad (2013) found in their study that 'Disparities perception by gender, group of ages, and house location' of' evaluating empirically perception on walking distance to shop by several subgroups in an urban neighbourhood area.'Balta-Ozkan, Watson, and Mocca, (2015) stated about spatially unevendevelopmentandlowcarbon transitions: Insights fromurbanandregionalplanning. Fan, Kanburand Zhang (2011) mentioned in their study that 'the evolution of regional disparities in China, and brings information andtrends up to date. Based on this assessment, it presents the broad outline of a strategy to harmonize growthand regional equity.' The paper of Harun, Che' Mat and Jalil(2012) explored empirically the impact of public expenditure expansion in reducing inter-ethnic and rural urban income disparity.'Kotharkar, Bqahadure and Sarda (2014) conceptualized, that "The compact city concept is adopted in city planning policies of many developed countries for the following benefits: efficient use of land while curtailing sprawl, reduction in transport network and reliance on mass transport, a socially interactive environment with vibrancy of activities, economic viability, etc." In this aspect Adaku (2012) suggested that "Interestingly, most planning authorities rarely know and consider the costs of alternative development patterns in their decision making process." In the study of Singh et al. (2014) they had implemented the focus study on the vulnerability of flood, impacted with the morphogenic and anthropogenic factors.Kundu, and Varghese (2010) revealed that "A class of methodology for constructing composite indices has emerged which is being widely used globally." With the influential study in Regional Geography Burton and Kates (1964) stated that "A variety of human adjustments have evolved in response to flood hazards in river valleys, of which engineering works are the most prominent." Bekele (2005) focused on the situation of the sprawling urban area from the city core to the fringe creates some problematic situation at the end of the 20th century. With the continuation of study literatures Fan (1997) formulized the controversy of the theoretical unevenness of the developmental concept in between the ladder-step theory and the Western theories at the level of wisdom. Khan (2000) established the relationship in between the unplanned urban development and its vulnerable impact on basin physical characteristics. In the programme of United Nations Development Programme (2004), it is stated that, "But disaster losses interact with and can also aggravate other financial, political, health and environmental shocks." As per as the research of Gencer (2013) "… today as more than half of the world's population lives in urban areas, and coupling with the impacts of climate change, risk reduction in urban areas becomes more significant than ever." Parikh, Jindal and Sandal (2013) 'Cities in 21st century are facing enormous changes' regarding population growth, urban expansion and some other negative impacts regarding the structural and functional growth of the city." Benjamin (1998) identified "In the case of urban centres of the developing countries, corrective measures for the environmental consequences of spontaneous or wrongly planned developments are often prohibitively costly." In his study Paul (2012) mentioned that " Nabadwip, one of important historical urban centre on Nadia district, is one of the fastest growing townships in the West Bengal." In the focused study uneven regional development is a significant factor which is caused by the socio-economic disparity of the study area, besides the flood condition creates a variation of impact depended on the elevation of the overall area. Mallik (2014) in his study on the Mayapur-Nabadwip area stated that the river morphogeny and flood affectivity has a greater relationship which ultimately impact of the locality of the study area." Hudson (2004) also identified that 'Regional uneven development is an enduring feature of capitalist economies with regarding some arguments on uneven development and social relations in the capitalist economic 'regional problem' within the circumstances of UK of 1928. Hamza and Zetter (1998) in their paper argued that 'urban areas are not disaster prone by nature'; rather that the structural and functional processes of raiding urbanization process and population dynamics which ultimately accelerate disaster vulnerability of the 'low income' groups. Regarding the field-study of Dasgupta, Roy, and Sarraf(2012) it is evident that "Undeniably, a major cause of periodic flooding of Kolkata during the rainy season is the 'Adaptation Deficit' that Kolkata faces at present to cope with intense precipitation events." Paul (2012) mentioned in his study that "Inequalities at the level of development have been an integral feature of the history of India's economic development." Padawangi and Douglas (2015) mentioned that Jakarta has entered an era of chronic flooding that is annually affecting tens of thousands of people, most of whom are crowded into low-income neighbourhoods in flood-prone areas of the city. Chakraborty (2010) formulized his article, with analysing the transformation in the social landscape in the river basin. Ramachandra, Aithal, and Kumar (2012) signified that the loss of the urbanising land features had been occurred due to some insufficient and unplanned management of flood plain area and urban dwellings. Also the study focused on some of the flood mitigation approaches with the regional development planning in Bangalore city.Friend, et al. (2014) postulated that 'this paper aims to fill a conceptual gap in the understanding of rapidly changing characteristics' of local disaster risk. The reduction of the risk might be identified in the Mekong Region. Lu, et al. (2015) researched that the

current study introduces "the spatial field model" to achieve comprehensive evaluation and multi-scale analysis of regional inequality.

Reviewing the pre-mentioned literatures the present study identified some focus on the categorization and issue of research and the research area. As in the pre-conceived research different developmental characteristics had been highlighted to show the regional disparity, sometime the flood affectivity or mitigation of the vulnerable condition caused by those situations. But the primary focus on the issue specific relationship in between the indicators of urban development, especially the trio-relationship in between the physical factor, developmental factor and flood affectivity in a particular study area has been formalized in the present term of the study which ultimately signifies the conceptualization of the issue as the unevenness of intra-regional development of urban space and associated vulnerabilities.

III. OBJECTIVES

The particular principle objective of the study area is to analyze the uneven inter-regional development of urban space and associated vulnerabilities in NabadwipMunicipality, Nadia district, West Bengal.
The other objectives associated with the study are:

- Tress out the factors of development at Municipality level.
- To formulize the intra-urban unevenness of development among the Municipality's Wards in 2017.
- To highlight the physiographic impact on flood situation in the Study area.
- Researching the facts as higher developed area affected mostly by flood in the study area due to specific factor.

IV. STUDY AREA

Nabadwip Municipality has been selected as the study area which is situated co-ordinately in between 88°2′E. to 88°23′E and 23°2′N. to 23°23′N in the western bank of river Bhagirathi-Hugli in Nabadwip C.D. Block in Nadia district, in West Bengal. The town has a total area of 11.66 square kilometres consisting of 24 wards with a population of 125,543 (Census of India, 2011) situation is. It is most significant cultural heart-land of 'Bengal' being the birth place of Sri Chaiynya, the founder of GoudiyaVaisnabism, from ancient to present. The study Municipality is an urban Class –I city criterion of Census of India (2011) with increasing population and residential growth. Besides the urban area around this Municipalityagglomerate with the Census Towns (C.Ts.) of the city boundary rapidly. As Nabadwip city is bounded with the river Bhagirathi-Hugli in the North-eastern side and the old river channel creates a boundary in between the Burdwan District and NabadwipMunicipality in the western side. The entire municipal area is flood –prone and several floods from 1991 to 2011 occurred due to various causes. The most local factor controlling the flood situation in this municipal area is elevation. The M.S.L. (Mean Sea Level) of the town is near about 18 metres but the local elevation varies area to area in this Municipality. As it is seen that the level of water during flood is high some of the portion of the high developed central area of the Municipality rather than its low developed fringe. The prime cause of this situation is that the elevationof some of the portion of the central part is low than its fringe. Those ultimately creates a significant controversy that in NabadwipMunicipality part of developed central part is more flood prone than the underdeveloped periphery's. For those reasons in the present study is conducted with NabadwipMunicipalityto establish the significant relationship in between the elevation, flood water level and level of regional development in the 24 wards of the Municipality and find out the present scenarios regarding this issue.

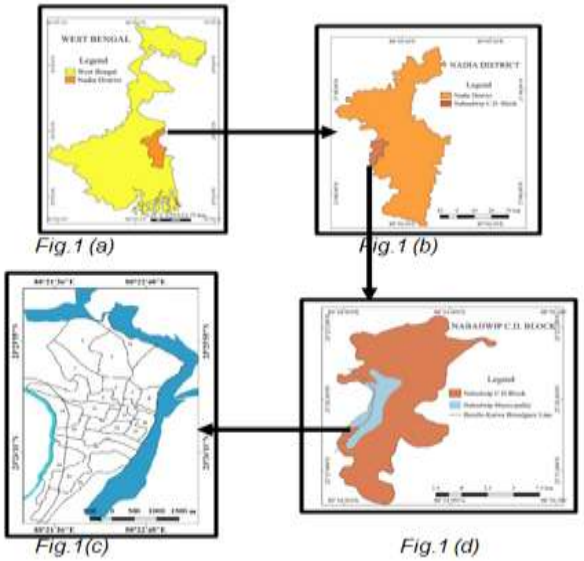


Fig.1 (a) Fig.1 (b) Fig.1(c) Fig.1 (d)

Fig.1 (a-d)-**Location map of the study area**

Hypothesis

The study is conducted with signification of the following hypothesis:

- The concentration of flood is sometimes higher in the developed area including some portion of the city core than the less developed fringe area affected by the variation of elevation.

V. MATERIALS AND METHODS

The analysis of the present study has been done by particularly using the secondary database and descriptive statistics. Major statistical (Using SPSS software), cartographic (using Microsoft Excel 2013) and G.I.S. (Geographical Information system techniques used by Quantum GIS, version 2.18) techniques are used to fulfill the mentioned objectives of the study spaces. Different library works, reviewing of journals, articles, academic papers and other e-resources have been used to build up the conceptual framework. Secondary databases are collected from mainly NabadwipMunicipality, Nabadwip, Nadia, West Bengal; District Census Handbook: 2004 of Nadia published by Census of India and the e-database of Census of India (2011).

The primary field work has been done at 24 wards of the Municipal area for verifying the realistic situation and realize the perception of the local residence about development and vulnerability of the municipal area.The major methodological frameworks have been build up depended on the present situation of Nabadwip as a class-I city (Census of India 2011). Besides some pre-defined study literatures has been conceptualized to build up the principal methodological orientation.

At first the centrality measures has been put forwarded on the selected network matrix to identify the possible central area (Central Business District) of the study Municipality through the implementation of the Shimble Index and Associated Number. Here these are,

Analysis of shortest path matrixis denoted as the number of arcs used in the shortest path between all possible pairs.Associated number isthe number of arcs needed to connect a node to the most distant node from it.Shimbel index is derived from the shortest path matrix, which indicates the number of arcs needed to connect any node with all the other nodes in the network by shortest-path matrix. The total of each row gives the Shimbel Index. D. König (1936) has developed an index known as König Number for describing the degree of centrality of any node on a network. The König number for each node is calculated by adding up the number of arcs from each other node using the shortest path available.

The available literatures show the application of the Composite Indices which is the focus methodology of the study area. Banerjee andDey (2014) used an empirical methodology with the application of PCA in the study on North Tweenty Four Parganas.Egena et al. (2014) suggested methodology of PCA in their study on body measurements in a population of indigenous Nigerian chickens raised under extensive management system. Besides the study done by Mazziotta and Pareto (2013)on methods for constructing composite indices revealed the measurement and application of composite indices also. Paul(2012) apply PCA on the inter-ward disparity analysis and urban development level analysis respectively in his study on Burdwan (2012) and Barasat (2012)Municipality. Moreover, Yong and Pearce (2013) in their guide and DiStefano, Zhu and Mîndrilă, (2009) in their study also focused on the Principal Component Analysis measurement.

The implementation of Principal Component Analysis has been done on the available data which has been suggested as the factors of development of the 24 wards of the study Municipality. The three simple but different basic criteria have been identified for the methodological orientation of Municipal Development, those are following in the table below (Table 1).

Table 1Criteria based selected factors of Development in Nabadwip Municipality

Criteria	Factors
Availability of Socio-economic variables per thousand Population (22 variables)	Male population, female population, total child, general, S.C. (Schedule Caste), S.T.(Schedule Tribe), total literacy, child literacy, total illiterate person, total workers, non-workers, total household, road construction scheme, nursing home, hotel, school, capacity of supply water per gallon/day, dumping sites, bank, ATM, water bodies, temples.
Number of variables per square kilometer (18 variables)	Total population, slum population, growth of population, household, road length, road construction scheme, nursing home, temples, hotels, schools, pumping stations, Water holding capacity/gallon/day, dumping sites, bank, ATM, length of drains, depth of water during water-logging situation, number of water bodies.
Distance of all the centers of municipal wards from the significant sites (6 sites)	Distance from station, bus stand, State General Hospital, Post Office, Police Station, Municipality

Source: Field Survey (February, 2017)

Composite indices method has been implemented through Factor analysis (Principal Component Analysis) on each of the pre-mentioned criteria to bring out the significant factors of socio-economic development. For the Composite Factor Analysis (Principal Component Analysis) (Pearson 1901) the following has been formulized,

$$P_1 = \Sigma\, a_{j1}\, X\, Z_j \text{ or } P_1 = a_{11}.\, Z_1 + a_{21}.Z_2\, a_{11}.\, +\, ...\, a_{n1}.\, Z_n$$

Where, P_1 denotes composite index of development of a unit study as first factor denotes the factor loading of the 'j'thvariable and 1 indicate the factor number, that is first factor – vector of factor loadings.Z_j denotes standardized value of the 'j'thvariable, which is expressed as:

$$Z_j = \frac{X_j - X_m}{\delta_j}$$

Where, X_j denotes original value of 'j'th variable, $X_m$denotes the mean(Simple arithmetic mean (x bar) = of'j'thvariable and $\delta_j$denotes the standard deviation of 'j'thvariable.

In this aspect,

$$\text{Mean} = \frac{\Sigma\boldsymbol{\alpha}}{\mathbf{n}}$$

$$\text{Standard Deviation} = \sqrt{\left(\frac{\boldsymbol{\alpha} - \square}{\mathbf{n}}\right)}$$

Where,
ᾱis the arithmetic mean
α Is the individual value of items
'n' is the number of terms in the distribution
Thereafter the elevation study has been done through basic GIS application of the Municipality to show the relationship in between the categories of municipal wards on the basis of factors score of development, local elevation and depth of water during flood.
Finally the fulfillment of hypothesis testing has been completed through establishing the relationship in between the selected indicators of development as well as building up the interrelationship in between the categories of municipal wards on the basis of factors score of development, local elevation and depth of water during flood of the selected wards of NabadwipMunicipality through simple correlation and regression analysis.
To find out the correlations in between the land, family and occupational status (their absolute and distance value) Pearsonian formula of 'r' (Pearson, 1901) have been used.

$$r = \frac{\mathbf{n\Sigma xy - \Sigma x.\Sigma y}}{\sqrt{\mathbf{n\Sigma x^2 - (\Sigma x)^2}}\sqrt{\mathbf{n\Sigma y^2 - (\Sigma y)^2}}}$$

Where,
r= Correlation Co-efficient
x= Independent variable
y= Dependent variable and
n= No. of observations
The linear regression model (Galton1894; Pearson1896) has been expressed by the following equation,

$$Y_c = a + b\, X$$

Where,
Y_c is a predicted value of Y (which is the dependent variable)
a is the 'Y intercept'
b is the change in Y for each 1 increment change in X
X is an X score (Independent variable) for which a value of Y is predicted
The 'F' value in the one-way ANOVA (Fisher, 1925) is calculated through the following formula,

$$F = \frac{\boldsymbol{Explainedvatriance}}{\boldsymbol{Unexplainedvariance}} \text{ Or,}$$

$$F = \frac{\boldsymbol{Between-groupvariablity}}{\boldsymbol{Within-groupvariability}}$$

The 'Explained variance', or 'Between-group variability' is

$$\sum_{\boldsymbol{i=1}}^{\boldsymbol{K}} \boldsymbol{ni}(\bar{\boldsymbol{Y}}\boldsymbol{i}. - \bar{\boldsymbol{Y}})^2/(\boldsymbol{K-1})$$

Where,
$\bar{Y}i$. Denotes the sample mean in the i^{th} group

$ni$is the number of observations in the i^{th} group
$\bar{Y}$denotes the overall mean of the data
And *K* denotes the number of groups
The 'Unexplained variance' or 'Within-group variability' is

$$\sum_{i=1}^{n}.\sum_{j=1}^{ni}(\boldsymbol{Yij}-\boldsymbol{\bar{Y}i.})^{2}/(\boldsymbol{N}-\boldsymbol{K})$$

Where,
$Yij$is the j^{th} observation in the i^{th} out of *K* groups and *N* is the overall sample size.
This *F*-statistic follows the *F*-distribution with *K-1*, *N-K* degree of freedom under the null hypothesis

The 'test of significance' has been done for the testing of the bivariate components. The formula of this method adopted by Fisher (1925) following Student (1908) is as follows.
The formula of the 'test of significance' is

$$t=\frac{r\sqrt{N-2}}{\sqrt{1-r2}}$$

Where,
t is the value of test of significant
N-2 is the degree of freedom
r is the value of correlation co-efficient

VI. RESULTS AND DISCUSSION

The overall situations of NabadwipMunicipality are reflected by some of its physical and socio-cultural affluent. The major structure and functions of urban-form is changed by some of its categorical and commodity based goods and services. The major characteristics of thisMunicipality is associated with some of the important indicators which determine the inter-ward disparity or unevenness with their variation in spatial dimension. Besides the physical elevation of the municipal area is also varies at its ward -level scenario controlled locally by the situation of the flow of old and new river course of the Bhagirathi-Hugli.Moreover, the discussion part also highlights the situation and interrelation in between the factors that in NabadwipMunicipality the vulnerably of flood is greatly influenced by the physical variation of elevation and thecondition of variability of the socio-cultural elements forming micro-level spatial unevenness.

Physical and socio-economic conditions of the municipal area of Nabadwip which fall impact on regional development

NabadwipMunicipality, as a Class-I city of West Bengal, India is in an increasing way of population growth and urban agglomeration. Situating in between the old and new river course of the Bhagirathi-Hugli, the Municipalityholds its alluvial-type feature of soilextending 97.39 square km area. The tropical monsoon type climate is modified by the river-sided situation of periodic winds in micro-climatic situation of Gangetic West Bengal with varying temperature of an average 25-35degree centigrade in summer situation and 5 to 15 degree centigrade in the winter. The overall average annual rainfall is 100 to 170 centimetres recorded in the meteorological station of Alipore, Kolkata (2016).NabadwipMunicipality, featured with its faster growth of urban population and agglomeration holds 125,543 population and 30,914 households (as per Census of India 2011). The Male and Female population of the area is respectively 65415 and 60128 followed by the total child population 8790. The adult and child sex ration of this Municipality are 919 and 940 and the overall literacy rate is 87.33%. The majority of religious class is Hindu (98.97%) inNabadwipMunicipality. There are several occupants' classes including daily labours, sweepers, shop-keepers, vendors, servicemen and businessmen, religious volunteers as such.As per the Statistical Handbook of Nadia District, 2007; 53 primary and high schools, two colleges, nine daily markets, one wholesale market, two hospital, one Family Welfare Centre (public), three public library and one cinema hall shows some glimpse of socio-economic infrastructural scenarios situated in Nabadwip.

A scenario of the unevenness of development in NabadwipMunicipality

The situation of socio-economic discrimination in the 24 wards of NabadwipMunicipality is measured through some of suggested methodologies. At first the road network study of the central portion of the Municipality has been measured through centrality measurement.

The selected road networks of the central portion of NabadwipMunicipality has been represented in the Fig. 2(a). The nodes are marked with alphabetic orders as 'A' to 'Z' and then 'AA' and 'AB'. Then the Shimbel index and associated number are measured by the suggested formulae of measuring 'Shortest Path Matrix' (Table 2).

Table 2 Network Matrix of the selected road networks and centrality of Nabadwip

Serial Number	Nodes	Shimbel Index	Associated Number
1	A	114	7
2	B	125	7
3	C	124	8
4	D	107	7
5	E	81	6
6	F	90	6
7	G	102	8
8	H	112	7
9	I	100	7
10	J	85	6
11	K	76	5
12	L	72	5
13	M	90	8
14	N	94	6
15	O	92	8
16	P	116	7
17	Q	94	7
18	R	95	7
19	S	79	5
20	T	88	5
21	U	101	7
22	V	91	6
23	W	97	6
24	X	108	7
25	Y	97	6
26	Z	109	7
27	AA	117	8
28	AB	118	8

Source: Calculated by the author from Annexure- Table 1

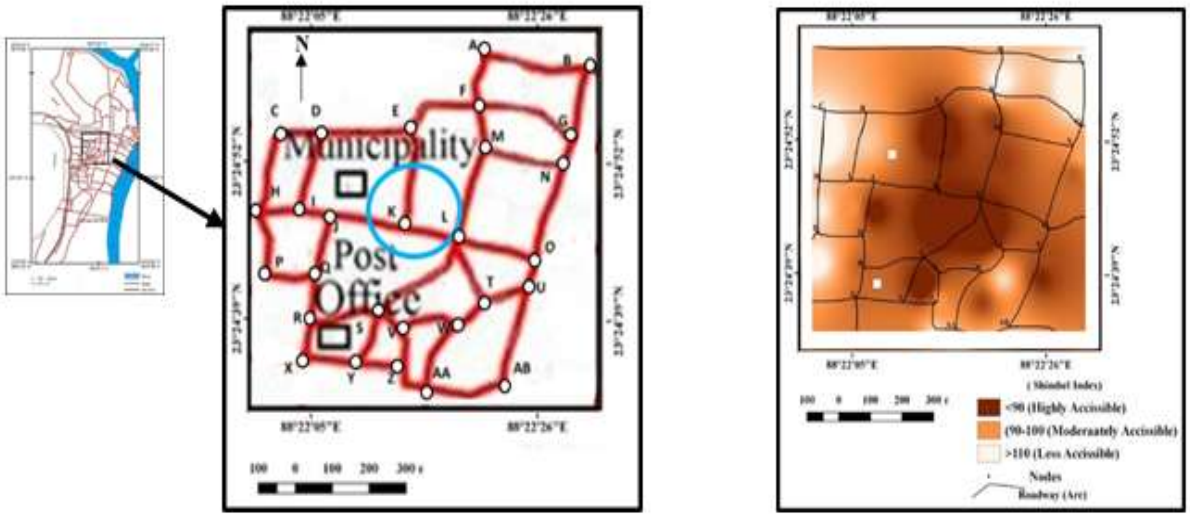


*Fig.*2(a) - **Selected road networks***Fig.*2(b) -**Accessibility zones**
Fig.2 (a, b) -**Centrality of the selected portion of transport networks of the study area**

The node 'L' represents (Fig. 2(b))the lowest value of Shimbel Index which is 72 and 'K' and 'L' together show lowest associated number which is 5. So, it is interpreted that the nodal point 'L' is the most accessible point in the Municipality. Besides, the most accessible central node of the selected networks of the study area is 'L', i.e. 'PanchMathar More' which bears the lowest Koenig number (5) as per the above shortest path matrix which is the central area of the Municipality.

The attempt ofinter-ward disparity is measured by the PCA analysis of the 24 municipal wards of Nabadwip. In the part of the database and methodology the details of the methodological framework has been represented. On the basis of the selected criteria the major factors have been weighted as well as the rotated component matrix and factor scores have been represented through the analysis in SPSS.
The pre-mentioned chosen socio-economic factors of development and disparity based on the three types of criteria have been analysed here and Rotated component matrix and factors score (factor loading >0.30) have been represented in the tables (Tables 3, 4 and 5) below.

Criteria	**Availability of Socio-economic variables/ thousand population**			
Serial Number	**Factors**	**Component**		
		1	**2**	**3**
1	Male	0.129	0.037	-0.916
2	Female	-0.129	-0.037	0.916
3	Total child	-0.483	0.77	0.167
4	General	0.258	-0.822	-0.015
5	SC	-0.234	0.824	0.009
6	ST	-0.417	0.031	0.103
7	Total literacy	-0.059	-0.475	0.677
8	Child literacy	-0.755	-0.017	0.357
9	Total Illiterate	-0.535	0.748	-0.198
10	Total workers	-0.813	0.186	0.351
11	Non -workers	0.813	-0.186	-0.351
12	Household	-0.011	0.109	0.817
13	Road construction scheme	-0.029	0.024	0.478
14	Nursing home	0.707	-0.065	0.114
15	Hotel	-0.095	-0.622	0.097
16	School	0.289	0.456	-0.039
17	Pump	-0.049	0.034	-0.377
18	Dumping sites	0.001	0.819	-0.014
19	Bank	0.567	-0.359	0.131
20	ATM	0.367	-0.396	-0.103
21	Water-bodies	0.618	0.261	0.338

Table 3 Rotated Component Matrix of factors of 'Availability of Socio-economic variables per thousand Population' (Criteria –I) in NabadwipMunicipality

22	Temples	0.607	-0.114	0.272

Source: Calculated by the Author

Table 4 Rotated Component Matrix of factors of 'Number of variables per square kilometre' (Criteria –II) in NabadwipMunicipality

Criteria	**Number of variables /square kilometre**			
Serial Number	**Factors**	**Component**		
		1	**2**	**3**
1	Total population	0.881	0.355	0.006
2	Slum population	0.051	-0.087	-0.581
3	Growth of population	-0.409	0.027	-0.351
4	Household	0.909	0.324	0.03
5	Road length	0.85	0.13	0.234
6	Road construction schemes	0.584	-0.645	-0.158
7	Nursing home	0.346	0.441	0.583
8	Temples	0.593	0.004	0.539
9	Hotels	0.263	0.816	-0.087
10	Schools	0.263	0.816	-0.087
11	Pumping stations	-0.002	-0.049	-0.377
12	Water holding capacity	0.764	0.292	-0.008
13	Dumping sites	-0.19	-0.427	0.347
14	Bank	0.46	0.678	0.44
15	ATM	0.278	0.736	0.234
16	Length of drains	-0.884	-0.159	0.056
17	Water-bodies	0.086	-0.234	0.711
18	Height of logged water	0.84	0.428	0.072

Source: Calculated by the Author

Table5 Rotated Component Matrix of factors of 'Distance (in km) of all the centers of municipal wards from the significant sites' (Criteria –III) in NabadwipMunicipality

Criteria	**Distance of all the centres of Municipal Wards from the significant sites**			
Serial Number	**Factors**	**Component**		
		1	**2**	**3**
1	Distance from station	0.951	-0.178	-0.133
2	Bus stand	0.986	-0.024	-0.028
3	Municipality	0.648	0.707	0.093
4	Police Station	-0.183	0.882	-0.359
5	Post Office	0.897	0.272	-0.125
6	State General Hospital	-0.145	-0.187	0.961

Source: Calculated by the Author

The dominant factors of development are identified here by measuring Factor Score. Regarding the criteria named 'Availability of Socio-economic variables per thousand Population' (Table 3), the dominant factors are Population/Demographic factors (total child, S.T. population, total literacy, child literacy, total illiterates, total workers and non-workers) and health and commercial factors(Nursing home, Bank, ATM) including temples in the case of first Factor (Factor-I). In the case of Factor-II demographic, educational and commercial factors including dumping sites are dominant. In the case of Factor-III, demographic and infrastructural factors are most influential.In The next criteria 'Number of variables per square kilometer' (Table 4), the significant factors in the case of Factor-I are demographic, commercial and infrastructural facilities. Factor-II dominates commercial and infrastructural facilities as well as Factor-III includes demographic and commercial activities.The third criteria 'Distance of all the centers of municipal wards from the significant sites' (Table 5) includes the dominant factors in the case of Factor-I, distance from station, bus stand and Municipality and post office; Factor-II, distance from Municipality and police station and Factor-III, distance from police station and state general hospital. The dominant factors of the criteria are implemented to determine the regional disparity of the city as well as to identify the inter-ward unevenness of the municipal area.

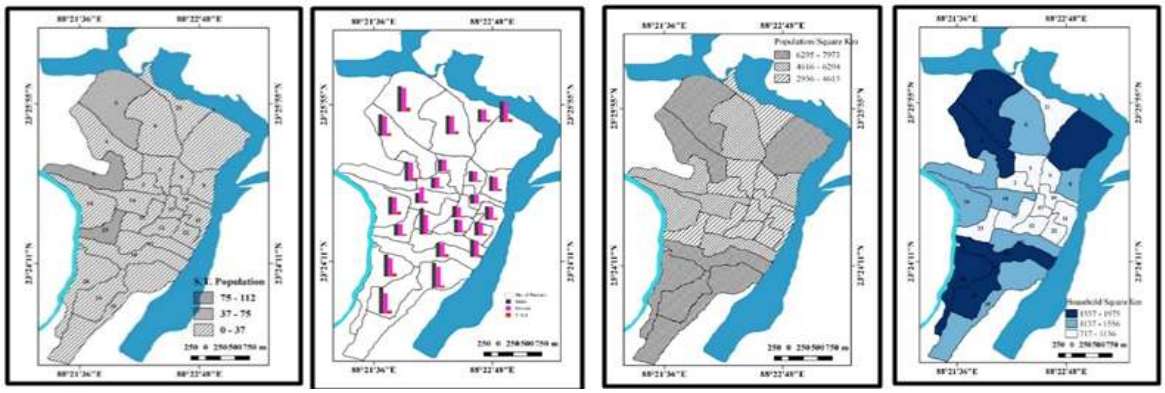


Fig.3 (a) - **Population density** *Fig.3 (b)* - **Male, female and child** *Fig.(c)* - **Scheduled Tribes** *Fig.3 (d)* - **Household**

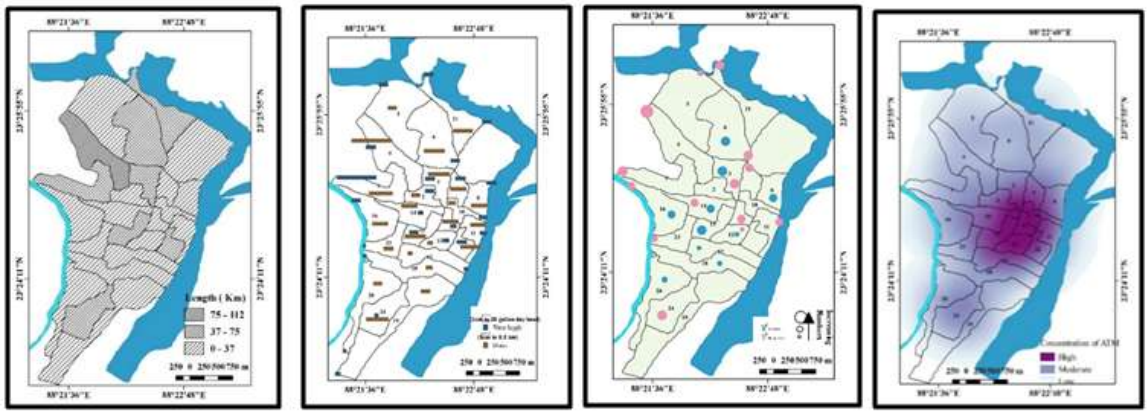


Fig.3 (e) - **Road length** *Fig.3 (f)* -**Water supply and drainage***Fig.3 (g)* - **Dumping sites and water-bodies***Fig.3 (h)* – **ATMs**

Fig.3 (a-h) -Some socio-economic scenarios of developmental aspect in Nabadwip

Table6 Composite REGR (Regression) Factor Score of the selected criteria based factors of 24 wards of Nabadwip

Serial Number	Word Number	Criteria		
		(I) Availability of Socio-economic variables per thousand Population	(II) Number of variables per square kilometer	(III) Distance (in km) of all the centers of municipal wards from the significant sites
		Composite REGR Factor Score	Composite REGR Factor Score	Composite REGR Factor Score
1	1	0.16074	-1.29945	-1.0699
2	2	1.14876	-0.5648	-2.22868
3	3	3.25551	1.27431	-1.87625
4	4	-0.00414	-0.84459	-0.30118
5	5	-0.23463	-1.4454	0.91833
6	6	0.21671	-1.04683	0.97247
7	7	1.19713	-1.13508	2.92402
8	8	-0.14096	0.5854	0.9621
9	9	-0.26903	0.77236	-0.26589
10	10	-2.90592	1.21807	-0.43276
11	11	-0.61626	-0.18552	1.57445
12	12	-1.76069	1.09876	-0.88329
13	13	0.03661	5.8531	-1.0795
14	14	4.46712	1.84065	-2.64631
15	15	0.6899	2.67438	-2.40513

16	16	0.7368	-0.92368	-1.10497
17	17	-0.06899	-0.64039	-0.16013
18	18	-2.30146	-0.53001	0.54787
19	19	-2.08099	-1.48436	2.37054
20	20	1.33321	-0.89479	-1.6937
21	21	1.88256	-0.78668	2.65716
22	22	-1.61432	-0.07263	0.72108
23	23	-1.36557	-2.25594	-0.96412
24	24	-1.7621	-1.20689	3.4638

Source: Calculated by the author

The wards of the Municipality have been classified based on the factors scores of the three different criteria and represented below.

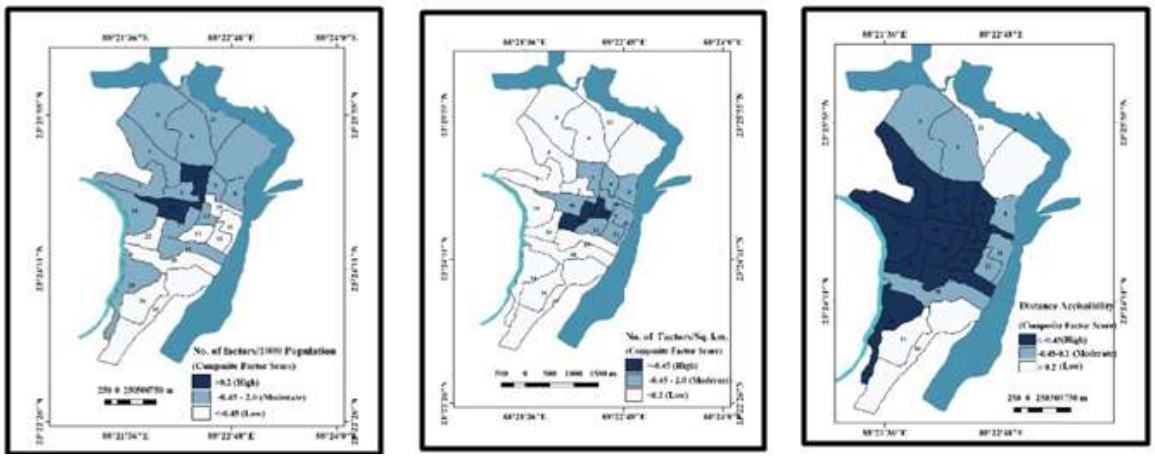


Fig.4 (a) - **Criteria - I** Fig.4 (b) -**Criteria - II** *Fig. (c)* - **Criteria - III**

Fig.4 (a-c) - The different developmental level of the wards of NabadwipMunicipality based on the three criteria based Composite REGR Factor Score

On the basis of the Composite Regression Factor Score (Table 6) all the wards of NabadwipMunicipality have been classified into three basic developmental aspects.

According to the REGR Factor Scores of the criteria 'Availability of Socio-economic variables per thousand Population' (Fig. 4(a)), the wards no. 14 and 3 are included in high; 1,2,4,5,6,7,8,9,13,15,16,17 and 21 are moderate and 10, 11, 12, 13, 18, 19, 22, 23and 24 are low Composite factor score of development. The REGR Factor Scores of the next criteria 'Number of variables per square kilometer' (Fig. 4(b)) show that the wards no. 13 and 15 are included in high; 3,8,9,10,11,12,14,and 22 are moderate and 1,2,4,5,6,7,16,17,18,19,20,21,23and 24 are low Composite factor score of development. On the basis of REGR Factor Score of the third criteria named 'Distance of all the centers of municipal wards from the significant sites' (Fig. 4(c)), the wards no. 1,2,3,4,7,9,10,12,13,14,15,16,17,19 and 20 are included in high (in this case low distance accessibility); 5,6,8,11,18 and 22 are moderate and 19, 21 and 24 are low (in this case high distance accessibility) Composite factor score of development. The variation of higher to lower REGR Factor Scores of the criteria – I and II and III indicate the intra-ward disparity regarding the unevenness of regional development in Nabadwip Municipality.

Some resultant vulnerable conditions

The developmental disparity and unevenness shows some resultant vulnerabilities in the wards of the Municipality. Two of the most significant and influential vulnerable conditions of NabadwipMunicipality are:

a. Waterlogging situation and
b. Flood conditions.

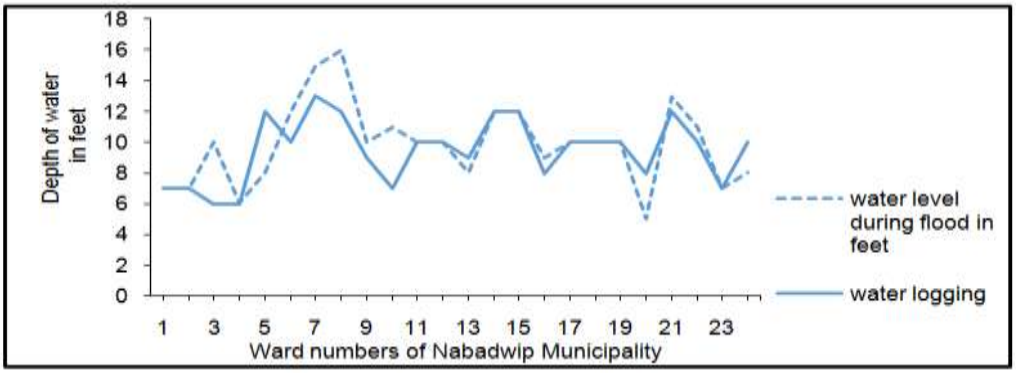


Fig.5 - Water level during flood and water logging situations in Nabadwip

During every year at the time of rainfall, perhaps its summer shower or the rainy season cats and dogs of the rainfall caused by 'western disturbance' the waterlogging situation occurred in mainly the wards (Fig. 5) marked as 5,6,7,14,15,17,18 and 22 due to some causes of rapid unplanned urbanization and poor sewage conditions. In the period of monsoon the overall excessive rainy condition in Gangetic West Bengal signifies a high water-level in Bhagirathi-Hugli and major or minor floods occur. In the year of 1999, 2000, 2006, 2007, 2009 and 2015 the flood conditions are noted in the residences of the Nabadwip Municipality with high water level condition in the ward of 45, 7,8,9,14,15,18,21,22 and 24. The overall situation highlights that some of the wards of the high depth of water level is the part of more developed central portion of the municipal area of Nabadwip. Thus it is clear that in Nabadwip some of the portion of the central portion of municipal area is more developed but mostly affected by the flood and water-logging situation than that of some of the fringe area.

Affluence of physiographic dilemma on the interaction between urban development and hazardous conditions

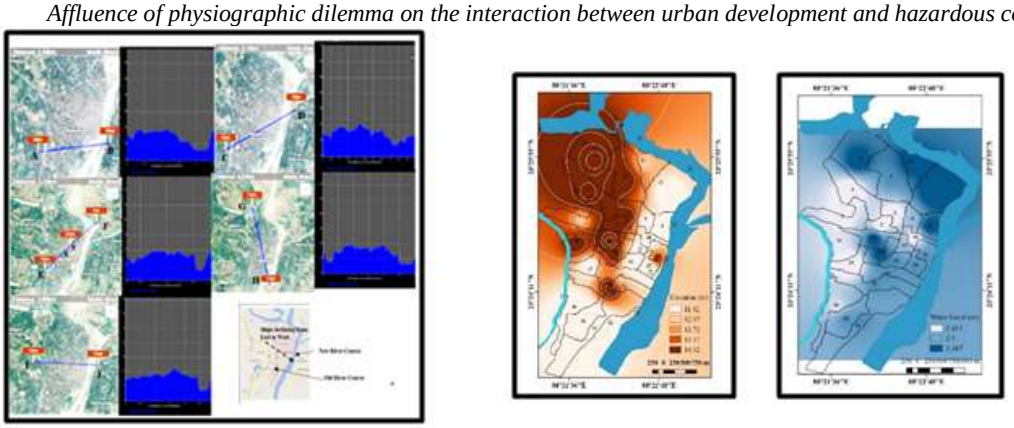
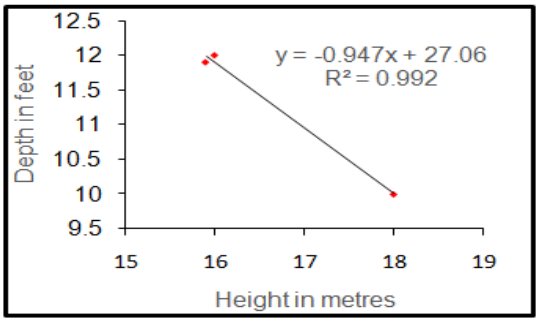


Fig. 6 (a) - **Elevation profiles** *Fig. 6 (b)* - **Elevation of Municipal Wards** *Fig. 6 (c)* -**Water level during flood**
Fig. 6 (a-c) - **The situation of elevation and level of water during flood in Nabadwip**

In the above figures (Fig. 6(a)) the relief features shows from the side of the old river course to the new river course of Bhagirathi-Hugli a variety of elevations. However, the profile drawn from A to B, Cto D E to F, G to H and I to J points directly crossed the central portion of the municipal area show that the central portion, specifically marked in the Fig. 6(a),'X' to 'Y' point the shape of the relief is as like a 'basin'. In this portion the elevation is low than the other part of the central portion of the municipal area.The comparatives figures (Fig. 6(b) and (c)) above signify that in the Fig. 6(a) the elevation profile is higher some of the portion (North-Western and Middle-Western) with moderate to low depth of water level (Middle Western and Western) during flood (shown in the Fig. 6(c)), supporting with the observation that in North-Eastern, Eastern and Southern Part of the Municipality the elevation is low and water level is high including Some of the Central portion observed at 11, 12 part of 13, 14 and 18 number wards.After the analysis and representation of the above discussion the final destination reveals that the interrelationship in between the elevation and water level during flood of the selected wards of Nabadwip Municipality. Here the wards no. 3, 14 and 15 (nearer to the central portion of Nabadwip) and 1, 4, 5, 16, 20, 23 (nearer to the Western boundary of that Municipality) have been chosen on the basis of their Criteria depended Composite REGR Factor Scores and the representation of the level of development. In between the wards the development unevenness and disparity are present. The above discussion justify that the elevation is also one of the most significant factors of determining the regional development. As the situation of Nabadwip shows that some portion of the higher elevated underdeveloped fringe area is less affected by the flood condition than that of some portion of lower elevated developed core area.



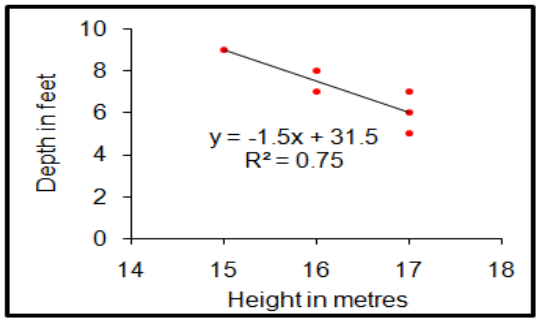


Fig.7 (a) - **Correlation (Ward numbers: 2, 3, 12, 13, 14 and 15)***Fig.7 (b)* -**Correlation (Ward numbers: 1, 4, 5, 16, 20 and 23**)

Fig.7 (a,b) - **Correlation in between the elevation and water level during flood in the selected wards of NabadwipMunicipality**

The above figures(Fig. 7(a) and (b))show the relationship in between the elevation (in metres) and water level during flood (in feet) in the selected wards of the Municipality. The above Fig. 7 (a) shows the highly negative correlation in between elevation and water level during flood (value of r = -0.9962). Thus, the lower elevation indicates higher depth of water level in the wards number 3, 14 and 15 (nearer to the central portion of Nabadwip). Besides, in the Fig. 7 (b) the value of r is -0.8660 which indicates the moderately high negative correlation in between elevation and water level during flood. Thus, the higher elevation indicates lower depth of water level in the wards number 1, 4, 5, 16, 20, 23 (nearer to the Western boundary of that Municipality).The correlation-regression model has been implemented to measure the relationship in between elevation and water level during flood in the selected wards of Nabadwip. In the following tables Annexure-Table 2-7) the results of the correlation-regression model have been shown with considering elevation as an independent variable.The correlation-regression model represents the value of correlation coefficient (R= 0.996) in Annexure-Table 2, which signifies the highly relationship in between elevation and water level during flood in the wards number 3, 14 and 15 (nearer to the central portion of Nabadwip). Here, the resulted value of R square is -0.996. The adjusted R square value is 0.993 and estimated standard error is 0.13785.The analysis of variance results into the 'F' statistics in Annexure-Table 3, which signifies the relationship in betweenelevation and water level during flood in the wards number 3, 14 and 15 and it is notjustified with the value of significance (0.055>0.05) of 'F' statistics (F=132.667) with (N-1) degree of freedom and 95 percent of confidence level. In Annexure- Table 4 shows 0.055>0.05 with (N-2=1) degree of freedom and 95% of confidence level where t= -11.518. So, the results justify the relationship in between elevation and water level during flood in the wards number 3, 14 and 15 is not significant.Thereafter, the correlation-regression model represents the value of correlation coefficient (R= 0.866) in Annexure-Table 5, which signifies the highly relationship in between elevation and water level during flood in the wards number 1, 4, 5, 16, 20, 23 (nearer to the Western boundary of that Municipality). Here, the resulted value of R square is 0.750. The adjusted R square value is and estimated standard error is 0.79057.The analysis of variance results into the 'F' statistics in Annexure-Table 6, which signifies the relationship in betweenelevation and water level during flood in the wards number 1, 4, 5, 16, 20 and 23 and it is justified with the value of significance (0.026<0.05) of 'F' statistics (F=12.000) with (N-1) degree of freedom and 95 percent of confidence level. In Annexure- Table 7 shows 0.026<0.05 with (N-2=4) degree of freedom and 95% of confidence level where t= -3.464. So, the results justify the relationship in between elevation and water level during flood in the wards number 1, 4, 5, 16, 20 and 23 is significant. The overall regression model, ANOVA and significance tests try to prove and justify the above mentioned hypothesis that is 'the concentration of flood is sometimes higher in the developed area including some portion of the city core than the less developed fringe area affected by the variation of elevation'. Due to the lower sample size the hypothesis is not justified in the case of city core but it is justified in the case of city fringe. The final territorial implications of the present study are just as follows; that although the regional development is uneven and in the case of city core it is more progressive; somewhere, the elevation, as a significant factor tries to maintain the development of a city which ultimately creates a reverse situation and relationship of inter-ward development and water level condition during flood; that the present study found in Nabadwip Municipality.

VII. CONCLUSIONS

The overall study aspects signify the presence of inter-ward disparity and resultant vulnerabilities in Nabadwip. This internationally noted Municipality is an urban-residential zone is now regionally developed area with some aspects like commercial activities, education, health, public transport systems, recreation, religious festivals, tourism and some other amenities. But, the risk and vulnerability of flood hazard inNabadwipMunicipality is increasing continuously from the decades of late 19th and early 20th centuries.Due to most obvious condition of the effectiveness of the variation of local elevation which is lower in some portion in

the highly developed central residential and commercial area of the Municipality and higher in some portion of the less developed fringe area; the water level condition during flood creates highly vulnerability in those portions of central areas and less vulnerability in those portions of fringe. The significance test does not signify the relationship in between elevation and water level during flood in the wards number 3, 14 and 15 because of the test has been implemented on a very small number of selected wards. But, the actual scenario is that the concentration of flood is sometimes higher in the developed area including some portion of the city core than the less developed fringe area affected by the variation of elevation (Significant in the case of the relationship elevation and water level during flood in the wards number 1, 4, 5, 16, 20 and 23). So, further research would be done regarding the previous significance tests of the hypothesis related with the unevenness of development and resultant vulnerable conditions in Nabadwiup Municipality in near and far future.

ANNEXURE

Table 1 Accessibility matrix (26/26) of the selected road networks of Nabadwip Municipality

Nodes	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	Σ
A	0	1	4	3	2	1	2	5	4	4	3	3	2	3	4	6	5	6	4	4	5	5	5	7	6	6	7	7	**114**
B	1	0	5	4	3	2	1	6	5	5	4	4	3	2	3	7	7	7	5	5	4	6	6	7	6	6	6	5	**125**
C	4	5	0	1	2	3	4	1	2	3	3	5	6	5	6	2	3	4	5	7	7	6	6	5	6	7	8	8	**124**
D	3	4	1	0	1	2	3	2	1	2	3	4	3	4	5	3	3	4	5	5	6	5	6	5	6	7	7	7	**107**
E	2	3	2	1	0	1	2	1	2	2	1	2	2	3	3	4	3	4	3	3	4	4	4	5	4	5	6	5	**81**
F	1	2	3	2	1	0	1	4	3	3	2	2	1	2	3	6	4	5	3	3	4	4	6	5	4	5	5	6	**90**
G	2	1	4	3	2	1	0	5	4	4	3	3	2	1	2	7	6	5	4	4	3	5	5	6	5	6	5	4	**102**
H	5	6	1	2	1	4	5	0	1	2	3	4	5	6	5	1	2	3	4	5	6	5	6	4	5	6	7	8	**112**
I	4	5	2	1	2	3	4	1	0	1	2	3	4	5	4	2	2	3	4	4	5	6	5	4	5	6	7	6	**100**
J	4	5	3	2	2	3	4	2	1	0	1	2	3	4	3	2	1	2	4	3	4	3	3	4	4	5	6	5	**85**
K	3	4	3	3	1	2	3	3	2	1	0	1	2	3	2	3	2	3	4	2	3	3	3	4	3	4	5	4	**76**
L	3	4	5	4	2	2	3	4	3	2	1	0	1	2	1	5	3	4	1	1	2	2	2	3	2	3	4	3	**72**
M	2	3	6	3	2	1	2	5	4	3	2	1	0	1	8	5	4	5	2	2	3	3	3	4	3	4	5	4	**90**
N	3	2	5	4	3	2	1	6	5	4	3	2	1	0	1	6	5	4	3	3	2	4	4	5	4	5	4	3	**94**
O	4	3	6	5	3	3	2	5	4	3	2	1	8	1	0	6	4	5	2	2	1	3	3	4	3	4	3	2	**92**
P	6	7	2	3	4	6	7	1	2	2	3	5	5	6	6	0	1	2	3	5	6	4	5	3	4	5	6	7	**116**
Q	5	7	3	3	3	4	6	2	2	1	2	3	4	5	4	1	0	1	2	4	5	3	4	2	3	4	5	6	**94**
R	6	7	4	4	4	5	5	3	3	2	3	4	5	4	5	2	1	0	1	3	4	2	3	1	2	3	4	5	**95**
S	4	5	5	5	3	3	4	4	4	4	4	1	2	3	2	3	2	1	0	2	3	1	2	2	1	2	3	4	**79**
T	4	5	7	5	3	3	4	5	4	3	2	1	2	3	2	5	4	3	2	0	1	2	1	5	4	3	2	3	**88**
U	5	4	7	6	4	4	3	6	5	4	3	2	3	2	1	6	5	4	3	1	0	3	2	6	5	4	2	1	**101**
V	5	6	6	5	4	4	5	5	6	3	3	2	3	4	3	4	3	2	1	2	3	0	1	3	2	1	2	3	**91**
W	5	6	6	6	4	6	5	6	5	3	3	2	3	4	3	5	4	3	2	1	2	1	0	4	3	2	1	2	**97**
X	7	7	5	5	5	5	6	4	4	4	4	3	4	5	4	3	2	1	2	5	6	3	4	0	1	2	3	4	**108**
Y	6	6	6	6	4	4	5	5	5	4	3	2	3	4	3	4	3	2	1	4	5	2	3	1	0	1	2	3	**97**
Z	6	6	7	7	5	5	6	6	6	5	4	3	4	5	4	5	4	3	2	3	4	1	2	2	1	0	1	2	**109**
AA	7	6	8	7	6	5	5	7	7	6	5	4	5	4	3	6	5	4	3	2	2	2	1	3	2	1	0	1	**117**
AB	7	5	8	7	5	6	4	8	6	5	4	3	4	3	2	7	6	5	4	3	1	3	2	4	3	2	1	0	**118**
Σ	**114**	**125**	**124**	**107**	**81**	**90**	**102**	**112**	**100**	**85**	**76**	**72**	**90**	**94**	**92**	**116**	**94**	**95**	**79**	**88**	**101**	**91**	**97**	**108**	**97**	**109**	**117**	**118**	

Source: Calculated by the author

Table 2 Model summery of the simple linear correlation-regression between elevation and water level during flood in the wards number 3, 14 and 15

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.996[a]	.993	.985	.13785
a. Predictors: (Constant), Elevation in metres				

Source: Calculated by the author

Table 3

Analysis of variance

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	2.521	1	2.521	132.667	.055[b]
	Residual	.019	1	.019		
	Total	2.540	2			
a. Dependent Variable: Water level in feet						
b. Predictors: (Constant), Elevation in metres						

Source: Calculated by the author

Table 4
Analysis of coefficients

Coefficients[a]								
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**	**95.0% Confidence Interval for B**	
		B	**Std. Error**	**Beta**			**Lower Bound**	**Upper Bound**
1	(Constant)	27.064	1.371		19.741	.032	9.645	44.484
	Elevation in metres	-.948	.082	-.996	-11.518	.055	-1.993	.098
a. Dependent Variable: Water level in feet								

Source: Calculated by the author

Table 5
Model summery of the simple linear correlation-regression between elevation and water level during flood in the wards number 1, 4, 5, 16, 20, and 23

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.866[a]	.750	.688	.79057
a. Predictors: (Constant), Elevation in metres				

Source: Calculated by the author

Table 6
Analysis of variance

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	7.500	1	7.500	12.000	.026[b]
	Residual	2.500	4	.625		
	Total	10.000	5			
a. Dependent Variable: Water level in feet						
b. Predictors: (Constant), Elevation in metres						

Source: Calculated by the author

Table 7
Analysis of coefficients

Coefficients[a]								
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**	**95.0% Confidence Interval for B**	
		B	**Std. Error**	**Beta**			**Lower Bound**	**Upper Bound**
1	(Constant)	31.500	7.080		4.449	.011	11.843	51.157
	Elevation in metres	-1.500	.433	-.866	-3.464	.026	-2.702	-.298
a. Dependent Variable: Water level in feet								

Source: Calculated by the author

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