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A Study in Water Balance and Climatic Characteristics of Varanasi

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Rainfall is the main source of water supply on the earth surface and it determines the moisture level at various depths of soil available to crops. The availability of moisture in soil is a controlling factor for growth and development of all types of vegetation especially for existing crops in an area. Day to day human activities are normally governed by the prevailing climatic conditions of a region while on the other hand climate itself is modified by different socio-economic activities of human beings like deforestation, farming practices, industrialization, rapid urbanization etc. The location and physiographic factors also combinedly influence the climatic characteristics of a region. In the same way climate helps to define climax vegetation of a region and also sets limits for crop growth. In this context, the numerical estimate of climatic water balance and its study has obtained an important place in geography

In the present study an attempt has been made to describe the climatic characteristics of Varanasi and to evaluate the water balance parameters for Varanasi according to the revised scheme of Thornthwaite and Mather (1955).

Keywords : *potential evapotranspiration, actual evapotranspiration, water deficit and water surplus, moisture adequacy index*

Introduction

Present farming systems are highly adapted to local climate along with topographical characteristics. In fact, agricultural practices are strongly controlled by thermal and moisture characteristic of an area. Though rainfall is the main source of water and determines the moisture level at various depths of soil available to crops, the actual availability does not depend on rainfall alone, as it should be balanced against the amounts due to evapo-transpiration (Singh,

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2005). In the growing period, the availability of moisture in soil is a controlling factor for growth and development of all types of vegetation especially for existing crops in a region. The amount of moisture that is lost to the atmosphere through evapotranspiration depends primarily upon the available moisture content in the soil, the temporal variation of which may be determined from knowledge of rainfall distribution. (Sharma, 1983). To explain the cropping pattern, moisture adequacy, a natural factor, and the intensity of irrigation, a cultural factor should be carefully considered (Mohapatra,2016). In agro-climatic studies water balance is a key factor to evaluate the amount of continual interchange of water between root zones of soil to the atmosphere. The term water balance means the accounting of all water in all various forms and states at a particular place (Mather, 1974). The precipitation and temperature are the two main factors which are essential for biological needs as well as plant growth. Precipitation constitutes almost all the entire water supply to the lithosphere which significantly provides moisture for various soil depths and later on this stored moisture through the process of transpiration and evaporation is returned to the atmosphere. In this process when the water reaches on the land surface through rainfall, part of it diverted as runoff, soon after the soils are saturated and the infiltered rain water returned in the upper layer of the soil atmosphere which is utilized for vegetation or crop growth.(Sharma and Lakshmi-kumar, 2006). Temperature is the another climatic element which plays a major role in survival and growth of plants. Solar radiation as a major source of atmospheric temperature significantly affects the magnitude of soil temperature. Amount of radiation determines the extent of evaporation, soil temperature as well as soil moisture. So the availability of moisture in the root zone of soil increases by rainfall and decreases by evapotranspiration. The exact information about the soil moisture availability in time and space context give the information about the cropping scheduled and crop combination in a better way.

The study of climatic water balance is one of the important aspects of applied climatology. In this perspective the knowledge of water balance elements in space and time is essential for the agricultural practices. In farming practices it provides information about water requirement for crops and vegetations as well as the water availability for the crops and plants uses. It also provides knowledge about the assessment of supplementary irrigation for the standing crops, if water deficit for a particular period exists.

The amount of moisture available can be best derived from the knowledge of Moisture Adequacy Index (Ima), which represents the ratio of actual evapotranspiration (AET) and potential evapotranspiration (PET). Moisture Adequacy Index indicates the moisture status in the soil for particular period. An excess or deficit of moisture in the root zone of soil and even in atmosphere highly depends on the magnitude of rainfall.

In order to obtain soil moisture, a leading climatologist Thornthwaite (1948) proposed a book-keeping procedure for the computation of the elements of water budget by treating precipitation as income, potential evapotranspiration as expenditure and the moisture stored in the soil as a reserve for use in times of deficient precipitation (Subrahma-nyam,et.al, 1963).

In recent years the growing demand of water in various sectors of economy for different purposes has drawn much attention of the scientists of many disciplines like applied climatology, agronomy, hydrology, industries, water management, geophysics etc to make better use of this precious resource for welfare of the human being. Specially, in agro-climatic studies a clear understanding of water balance elements like spatio-temporal occurrence and distribution of precipitation (water supply), actual evapotranspiration (the amount of water that actually evaporates and transpires), potential evapotranspiration (water need), the water deficiency (water requirements) and water surplus (irrigation potential) has become an important consideration and also it helps in various agricultural operations.

Objectives

The main objectives of the present study are:

* To derive water balance parameters on the basis of climatic elements to find out seasonal variation in water surplus /deficit.
* To determine moisture adequacy index

Data sources and methodology

The required data of climatic elements like rainfall, temperature, were obtained from the Director, IMD, Pune and Geophysics Department of BHU,Varanasi for the period of 30 years on request. Some other important informations were collected through online published research papers and journals. The modified scheme of Thornthwaite and Mather (1955) has been applied for computation of various water balance parameters like PE, AE, WS, and WD. Further, in order to find out the seasonal variation in soil moisture, Moisture Adequacy Index (Ima) as suggested by J.O.Ayoade (1972) later on V.P. Subramanyam (1983) has been computed. The Ima value represents the ratio between Actual evapotranspiration and Potential evapotranspiration expressed in percentage.

Study area

Varanasi is one of the oldest living city and very famous educational and religious centre of the world. It is situated in a sub-tropical interior of the middle Ganga plain having subrecent deposition of Pleistocene period. It lies between 25^0 18' N. latitude and 83^0 01' E. longitude. Varanasi and its surroundings are mainly underlain by Gangetic alluvium which constitute inter bedded layer of sand, silt and clay (Singh and Singh 2010). The district ofVaransi covers an area of 1535 km^2 at the elevation of 76m (msl).

Climatic characteristics

Varanasi is latitudinally situated in a subtropical interior part characterized by monsoon climate. Thus the study area experiences the complete reversal of the weather conditions by seasonal reversal of wind direction. The year is mainly divided into four distinct seasons by India Meteorological Department: south-west monsoon season (Mid Jun-Sept), post monsoon season (retreating monsoon, Oct-Nov) winter season (Dec-Feb), and Summer Season (March to Mid June).

Climatic water balance

Water balance is a key factor to evaluate the amount of continual interchange of water between root zone of soil and the atmosphere. In this perspective the knowledge of water balance parameters in space and time is essential not only for the hydrological processes but also to the agricultural practices. The wa-

ter balance gives a good insight of ecologically sensitive parameters. It provides useful information about the existing moisture condition of an area.

Evapotranspiration

To compute the evaporation/evapotranspiration from free water surface and land areas of the earth, a climatic water balance establishes relationship between precipitation and evapotranspiration in quantitative term. In this regard a leading climatologist C.W. Thornthwaite (1931, 1948 and later on in 1955) firstly introduced the concept of Potential evapotranspiration and proposed an empirical formula to obtain its value on the basis of mean monthly temperature.

In water balance studies, evapotranspiration is a major component to measure the degree of dryness and wetness of a region. Like precipitation it is also an important parameter to determine the climate of a region. From a comparison of the seasonal march of precipitation with evapotranspiration, the magnitude of moisture parameters i.e. water surplus, water deficit, soil moisture storage and water runoff may be determined (Singh, 1977). The term evapotranspiration refers to a combined loss of water through evaporation (from the soil, water bodies and snow cover) and transpiration (from plant species). It represents transfer of water from the earth back to the atmosphere.

On the basis of the march of precipitation from month to month and place to place a region experiences both wet and dry seasons in a year. The above aspects are explained as follows (Thornthwaite and Mather,1955): (1) period of full storage, when precipitation exceeds the water need and a moisture surplus (S) accumulates, (2) the early part of a dry period, when the stored soil moisture and precipitation used in evapotranspiration , is termed as period of soil moisture utilization, (3) when soil moisture storage steadily diminishes, the actual evapotranspiration falls much bellow the potential and a moisture deficiency (D) occurs and (4) a moisture season, when precipitation again starts exceeding the water need, soil moisture is recharged till it attains its full capacity. After the completion of this recharge, a surplus (S) commences again.

1. Potential evapotranspiration

PE is the amount of water that would evaporate and transpire from a wet vegetated surface if soil moisture were always available in sufficient amount for optimum use. So the annual and seasonal patterns of PE exhibit a close resemblance to the distribution of temperature. The average annual PE is about 1494mm. On an average, the maximum water need is observed in the month of May (204 mm) and the minimum in January(25).

The average seasonal PE values are highest in SW monsoon season (719mm) because of high temperature, longer day duration and highest vegetal covers. However it is found lowest in winter months (95)due to low temperatur

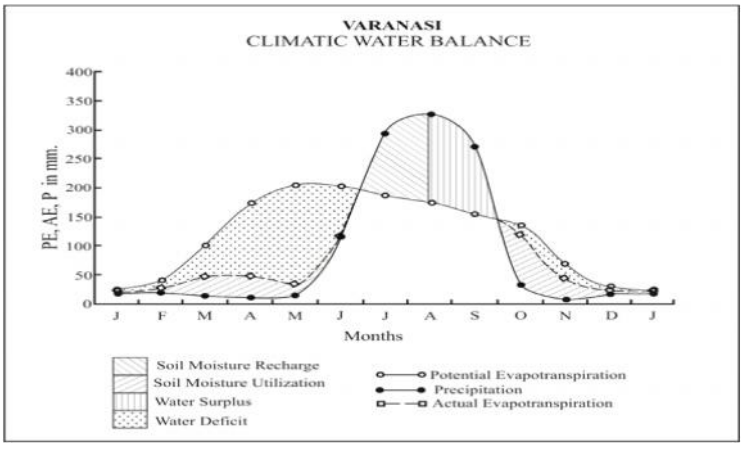
Table 1: Water Balance Parameters in mm (Field Capacity = 250mm),Varanasi

Parameter	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual (mm)
T^0C	15.9	18.97	24.3	30.2	32.9	32.7	29.7	29.2	28.6	26.5	22.1	17.3	25.7
P	18	20	15	10	14	115	292	325	270	34	8	16	1137
PE	25	40	102	172	204	202	186	175	156	134	68	30	1494
P-PE	-7	-20	-87	-162	-190	-87	106	150	114	-100	-60	-14	370
ST	120	111	78	41	19	13	119	250	250	167	131	124	
ST	-4	-9	-33	-37	-22	-6	106	131	0	-83	-36	-7	
AE	22	29	48	47	36	109	186	175	156	117	44	23	992
WD	3	11	54	125	168	93	0	0	0	17	24	7	502
WS	0	0	0	0	0	0	0	19	114	0	0	0	133

Source: Computed by author, Relevant data Obtained from IMD, Pune .

2. Actual evapotranspiration

Actual evapotranspiration is the most important water balance parameter which may be expressed as the actual amount of water lost to the atmosphere under the existing climatic condition and moisture stored in the soil. So its seasonal distribution is highly controlled by the amount of rainfall and moisture available in the soil region. On an average it is lowest in the month of january(23mm) and highest in the July (186mm) in the study area. The amount of actual water loss is highly variable from season to season.



In SWmonsoon season (JJAS) it is highest (626mm). In this period AE increases due to adequate moisture supply through rainfall. Thereafter it started to decrease from the months of Post-monsoon season till the end of winter season. From the beginning of summer months the amount of actual water loss gradually increases with rising temperature.

Table 2: Seasonal Distribution of Water Balance Parameters at Varanasi.

Season	Winter Season					Summer Season					SW Monsoon Season					Post Monsoon Season				
Parometers	P	PE	AE	WD	WS	P	PE	AE	WD	WS	P	PE	AE	WD	WS	P	PE	AE	WD	W
Volue in mm	54	95	74	21	0	39	478	131	347	0	1002	719	626	93	133	42	42	202	161	41

P = Precipitation, PE - Potential Evapotraspiratiion. AE = Actual Evapotranspiration. WD = Water Deficit. WS = Waler Surplus.

3. Water deficit

The water deficit is expressed as the difference between water need (PE) and actual evapotranspiration (AE). It is simply the shortage of moisture that is not available for utilization. In monsoonal climate where the seasonal rainfall variability is high, the climate becomes drier at the end of moist period. Excepting three months of rainy (JAS) season, remaining other months experience varying amount of deficiency in the year.

On an average the deficiency occurs highest (347mm) in dry summer season due to low or no rainfall. Due to negligible or meager amount of rainfall and low evapotranapiration winter season observes least amount of water deficit (21mm).

It is one of the important water balance parameter which indicates the time of irrigation scheduling for the standing agricultural crops.

4. Water surplus

The surplus water is that part of rainfall which is excess from the evapotranspiraion and soil moisture storage. Therefore the water surplus represents the amount of water that is left after fulfilling the demands of the atmosphere and the soil. The comparison of monthly P, PE and moisture storage gives the information about the moisture surplus of the region. In the study area July, August and September are the rainiest month of the year. When the soil is fulfilled with rain water after retaining the moisture to its field capacity surplus occurs usually in the month of August and September (133).

Evaluation of Moisture Adequacy Index

Basically, this study focuses upon the assessment of soil moisture and to evaluate moisture status in soil according to their moisture holding capacity. The seasonal moisture regime and the length of the day in relation to march of thermal regime are the major determinants of plant development (Subrahmanyam, 1982). In this context the climatological water balance provides ecologically sensitive parameter like Potantial Evapotranspiration (water need), Actual Evapotranspiration (water loss), Water Deficit (irrigation requirements) and Water Surplus (irrigation potentials) which are relevance to agriculture (Singh, 2005). With the help of derived water balance parameters it may be possible to reveal the accumulation or depletion of soil moisture. In order to assess the soil moisture status, two water balance parameters are considered. The Moisture Adequacy Index (Ima), is defined as the ratio between ac-

tual evapotranspiration (AE) and potential evapotranspiration (PE) expressed in percent. It is a good indicator of the available moisture in the soil in relation to water need. The moisture adequacy index is a true representative of moisture effectivity, thus, can be used in correlative studies of vegetation in relation to climate (Gautam et al, 2012). An excess or deficit of moisture above or below field capacity in the root zone of the soil depends upon the relative magnitude of rainfall over the area. The information on spatial and temporal availability of moisture adequacy index could be help-full for the optimal utilization of water resources (Mohapatra, 2016).

Lang's rain factor (1920)

In the study of agricultural planning and delimitation of climatic region, climatic aridity is used as an indicator. In this regard Lang proposed a simple index i.e. rain factor. It is obtained by dividing the mean annual precipitation and mean annual temperature in degree Celsius. On the basis of Lang's rain factor Varanasi falls into the Sub-humid dry (HS1) climate.

Köppen's climatic type

Köppen proposed his first vegetation based empirical climatic classification in 1918. It was revised and modified by him from time to time and the final form of scheme was presented in 1936. In his final classification he used certain critical values of temperature (warmest and coldest months) and precipitation (driest and wettest months). He accepted that vegetation is the best expression of the totality of climate so that his many of the climatic boundaries have been selected with vegetation limits. The Köppen's system of climatic classification is largely quantitative.

To find out the climate of Varanasi, mean annual precipitation and mean monthly temperature have been used as criteria. According to this scheme the study area experiences Cwg (Humid-mesothermal) type of climate.

Thornthwaite's rational classification of climate

In terms of water balance, Thornthwaite established a quantitative relationship between climatic elements and moisture availability essential for survival of vegetation to define climatic types (Singh and Singh 2011). His new (after 1938 and 1948) scheme of climatic classification was based on the concept of Potential Evapotranspiration (PE) the term coined by him and defined as the total amount of water that would be evaporated from the surface and transpired by plant species if there is no dearth of moisture

The degree of dryness and wetness of a place may be determined by computing the water deficit and water surplus in relation to water need. If the supply of water (precipitation) is less with respect to water need it will show water deficient situation but when supply becomes larger than the need, it shows the wet situation. The moisture index refers to moisture deficit or surplus in relation to potential evapotranspration i.e. water need. These indices are significant for delimitation of climatic types (Singh,2012).

On the basis of the climatic indices (code), Varanasi experiences Dry-Sub-humid Megathermal third with little or no summer water surplus and summer concentration of third order Megathermal type of thermal efficiency ($C_1A'_3da'_3$) type of climate.

Table 3: Climatic indices and Climatic Types of Varanasi Based on Thornthwaite's Rational Classification

Met. Station	Im	Climatic Code	TE	Climatic Code	Ih	Climatic Code	SCTE	Climatic Code	Climatic Types
Varanasi	-24.2	C_1	149.4	$A`_3$	8.9	d	38.8	$A`_3$	$C_1A`_3da`_3$

Source : Computed by author, Relevant data Obtained from IMD, Pune.

Ayoade' moisture adequacy index

In 1972 Ayoade presented a new concept of climatic classification which is primarily based on Moisture Adequacy Index. He suggested the ratio of actual evapotranspiration to potential evapotranspiration in percent as a better measure of moisture availability of a region. The Moisture Adequacy Index (Ima) thus, is defined as the ratio between actual evapotranspiration (AE) and potential evapotranspiration (PE) expressed in percent. It is a good indicator of the available moisture in the soil in relation to water need. Thus Ima might be useful indicator for irrigation planning in the study of agriculture droughts and land use planning in applied climatology.

Ima value computed for Varanasi is shown in Table 4. Moisture Adequacy Index shows that district enjoys moist sub-humid type of climate due to higher Ima values.

Conclusion

The above discussed water balance parameters show that there is a little water surplus (133mm) only in rainy season. The two major components to measure the degree of dryness and wetness i.e., PE (1494mm) which is considered as need of water and AE (992mm) showing amount of evapotranspiration there is large difference. Lang's rain factor index shows that study region lies in Sub-humid dry climatic type of climate, while as per Koppen's classification it comes into Cwg ((Humid-mesothermal) type. Thornthwaite's revised scheme put the area into $C_1A'_3da'_3$ type of climate. The Ayoade scheme provides the knowledge about moisture adequacy index which is basically the ratio of AE and PE expressed in percent. On the basis of moisture adequacy index the area experiences moist sub-humid type of climate.Moisture adequacy in-

Table 4: Derived Water Balance Parameters (AE and PE), Moisture Adequacy Index (Ima) and climatic types of Varanasi

Station	PE(mm)	AE(mm)	Ima% 100(AE/PE)	Climatic code	Climatic type
Varanasi	1494	999	66.9	B	Moist sub-humid

Source : Computed by author, Relevant data Obtained from IMD, Pune.

dex is a good indicator of the available moisture in the soil in relation to water need. Such informations are very useful for proper irrigation scheduling during the period of agriculture droughts.

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A Critique of Indian National Water Policies: Some Major Issues and Insights

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Abstract

Indian national water policies are generally criticized for not having any convergence with the expectations and requirements of different water-resource-regions of the country. Structural allocation-regulation mechanisms have disproportionately dominated this policy regime for generations. Still, a vast stretch of the country is in urgent need of non-structural solutions and use of conjunctive resource management principles. Officially, these policies are claiming to shift their focus from supply ends towards demand adjustments. However, the existing patterns of water demand of the population across the country have never been comprehensively assessed. So, this stated policy goal of demand adjustment does not have any proper base. This paper has included a number of vital issues in the said contexts in order to explain the gap between policy formulations and geographical realities of the nation. A thematic overview of the problem has been prepared with the help of a number of secondary data sources.

Key words: *national water policy, aquifer, water demand, water management, microfinancing.*

Introduction

The National Water Policy (NWP) was adopted by the National Water Resources Council during its 2nd meeting held on 9th September 1987. This policy guided the formulation of policies and programmes for water resources development and its management. Thereafter, new challenges emerged in the water resources sector, which necessitated review of the National Water Policy. The National Water Policies (NWP) is the jurisdiction of the Union Ministry of Water Resources. The policies are somewhat indicative in nature without

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any actual enforcement power because, the country does not have a National Water Law. So theoretically, they do not possess much importance than being some general list of guidelines for the state machineries. Nevertheless, these policies have had significant impacts upon the nature of water resources administration and management across the country. Strong provisions for finance and technical workforce creation have been the priority areas of the NWPs so far. The public or semi-public water utilities and national/international financial services have been the greatest beneficiaries of this impressive government funding schemes (Sohoni, 2012). Paradoxically, the community has achieved the least as both the drinking water and irrigation sectors have not been met with the promised success by the NWPs (Bansil, 2004). The national agro-economy still predominantly have a rain-fed character, and both rural and urban water supply regimes are facing some stiff challenges of deficient quantity and quality (Thakkar, 2012). The vast geographical diversity of the country and associated socio-ecological settings are major potent factors which have somewhat remained unnoticed by the policy makers. Consequently, a very poor inter-linkage between the NWPs and other relevant resource or service provision policies (agriculture, healthcare, forests, environment etc.) have resulted in an ever expanding diameter of administration costs for the governments (Shah et al., 2004). However, recent growing concerns over global climatic change have made it urgent for the water resource management administration to acknowledge and appreciate these strong geographical factors (Thakkar, 2012). Still, ground level implementation processes of these recent policies or schemes are visibly very sluggish due to an apparently inflexible institutional design of the administration (Tiwari and Nair, 2011).

The first NWP in the post-independent period was formalized in 1987 which was subsequently revised in 2002 and 2012 (Seth, 2012). Interestingly, none of these revisions had have identified or properly explained the reasons behind the apparent failure of their predecessor. Two very important missing factors in the NWPs so far have been a holistic management vision for water and an optimal spatial scale of operation. The first major intervention plan for the country's water resource sector was the commissioning of the Damodar Valley Corporation (DVC) in 1948 which was originally a prototype version of the Tennessee Valley Authority (TVA) of the USA. Such a major investment was undertaken at a stage when the nation did not even have any stated water policy. So, suitability or adaptability of such plans for the regional geography could never be fully explained, and subsequently, similar plans were followed on a nation-wide scale in large numbers. Several advantages of such big project were promised like increase irrigation-command, flood control, enhanced hydro-electricity generation etc. However, there are hardly any authentic scientific studies about the success of such projects (Thakkar, 2012). On the contrary, these projects have further intensified flood events and their irrigation or hydro-electricity generation capacities have so far been rather limited. NWPs have deliberately been kept silent over micro level sustainable water resource management options which have traditionally defined the country's agro-based rural economy. Structural-engineering

measures (dam construction, river flow diversion etc.) have dominated the imaginations of the water planners, and non-structural measures for flood or drought control (land use zoning regulations, water demand adjustment etc.) have completely been excluded from the policy framework (ADB, 2006). In the background of all these existing complexities, this paper has briefly portrayed a possible interface between the NWP and the country's geographical realities for a better and sustainable water-secured future.

Objectives

1. To highlight the major institutional deficiencies of the NWPs against some major spatial dimensions of water resource management problems.

2. To suggest a holistic and conjunctive policy framework for water and allied resources and services sector in India.

Database and methodology

The article is based on a number of secondary data sources at national and sub-national levels, viz. India Micro Irrigation Program Survey 2011, published reports of the Comptroller and Auditor General (CAG), Central Ground Water Board, and civil society organization like the Development of Human Action (DHAN) Foundation etc. Processed and extracted both types of information have been used to explain the apparent link between regional geography and policy making. Several empirical studies and observations have been cited as support evidences. Finally, a logical and exploratory research frame has been developed. A maximum space has been given for the priority areas cited in the national water policies and their feasibility against the existing geographic realities of the nation.

Observed problems with irrigation water management strategies

Apart from technical capabilities, institutional performance also has a profound impact upon the success of water resource management policies (Griffin, 1999). The NWP 2002 had duly acknowledged the importance of new knowledge creation for an optimal water resource management and disbursal mechanism. However, this objective was never realized up to the existing potentials especially in case of irrigation water management. Even the concerned policies have somewhat showed a divergent trend from some other national level programs in this regard; like the Common Guidelines for Watershed Development Projects (2008) which has aptly recognized the needs of an equity based collaboration between government and non-governmental bodies to explore and harness locally available knowledge about the existing agro-ecology for better and efficient water management. The NWP 2012 does not include any component of the said guideline which may result in further isolation of the public water utilities from watershed planning tasks and responsibilities. This ongoing trend has already produced a series of serious consequences like water logging and salinization problems in various parts of the country. The underlying cause has been the absence of any comprehensive irrigation policy within the NWP which may well incorporate the complexities and variations in the country's geography. Currently, the basin level approach adopted by the major and medium irrigation projects is not well-coordinated with the requirements of the watersheds within the same basins. The watersheds do not have any institutional representation within the policy provisions. The 12th Five Years Plan has incepted

the idea of forming aquifer management committees at successive administrative levels (village or development blocks) for participatory ground water management. However, such ideas may be having better applicability at watershed levels to ensure participation from all stakeholders.

The NWP 2012 is practically silent over needs of increasing the soil moisture content, but still, extremely vociferous over options like inter-basin river water transfer or installation of more multipurpose projects. However, no provisions have been made for assessing the carrying capacities of the river basins or their cumulative impacts studies. In terms of numerical strength of dams, India has the 3rd top position in the world with more than 5000 dams of which 96 percent primarily function for irrigation (Thakkar, 2012). The ultimate irrigation potential created by these dams has remained completely unchanged in between 1972 to 2007; despite a massive investment of more than US$ 271 billion (INR. 18254 billion) which was around 69 percent of the total plan expenditure on irrigation (Planning Commission, 2009). Till 2007, these dams used to irrigate about 33.74 million hectare (around 30%) of the total gross irrigated area of the country (Planning Commission, 2009). Further till 2011, around 91 percent of these functional dams were concentrated within 5 states only (MoWR, 2011). Rest 70 percent of the total net sown area of the country has received the least from this generous government funding on irrigation.

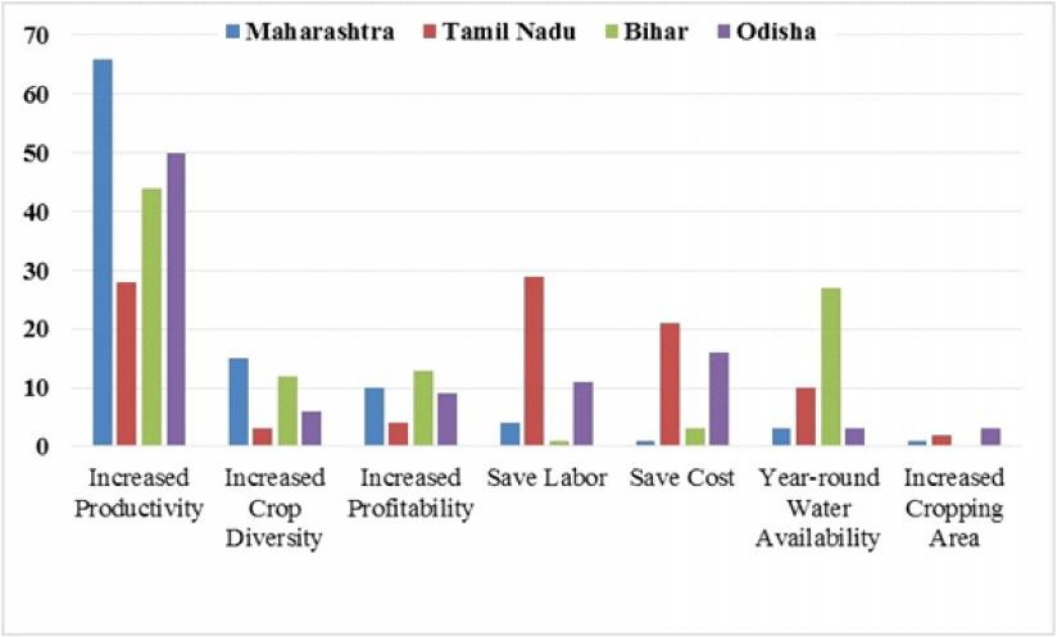
In some states like Bihar, West Bengal, Andhra Pradesh and Tamil Nadu, new farming techniques like the system of rice intensification (SRI) has shown impressive results in terms of reducing irrigation water consumptions (Table 1). Such non-structural biological measures have additional advantages of minimum environmental impacts and lower investment demand. Surprisingly, the NWP 2012 has no space for any of such provisions. Although, it has recognized the importance of micro-irrigation technologies like drip or sprinkler, but, the policy has certainly failed to assess the economics of these technology. Success rates of such measures are primarily dependent upon the marginal monetary returns which is the main driving force behind adoption of these technologies by the farmers. The Indian micro-irrigation program survey (2012) across the four

Table 1: Progress of the system of rice intensification techniques in the state of Bihar.

Particular	**2007**	**2008**	**2009**	**2010**
No. of farmer	128.00	5146.00	8367.00	19911.00
Land under SRI (hectare)	30.00	544.00	786.00	1412.00
SRI Yield (tons/hectare)	10.00	7.75	6.50	3.22
Traditional paddy Yield (tons/hectare)	2.70	2.36	2.02	1.66
Highest SRI Yield (tons/hectare)	18.18	19.30	14.20	6.50
Climatic conditions	Normal	Water stressed	Drought	Extreme drought

Source: Behera, 2011

states viz. Bihar, Maharashtra, Odisha and Tamil Nadu has found that an average 47 percent of the surveyed farmers have purchased micro-irrigation equipment for crop productivity enhancement; rather than for water savings (Figure 1). This aspect of farmers' behavior needs special policy focus. The National Food Security Mission (2007) is providing financial assistance for promotion of micro-irrigation practices, but, the scale of per capita allowance is currently too meagre. The NWP 2012 could have joined its provisions with the Ministry of Agriculture in this mission for up-scaling the penetration capacities of these ongoing schemes; without any additional increase of administration costs for the government. Similarly, the policy failed to target the nexus between the heavy electricity and diesel price subsidies on ground water pumping in a number of states like Uttar Pradesh, Punjab, Haryana etc. which is a main reason for ground water depletion (Shah, 2013). So, the stated policy goal of irrigation water demand management has hardly a sense of the existing geographical complexities (Shah,2004).



Source: India Micro-irrigation Program Survey, Ministry of Agriculture, 2011

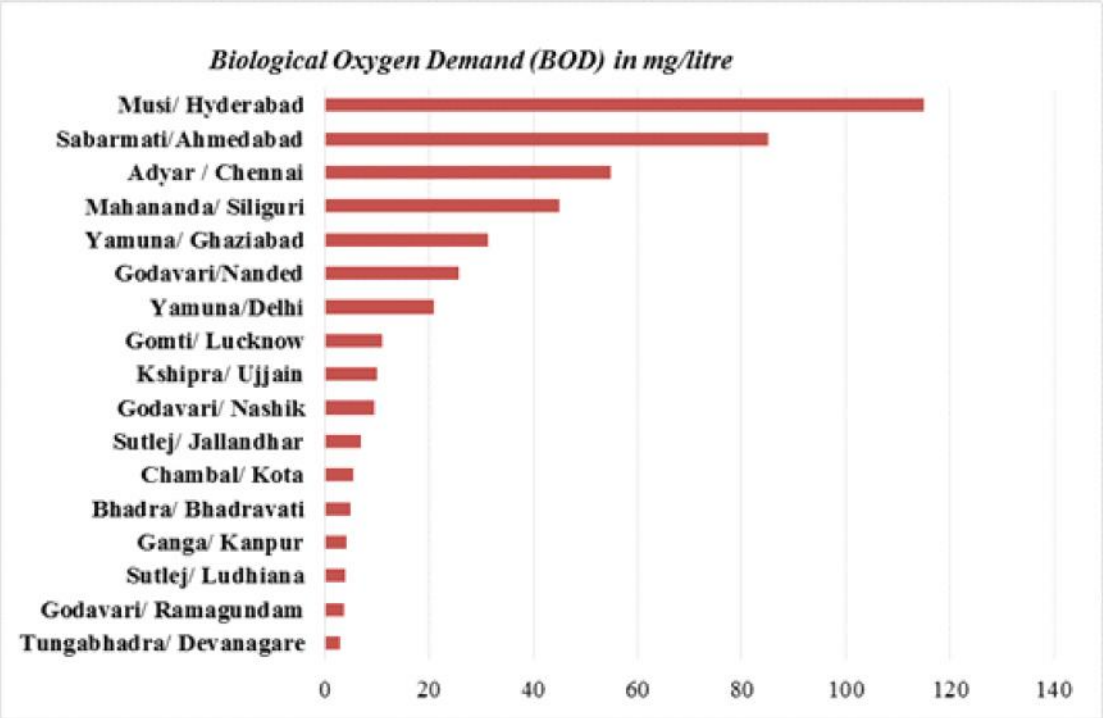
Fig. 1: Farmers' perception towards adaptability of micro irrigation tools

Ecological restorations of rivers and aquifers

Ecological restorations of rivers and provisions for inter-basin river water transfer are completely contradictory objectives cited in the NWP 2012. At a point, the policy speaks on the need of keeping aside a portion of the river water as environmental flow for meeting the ecological needs, but then, it promotes the agenda of inter-basin river water transfer on case-specific merit basis. The important issue of measuring or defining this environmental flow for different rivers has been left merely as a

matter of chance. The problem remains with the administrative perception which understands ecological restoration only in terms of water quality and not in quantity. A report by the Comptroller and Auditor General (CAG) of India (Report No. 21 of 2011-12) indirectly confirms this existing piece of reality. The said report has published the pollution status of a number of Indian rivers, and in each case, the pollution status has been measured in terms of biological oxygen demand, dissolved oxygen contents etc. (Figure 2). The natural flow regimes of those rivers were not considered at all as a parameter for monitoring and assessing pollution levels. At the same time, the report further provides a grim picture of the institutional deficiencies of the water administration. A total 28 Indian states were covered in the report, and efficiency levels of their pollution control practices were assessed with the help of 16 selected parameters (See Figure 3). Surprisingly, not in a single parameter not more than 16 states could qualify, and in case of parameters like 'quantification of nutrients' or 'impact of human activities-industry', there were zero representation by the states. So, how much justice would be done to the ecological restoration tasks of rivers is already under doubts.

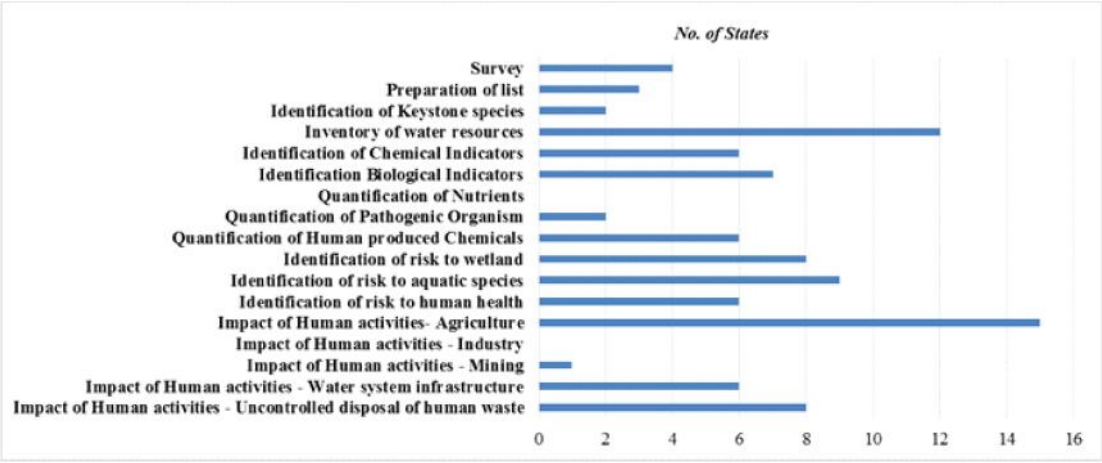
The Allahabad High Court released a land mark decision on 12th January 2011; by giving order to the state government of Uttar Pradesh to release at least 50 percent water from the Narora barrage to the river Ganga. The court aptly considered the serious issue of unchecked water withdrawal from the river for



Source: CAG, 2011-12

Fig. 2: BOD status of some major rivers in India.

irrigation purpose; which according to the Uttar Pradesh State Pollution Control Board eventually led to the degradation of the water quality. Such decisions strongly points towards the needs of proper definitions and categorization of the environmental flow regimes for the natural drainage systems of the country. More worthey were originally built, because, in most of the cases additional reserve of water in the upstream catchment results in increased water demands due to changed cropping practice and allied activities. There are other ecological hazards associated with these water transfer plans through long distance canals across the north-



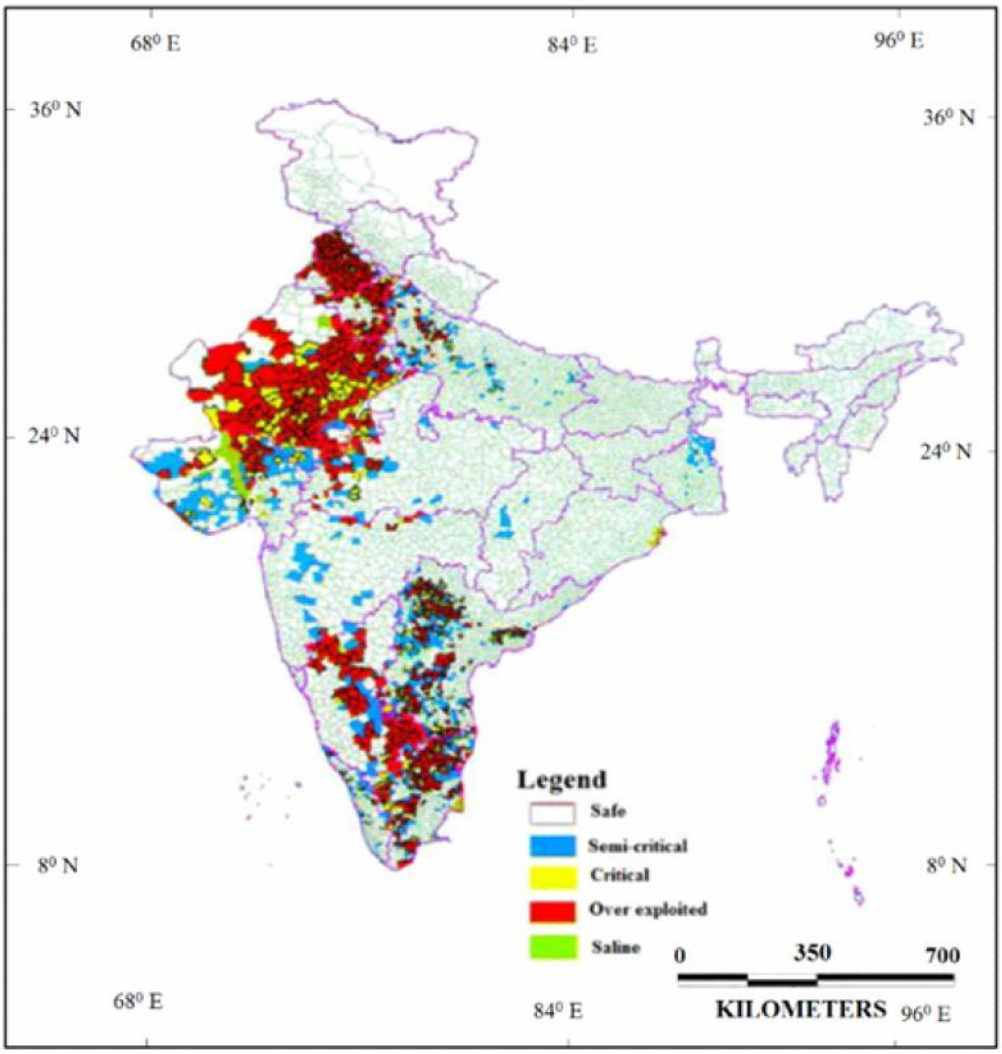
Source: CAG, 2011-12

Fig. 3: Institutional and technical capacities of the Indian states in assessing inland water pollution

risome fact is that the NWP 2012 continues to promote the objective of river interlinking which entails transferring of 'surplus' water from the 'water-rich' eastern and north-central regions to 'water-deficient' western and southern regions of the country. However, expert reports like that of the state government of Bihar in 2003 has assessed the practical challenges in measuring and transferring this water from one state to another (Mishra, 2011). Such interlinking projects are heavily dependent on construction of dams and reservoirs on strategic geographic locations. These dams have always been a boiling pot for political conflicts and debates, because once installed, these dams are hardly effective in supplying the promised volume of water to downstream for which ern plain. Due to the existing flat topography of the plains, these dams would act like barriers to surface run-off during the monsoon which would led to water logging condition over a sizable chunk of the geography.

The NWP 2012 has acknowledged the importance of conserving the declining ground water reserve of the country and arresting the problem of ground water contamination. However, it could not identify the ground water hotspots of the country which are in urgent need of policy intervention (Thakkar, 2012). From recent climate change point of view, the western and peninsular region of the country should be considered as the ground water hotspots (ibid). Most of these regions are suffering from over-exploitation problems of ground water (

Figure 4). These are the regions which were upfront during the agro-production boom following the green revolution in 1967-68. This production boom was mainly supported by the injudicious exploitation of local and regional aquifers (Shah, 2004). Unfortunately, like other state governments, these states too do not have any specific program to mitigate their ground water degradation (Thakkar, 2012). In this backdrop, the Union Government initiated the 'Artificial Recharge of Ground Water through Dug wells' scheme in 2008 across the states of Tamil Nadu, Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh and Rajasthan. Still up to 2010 (targeted timeline of the program), only 15.75 percent of the total allocated outlay of US$ 27 billion (INR 1798.71 crore) could be spent by those states.



Source: CGWB, 2006, p. 20

Fig. 4: Concentration of the ground water depleted areas in India

The NWP 2012 did not specify the priority areas for water resource allocation. This gap may affect the ground water economy and ecology in a more severe way than the surface water resources, because, utilization patterns of ground water is very much decentralized and complicated. It has created wide loops for the ground water exploiting industries like soft-drinks or packaged water procurement. The case of Kerala state government vs. the Coca-Cola authority over the disastrous ground water degradation in Plachimada during 2011 is remarkable in this context.

Water demand adjustments

The NWP 2012 has sought to manage the future demand of fresh water with ensuring a desired efficiency in water use. Although at the same time, it has a core objective of "enhancing water availability for use". Ironically, here the policy badly misses an important fact that increased water availability may also invariably result in increased water demand and consumption due to changed agro-production patterns and industrial activities. Such consequences would only further aggrieve the conditions of the already marginalize population and service areas like drinking water or small farmers, as major volume of the increased water supply may well be consumed by the big water using sectors. The example of the Ukai dam on Tapi River in South Gujarat is an eye opener in this issue. Lower catchment of the river basin is primarily located within the dry tropical climatic belt with 50-100 cm of annual monsoon rainfall, and it has a combination of alluvium, red, yellow and regur soils. Such geographical settings are only suitable for crops like groundnut, cotton, millets, oilseed, wheat etc. (Subramaniam,1991). Still, commissioning of the Ukai dam in 1972 has encouraged water guzzling cropping like sugarcane especially in the Surat district (Verma and Satpathy, 2004). Consequently, in between 1972-73 and 1997-98, the state Gujarat has witnessed a phenomenal rise (annual 13.3%) in its sugarcane production. In 2009, following a low monsoon intensity, the Ukai dam recorded a low water reserve (49% of its live storage capacity). Even under such critical condition the state government of Gujarat decided to provide irrigation water supply to the sugarcane cultivators and not to the paddy fields. So, merely increasing the water availability would not necessarily meet the actual demand unless basin specific priorities are measured and comprehensively included into the policy.

Spatial and sectorial conflicts and disputes are major impediments for attaining the objective of sustainable water demand management. Although, the NWP 2012 has acknowledge the importance of resolving the spatial disputes with the trans-state-boundary rivers; by proposing the formation of a permanent water dispute tribunal at the center, but, it seems to be completely under darkness regarding an emerging pattern of sectorial water conflicts. These types of conflicts are more pronounced in between irrigation and industrial water demands, and rural and urban water demands. The incidents in Maharashtra in 2005 and 2010 may well be cited in this context where the respective state government issued ordinance to divert 1500 million cubic meter of water from 38 dams across the state to industries and cities (Dandekar, 2011). The ordinance resulted in an irrigation deprivation for 2, 62, 503 hectare of farm land, and consequently a legal confrontation took place between the farmers and the Maharashtra Water Resources Regulatory

Authority (MWRRA). An initial source of these disputes are the dams and reservoirs constructed over the surface drainage network which appear as lucrative for both the agriculture and industry sectors. Non-transparent and corrupt management of these dams further fuel such conflicts (Thakkar, 2012). With the NWP 2012 showing determination for more number of river valley projects, such disputes and conflicts are expected to increase in numbers and intensity. Also, the urban centers of the country generate 38, 254 million liters of untreated sewage which is responsible for 70 percent of the fresh water pollution of the country which is a potent cause for struggle between the rural India and these urban bodies. The legal battle in 2011 between the Tamil farmers' organization 'Tamizhaga Vivasayeegal Sangam' and number of textile and dye industrial units over the observed water pollution problem of the Noyyal river by those industries is worthwhile for this study.

The National Initiative on Climate Resilience Agriculture (2010) has a core thrust on promoting the agro-biodiversity of the country as a response to these future climate change impacts (Thakkar, 2012). Production and extension of new drought tolerant crop varieties are an integral plan of these plan, which primarily rely on in situ concept, *i.e.* bringing the genetic resources back to the field and within the farmers' communication levels. However, there is no participation from any of the mainstream water resource management agencies in this mission, despite, climate change related challenges mitigation is an important part of the NWP 2012 and agriculture is one of the key vulnerable sector towards climatic change. Paradoxically, at a great expense of the local and regional environment, the policy is somehow justifying the constructions of more dams and reservoirs for augmenting the irrigation water supply as a measure against climate change. Here, the debatable clean development mechanism (CDM) of the United Nations Framework Convention on Climate Change (UNFCCC) has a clear influences upon the policy. In Himachal Pradesh for example, a total 509 small dams have been approved till March 2011 (Ganeriwal, 2011). Most of these projects do not have any significant positive impact upon the local water availability or run-off management. On the quite contrary, regular storage of sizable volume of water by these reservoirs has disturbed irrigation water supply to 2500 hectares of farmland across 12 village units. Recently, the Sutlej basin, Betwa sub-basin and Cauvery delta region have been shortlisted by the Ministry of Water Resources for developing strategies against climate variability under the technical assistance of the Asian Development Bank (Thakkar, 2012). This may also result in a lobbying for more number of surface hydro-projects in these regions as ADB has been a big proponent of the CDM, and is actively financing several hydro-projects in Himachal Pradesh (Ganeriwal, 2011).

Micro-financing for integrated land, soil, and water resources management

The NWP 2012 has provisions for micro level water pricing, but, it certainly failed to identify the needs of micro level resource mobilization as measures for community resilience building against events like droughts or floods. Generally, the poorer and marginalized populations are more vulnerable towards such climatic vagaries because they pose few or no livelihood alternatives and limited institutional capacity. Any successful micro-level resource

management ventures need to have a comprehensive inclusive character towards these sections of the population. Micro-financing programs have been particularly very successful in poverty alleviation and ensuring grass-root level livelihood security. In the southern states like Tamil Nadu or Kerala, the women self-help groups (SHGs) and primary agricultural credit societies (PACS) have delivered measurable progress in promoting these micro-financing programs (Mishra, 2008). The positive impacts of these micro-finance ventures have been seen on micro-level resource management sectors like small water bodies, forests, pasture land etc. (DHAN, 2012). Here, increased credit absorbing capacity of the communities has helped them to recognize the livelihood related benefits of sustainable resource management practices. Programs like the Vayalgam Tank Development Program (DHAN,2006) have largely been financially supported by the micro-finance groups, and more than 74 percent of the overall program expenditure is met from these groups. Surprisingly, the NWPs have never fully acknowledged this existing strong mechanism of micro-level integrated management of land, soil and water. The knack is still very much prevalent to visualize water resource management and planning tasks in isolation from these allied sectors. These sectorial interlinks and dynamics are the important missing-links in these policies which have only resulted in further degradation and degeneration of the existing water governance.

The NWP 2012 has included provisions for multi-level stakeholder participation for land and water resource management, with scientific inputs from local research and academic institutes. Such a policy frame may be an encouraging context for the grass-root level natural resource managers and planners. Still, the need of hour is perhaps of stakeholder-partnerships and not just token stakeholder participation and consultation. Already in case of the National Environmental Policy 2006, the water resource management agencies have by and large learned to circumvent the clauses of stakeholder partnership and consultation process by applying several proxy methods (Pandey et al., 2013). So, the same fate may also follow the NWP 2012. During the implementation of the VTDP in the southern states, it has been well observed that financial resource (25% of the project costs) sharing strategies are the best way of articulating such partnerships. It can also ensure a better and effective equity in disbursal of project's benefits among the local population (DHAN, 2012). Under such partnerships, the local communities have been actively involved in all the vital stages of the projects right from the pre-feasibility study to the project execution and subsequent management of the built-up infrastructure. A high level of transparency and efficiency are the observed advantages of such engagements, which have so far remained a missing aspect in Indian water resource administration particularly in case of large surface water infrastructure like dams and reservoirs. Non-transparent and unscientific management of these infrastructures have yielded negative and unpredictable consequences like increase in flood frequency or degradation of irrigation and hydro-power generation capacities etc. (Thakkar, 2012). At this point, a resource sharing (micro-finance) based management designs can effectively upscale the performance of these built-up infrastructures.

The NWP 2012 has a stated mission goal of reducing risks for the population against water related natural disasters like droughts or floods. Micro financing measures can also be used as essential aids for this tasks. Already during the devastating tsunami in Tamil Nadu in 2004, it was well observed that people having the facilities of micro-finance show comparatively a better recovery speed (DHAN, 2012). Such disasters not only cause loss of lives or properties but also inflict considerable damage on the productive assets like farm or grazing land. During the tsunami (2004) for example, inundation of sea water caused salinization of vast tracts of agricultural land and sludge-intrusion in the small water bodies which are vital for fishery. Reclamation of these resource bases needed a considerable one time investment which was often beyond the financial capacities of disaster hit people. Eventually, micro-finance played a strategic role in this important task of rehabilitation. Social impacts and penetration capacities of these small finance is often many time greater than the government funded relief measures, because people enjoy more better timing and flexible investment options with the former. Currently, the NWPs shows an indirect association with the National Resettlement and Rehabilitation Policy 2007 which is already been badly circumvented in a maximum number of surface-water projects across the country. The resettlement policy has even created a loop for the water-planners to do away with the burning issues of displacements and rehabilitation by offering mere amounts of monetary compensations (Pandey et al., 2013). Alternatively, the micro finance measures are having a wider positive implication in this context, but they are yet to become a regular feature of the NWPs.

A National water law for community water rights

The NWP 2012 has proposed to articulate a national framework water law which may guide different state government in managing their water resources. The proposal has recognized the ground water as a community resource, and also briefly discussed about the institutional requirements for optimal management of surface and ground water. However, the policy has not specified the important context of customary water rights which are inalienable part of the community resource; both in case of surface and ground water. Farming and non-farming communities have exercised these customary rights to water and other associated usufructs according to century-old social norms. India rural landscape has an estimated number of 200,000 to 350,000 tanks which are basically managed by these customary rights and norms, and serve as vital water source for multiple social groups like village farmers, fisher folks, artisans etc. (ADB, 2006). The water *'Mamul namas'* (documented records) in Tamil Nadu written during the 19th Century A.D. are the valuable examples of this social system (Gurunathan and Shanmugham, 2006). Enforcement of the 'Permanent Settlement Act' in 1793 and *Ryotwari* land tenure ship (1802) by the British-Indian government, and subsequent introduction of the High Yielding Variety (HYV) Program in 1966-67 in post-independent India, supported by highly subsidized (and indiscriminate) ground water irrigation; severely damaged these customary right based tank management systems (DHAN, 2004; Rao, 2009). Degradation of these customary tank-rights have been one of the major causes of the acute ground water problems in India, because, these tanks also used to play a

dominant role in ground water replenishment. So, any national level legislation on water should also take a due consideration of these existing customary water rights in order to avoid such similar consequences.

A major component of the said customary water rights is the water usufructs (appropriation rights) which are traditionally defined in considerable detail forms under various geographical settings (DHAN, 2004). Such measures ensure peaceful resolutions of conflicting water demands over a tank. Ramnathpuram district in southern Tamil Nadu for example is located within the drought prone belts. Here, the local tank-management customs oblige every farmer having plough land within the *ayacut* (tank command), for compulsory contribution of resources for annual maintenance works of the tanks, and no individual is exempted from this charge. Certainly, there are strict penal provision for violation of these norms and customs which some time can also create conflict with the broader state legislations. Even when India does not have a national water framework law, the various state governments have already enacted specific state legislations regarding various usufruct rights on water. In most of the cases, these state legislations like the Tamil Nadu Fish Farmers Development Agency Act 1980, although recognizes the customary rights of the village community over the tanks, but does not grant them any absolute status. Consequently, these customs remain challengeable in face of legal battles. These complicated interactions between formal or informal management principles, and indigenous norms and customs create unmanageable complexities for the policy makers and planners. Here, a national water framework law is expected to offer a viable solution of these complexities. Indigenous water resource management practices like the tanks are still an essential component of modern and sustainable water resource planning, and their associated social systems too deserve legal recognition and empowerment as well.

The notion of community participation is largely misunderstood inside the Indian water resource policy regime. In a majority of cases, the community participation is either seen as an end-solution in itself or only an additional clause for project implementation. Consequently, the community itself has to face several exclusions and exploitation in the name of participation (Ahluwalia, 1997). The recent considerable investments on watershed projects by domestic and international NGOs and financial institutions can be taken as an example. Many such ventures have so far receded in face of local level resource conflicts or have created unsuitable infrastructure for the local hydro-ecology across the nation. A sizable number of these failed-projects were concentrated in the geographic belts which are suffering ecological degradation due to ongoing problems of greenery or soil loss. This may be a worrisome fact, because, the policy think-tank has been promoting community-based watershed development projects as an effective alternative of conventional expert dominated technical solutions. Failure of these projects may also affect the core components of the recent participatory water demand management policies like the village level aquifer management program announced in 2011 (Shah, 2013). So, there is a visible need for standardizing the norms and guidelines of community-based watershed projects across the nation. If the promised national water frame-

work law is eventually realized, then this aspect of community participation should receive an utmost priority in terms of legal clarifications and necessary safeguards for community interests. At the same time, the decision making capacity should be developed at the lowest tier of the administration; in order to ensure that a national level water framework law does not end in further legal confrontations among local interests.

Conclusion

Water resources management policies in India have been a disaggregated collection of political and economic priorities for more than half century. Although, scoping mechanisms or ground implementation have always remained some undefined aspect of these policies. Geographically, the water resource regions of the country have their different patterns of priorities and problems. These diverse patterns even challenge the very rationales of a national water policy, because the associated institutional designs (of these policies) are observed to be too simple and indifferent to deal with such geographical complexities. Such institutional models are a direct inheritance from the colonial past of the country which was primarily designed to forward the interests of the then colonial rule. Water policies have seen two major revisions in 2002 and 2012, but the much required institutional reform measures were not undertaken simultaneously. Occasional scientific studies on the hydro-geo-ecological health or related aspects of the country have clearly indicated towards the planning and management inefficiencies of the water governance, but positive effects of these studies have never been featured in the policies. Very recently, the water administration has incorporated some specific interventions on climate challenge mitigation in the form of some new programs and schemes. However, financial viability and sustainability of these strategies are debatable, because these have only incorporated the structural measures which need continuous vigilance and resource mobilization on the government side. On the other hand, measurements of the social impacts of such interventions have been a pending task. These impacts are essentially the product of the interactions between the regional geography and policy tools. So, unless the geographical components are comprehensively explored in policy doctrine, the national water policies are less likely to play any real-time strategic role for the country.

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Urbanisation in North East Bihar: Pattern and Potential

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Abstract

*North East Bihar surrounded on three sides by the rivers and on one side by the Himalayas has less than 10 per cent of the total population living in urban areas. Frequent floods, predominance of agricultural activities, lack of mineral resource base and unwillingness of the stakeholders are major factors f*or low level of urbanisation and it can be resolved through state intervention and suitable regional development strategy. This paper aims to examine the spatial spread of existing towns as *well as the potential level of urbanization by taking into account urban and rural settlements. The paper is based on secondary data collected from census volumes and govt. documents.*

Keywords : *urban areas, economic base, urbanization, potential, settlements.*

Introduction

Urbanization as a process involves the multiplication of points of population concentration as well as increase in the size of individual urban concentrations. A historical account of urbanization reveals that the politico-administrative processes have played significant role in the process of urbanization at the macro and micro level and the same has been reflected in the emergence of new state capitals and other urban centres. Urbanisation at the global level has risen significantly from 13 per cent (220 million) in 1900, to 29 per cent (732 million) in 1950 and 52.1 per cent (3.63 billion) in 2011 (UN: 2011). The North-South divide is significantly visible and developed world is characterized by high level of urbanisation as compared to the developing world. India has been traditionally known as the land of villages with less than one third (31.16 per cent) population living in urban areas (2011) which is far below than the world average. But the absolute urban population of India is gigantic (377 million) next only to China. It has increased by more than five times in the last fifty years (1961-2011). For the first time, urban population growth rate has surpassed their rural counter-

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part and there is a significant increase in the total number of towns. The last decade (2001-2011) witnessed the emergence of more than 2500 new towns, which is far more than the number of towns which emerged in the last hundred years (1901-2001).

The number of metropolitan cities has increased from 2 in 1901 to 5 in 1951 and 53 in 2011. India has a young and rapidly growing population where 65 % of population is below 35 years of age a potential demographic dividend, and the country needs thriving cities if this dividend is to be utilised for the development. New McKinsey Global Institute (MGI) research estimates that cities could generate 70 per cent of net new jobs created by 2030, produce around 70 per cent of Indian GDP and drive a near fourfold increase in per capita income across the nation (MGI: 2010). The metropolitan centres are going to experience decreased growth rate but their spatial expansion along arteries of transport and urban growth in industrial cum commercial centres would take place rapidly with increasing tertiary activities. So the question arises, whether this higher pace of urbanisation in the last decade has been uniform in the whole country or some of the areas are still lagging behind and struggling for their economic revival. This paper attempts to find out answer of this question from a regional perspective taking into account North East Bihar which is least urbanized, flood affected region with almost no natural resource base.

Objectives

Objectives of this paper are

- To critically examine the definitional issues of urban areas as given by the Census of India and the ambiguities arising out of the discretionary powers given to the state government;
- To highlight the spatial pattern of urbanization considering different measures like percentage method, rural population served by an urban centre and the distance covered by an individual to get goods and services;
- To give an account of evolution and spread of urban centres over the space and potential urbanization by studying the large rural settlements and their role in the process of regional development.

Methodology

Data for the study have been collected from various (published and unpublished) sources like Census publications (1961, 1971, 1981, 1991 2001 and 2011), Town Directory, District Census Handbooks, District Statistical Handbooks and other relevant literatures. Potential urbanisation is calculated by considering population of rural settlements with population above 20,000 as potential urban centres. Data collected from various sources have been processed, analyzed and depicted using statistical and cartographic techniques and relevant GIS software.

Study area

With the formation of Jharkhand as a separate state on 14th Nov.2000, the state of Bihar is recognised primarily as a plain area divided by the river Ganga with a very small but significant Himalayan foothill region in the northwest corner. The two broad units of the state is known as north Ganga Plain and south Ganga Plain which is further subdivide into smaller regions. North East Bihar Plain is a well de-

fined geographical region with internal homogeneity lying east of the Kosi , north of the Ganga and west of the Mahananda River. The region coincides with the Kosi Plain (Singh 1971) and is further subdivided into East Kosi Plain (Purnea Plain) and West Kosi Plain (Saharsa Plain). Frequent occurrence of floods in monsoon season and shifting of channels have made this region a khadar land. It is also the moistest part of Bihar with rainfall varying from 125 cm and above in the SW to 200 cm and above in the NE corner of the region. The favourable hydrology and soil elements have led to growth of natural grasses in the plain areas. Underground water table is normally high and water logging is a common problem in North East Bihar. Consequently the region is favourable for rice and jute cultivation. Jute is a leading cash crop of the area with distinctive agricultural characteristics. Being located in the plain area the region lacks mineral resources and mineral based industry. The most important industry in this region is Jute industry followed by Matchbox industry, Rice and Oil mills. Bihar is one of the least urbanised states (11.3 per cent) and the North East Bihar is a flood prone area with lesser degree of urbanisation (7.4 per cent). The region falls in North East Alluvial Plain Zone II of agro climatic region. Administratively North East Bihar covers eight districts of North Bihar accounting for 20.4 per cent of the geographical area and 17.9 per cent of the state population. Urban population of the region is 11.78 per cent of the state's total urban poplation.

Table 1: North East Bihar: Basic Demographic Characteristics

S.N	Spatial Unit	Total Population	Urban Population	Rural Settlements with above 20000 population	Level of Urbanisation In per cent	Potential Urbanisation In per cent
1	Saharsa	1,900,661	156540	179861	8.2	17.7
2	Madhepura	2,001,762	88461	203849	4.4	14.6
3	Supaul	2,229,076	105558	138020	4.7	10.9
4	Purnea	3,264,619	343005	160332	10.5	15.4
5	Araria	2,811,569	168777	95483	6.0	9.4
6	Kishanganj	1,690,400	161123	Nil	9.5	9.5
7	Katihar	3,071,029	273822	154578	8.9	14.0
8	Khagaria	1,666,886	87159	154679	5.2	14.5
	North East Bihar	18,636,002	1384445	1086802	7.4	13.2
	Bihar	103,804,637	11729609		11.3	

Source: Respective District Census Hand Books 2011, Series 11, Part XII A

Definitional characteristics of urban centres

From 1901 onwards, the Census of India has set up its own criteria to identify the urban places and there have been changes in these criteria from time to time. However since 1981 there has hardly been any change in these criteria. Census 2011 defines an urban place as:

(a) Any places with a municipality, corporation, cantonment board or notified town area committee; or

(b) Any other places which satisfies all the following criteria:

(i) A minimum population of 5,000;

(ii) At least 75 per cent of the male working population engaged in non-agricultural pursuits and

(iii) Population density of at least 400 per sq. km.

On the basis of these criteria urban places are categorized into statutory towns and census towns. Census towns are further categorized into three groups on the demographic basis. They are metropolitan areas (with population above ten lakhs), cities (with population between one to ten lakhs) and towns (population below one lakh).Thus Census of India identifies following six types of urban centres on the basis of population size:

- Class I towns (population 100000 and above)
- Class II towns (population between 50000-99999)
- Class III towns (population between 20000-49999)
- Class IV towns (population between 10000-19999)
- Class V towns (population between 5000-9999) and
- Class VI towns (population below 5000).

Besides, the Census confers wide discretionary powers to its officers at the state level to identify the towns in the local context. This arbitrariness has led to the sudden increase or decrease in the number of towns in different states from one census to the next. Census 2011 has recorded an increase of 2774 towns (2532 census towns and 242 statutory towns) at all India level. Bihar has witnessed an increase of 60 census towns in 2011 Census. Bihar Municipal Act (2007) part II spells out criteria for identification of statutory towns in following words:

"The State Government may, after making such inquiry as it may deem fit,and having regard to the population of any urban area, density of population there in, the revenue generated for the local administration of such areas, the percentage of employment in non-agricultural activities in such areas, the economic importance of such area, and such other factors as may be prescribed, by notification, declare its intention to specify such area to be a larger urban area, or a medium urban area, or a transitional area to be a Nagar Panchayat or urban growth centre provided that no such declaration shall be made unless the population in the case of transitional area, that is small town, is twelve thousand and more but not more than forty thousand provided further that the non agricultural population in all the cases shall be 75 per cent or more".

The Act further explains revenue generated for the local administration should not include taxes, loans and grants received from the State Government/Central Government or institution or other sources.

Pattern of urbanisation

Bihar continues to be one of the least urbanised states of India with 11.3 per cent of the total population living in urban areas. The state seems to represent the 'subaltern' character of urbanisation which refers to the growth of settlement agglomerations, whether denoted urban by the Census of India or not, that are independent of the metropolis and autonomous in their interactions with other settlements, lo-

cal and global (Denis et al.: 2012). This seems to be true when we see a large number of settlements fulfilling the criteria yet not identified as urban centres. The pattern of urbanisation in any area is measured in a number of ways and the most common and the best understood criterion is the percentage of urban population to the total population. In relation to developed countries, India is less urbanised with less than one third population living in urban areas (Census 2011).However the percentage of population living in urban areas has been continuously increasing from macro to micro region. North East Bihar with eight districts has level of urbanisation (7.4 per cent) even less than the whole of Bihar (11.3 per cent). Here none of the eight districts have the level of urbanisation more than the state average. Madhepura and Supaul districts (earlier sub divisions of Saharsa district) have less than 5 per cent of population living in towns. Purnea is the only district where the level of urbanisation is more than 10 per cent and in remaining five districts it is between 5 to 10 per cent. The study area has total 86 CD blocks out of which only 20 has urban population (Table 2/Fig.1).

Table 2: Block Level Urbanisation (%)

Level of Urbanisation	**CD Blocks**	**No. Of CD Blocks**
Above National Average (31.16%)	Katihar (74.8), Purnea(63.4), Kahra (52.4), Kishanganj (43.9).	4
Between State Average and National Average (11.3-31.16%)	Madhepura (22.2), Nirmali(20.5), Araria (18.5), Supaul (18.2), Forbesganj(17),Kasba(16.2), Bahadurganj(14.6),Manihari(13.9), Murliganj(13.4), Khagaria(13) and Gogri(11.9).	11
Between State Average and Regional Average (7.4-11.3%)	Basantpur(9.9),Banmankhi(8.6).	2
Below Regional Average (7.4%)`	Thakurganj(6.3), Singheshwar(3.9), Barsoi(1.8).	3

Source: Respective District Census Hand Books 2011, Series 11, Part XII A

Another alternative measure of urbanisation is concerned with the distance that rural people have to travel to the nearest urban place on a periodic basis to obtain goods and services. This means that greater is the distance between rural and urban areas lower will be the level of urbanisation as the towns will be spread farther apart and are fewer in number. The maximum distance that a rural folk has to travel to reach nearest urban centre is calculated by using the formula $D=\sqrt{A/2.6}$ where D is the distance to be covered and A is the area. With the passage of time as the level of urbanisation and number of urban centres increases there

will be decrease in the distance that a rural folk has to cover. At the state level the average distance covered is 13.5 Km. and in the north East Bihar it is 18.8 Km. At district level Saharsa (27.4 Km.) followed by Purnea (20 Km.) and Katihar and the distance covered is minimum in Madhepura (15Km.) and Kishanganj (15.5 Km.). Another equally meaningful alternative to measure the level of urbanisation is the size of rural population served by a town. It is important in the sense that India is primarily a land of villages with large number of population living in rural areas and their dependence upon nearby towns for day to day requirement of goods and services is indispensible. In Indian context these urban centres serve as focal points of socio economic change and perform a variety of roles. Rural population of an area divided by the number of recognised urban centres may be used as a convenient measure. Rural population also termed as the threshold population of a town depends upon the level of urbanisation i.e high level of urbanisation results in lower population threshold and vice versa. Lower population threshold is the product of high per capita income, high level of services and larger number of urban centres. According to 2011 Census the average threshold population for the whole country is 80000 people and in Bihar it is 4.6 lakh and for the North East Bihar it is 8.2 lakh. At the district level, Saharsa has the highest threshold (17.4 lakh) followed by Purnea (9.8 lakh) and Katihar(9.3 lakh) and Kishanganj(5.09 lakh) has the lowest threshold. It is obvious that in all the eight districts threshold population of a town is higher than the state and national average showing lower level of urbanisation in the area.

Urban structural pattern and distribution of towns

The urban landscape of India is characterized by the presence of metropolitan apex with few large cities and large number of small and mini towns and North East Bihar is not an exception. There is no metropolitan city in the entire region. However in the last five decades the number of Class I towns has increased to four accommodating 56.7 per cent of the urban population. On the other extreme there is no Class VI town and only two Class V towns accommodating one per cent urban population of the region (Table 3). Class II and III towns are the potential centres accounting for two third of the numeral strength and 38.3 per cent of the total population.

Ramachandran (1989) calls these two categories of towns (II/III) as medium towns which can perform as an important functional link within the urban system, serve as market centres for agricultural produce and has rural oriented tertiary sector. In the last fifty years (1961-2011) the number of urban system has increased from 15 to 21. Katihar (59344) was the only Class II town of this region in 1961 and was the largest town located on the Kanpur-Guwahati railway line and the three leading functions of the town according to workers were transport, industry and commerce (Ahmad-1965). It got the Class I city status in 1981 census and in the last fifty years population of the town has increased by four times and presently it is the second largest city of the region. Purnea (40602) a Class III town

Table 3: Distribution of Population Under Different Categories of Towns in North East Bihar

Size Class	Population Size Size	1971			1991			2011		
		India	Bihar	N E Bihar	India	Bihar	N E Bihar	India	Bihar	N E Bihar
I	Above 1 lakh	57.0	39.9	Nil	65.2	44.4	34.0	60.79	57.5	56.7
II	50000-99999	11.0	13.2	36.7	11.0	22.0	18.3	10.15	15.6	18.0
III	20000-49999	17.0	25.4	33.7	13.2	25.5	40.3	14.12	21.6	20.3
IV	10000-19999	10.0	17.8	23.0	8.2	7.8	7.4	10.47	2.9	3.0
V	5000- 9999	4.5	3.5	6.6	2.1	0.3	Nil	3.97	2.2	1.0
VI	Less than 5000	0.5	0.2	Nil	0.3	Nil	Nil	0.5	0.2	Nil
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Respective District Census Hand Books 2011, Series 11, Part XII A

in 1961 and district headquarters was the second largest town. It attained the status of Class I town in 1991 and in the last twenty years the population recorded an increase of 245 percent. Population growth rate for the last two decades were 49.4 and 64.4 per cent respectively. Other Class III town in the region was Kishanganj, a sub divisional town of Purnea district is an important centre of jute trade. It became Class II town in 1981 and Class I town in 2011 recording little less than four times increase in population during five decades.

It is evident from the table that there has been a gradual increase in the number of towns but urban population of the region has recorded more than five times increase in the last fifty years. Physiographically, North East Bihar is divided into two regional units namely Saharsa plain with 9 urban centres and Purnea plain with 12 urban centres. Maximum number of towns falls in Class III towns termed as medium towns with population between 20000-49999. Such towns are characteristic feature of plain area and play significant role in shaping urbanization pattern and are an important component of the urban system. There are four towns each in Class I and Class II towns in North East Bihar all of them except Khagaria are district headquarter towns having administrative function in dominance.

Rural settlements viz a viz potential urbanisation

In Bihar there are 4345 rural settlements with population above 5000 (a threshold population for town) and 161 rural settlements whose population is above 20000 which are potential medium sized (Class III) towns. Notification of municipal areas comes under juris-

Table 4: Population of Urban Centres in North East Bihar (1961-2011)

Town	1961	1981	2001	2011	Class	Increase in Population
Purnea(Municipal Corporation)	40,602	91,144	171,687	282,248	I	6.95 times
Katihar(Municiapl Corporation+ OG)	59,344	122,005	190,873	240,838	I	4.05
Saharsa (Nagar Parishad)	14,803	57,580	125,167	156,540	I	10.62
Kishanganj (Nagar Parishad)	27,002	51,790	85,590	105,782	I	3.91
Araria(Nagar Parishad)	13,924	33,363	60,861	79,021	II	5.67
Supaul(Nagar Parishad)	17,460	30,732	54,085	65,437	II	3.75
Madhepura (Nagar Parishad)	11,832	21,742	45,031	54,472	II	4.60
Forbesganj(Nagar Parishad)	15,846	28,260	41,499	50,475	II	3.18
Khagaria (Nagar Parishad)	13,731	25,252	45,221	49,406	III	3.60
Jogbani(NP)	8,852	18,461	29,991	39,281	III	4.43
Gogri Jamalpur(NP)	-	18,896	31,106	37,753	III	1.97
Bahadurganj (NP)	-	16,786	28,118	36,993	III	2.21
Kasba(NP)	13,051	18,731	25,524	30,421	III	2.33
Banmankhi Bazaar(NP)	6,976	17,491	25,187	30,336	III	4.34
Murliganj (NP)	9,848	16,804	22,936	28,691	III	2.91
Manihari(NP)	-	12,592	21,803	26,629	III	2.11
Nirmali(NP)	5,423	10,108	16,141	20,189	III	3.72
Birpur(NP)	8,061	12,953	17,982	19,932	IV	2.47
Thakurganj(NP)	-	10,760	15,300	18,348	IV	1.70
Raghunathpur(CT)	-	-	5,601	6,355	V	1.13
Singheshwar Asthan	-	-	-	5,298	V	-
Urban Population	266,755	615,450	1,05,9,703	1,38,4445		5.18

Source: Respective District Census Hand Books 2011, Series 11, Part XII A

diction of 'State List' as per the Constitution of India. One can easily find out influence of local political economy of the state in the process of recognition of the statutory towns. As per Bihar Municipal Act, 2007, declaration of intention to constitute a municipal area is based on population and other characteristics of the settlement. According to the act population size of the urban area should be twelve thousand and more but not more than forty thousand for a small town or transitional area to be a Nagar Panchayat or urban growth centre. Besides, it

also considers density of population, revenue generated for the local administration, more than 75 per cent employment in non-agriculture activities and economic importance of such areas. In another clause, the State Government may, by notification, determine separate conditions, to constitute any hill area, pilgrim centre, tourist centre or mandi as a municipal area (Govt. of Bihar: 2007,2011).Bihar Municipal Act, 2007 did not consider significance of services like administration, education, health, finance, trade and transport in notifying new statutory towns. The significant increase in the population size of the settlement i.e. ten thousand or even more, itself creates demand for market and services. As a result, market and other services grow rapidly in these large villages. Similarly, it also ignores the increasing built-up area, role of agglomeration and out growth in process of notification of new statuary towns.

Ideally, a Gram Sabha should show its interest to change the status. Panchayati Raj Institutions like Panchayat Samiti and Gram Sabha can initiate the process and pass a resolution to notify the area as urban and the district administration should send this proposal to urban development department of the state government for approval. Regulation for establishing urban local bodies varies from state to state and sometimes within the state as the demand for such status is usually raised but discouraged by the local people because of the notion that they will have to pay more tax for basic amenities. On the other hand, census towns are administered by Gram Panchayats and Rural Development Department of the State Governments. So if the rural settlements are fulfilling the criteria of urban area, they should be granted the status of census town. However, there is possibility of poor urban basic services, amenities and infrastructure in such towns.

In the North East Bihar there are more than one thousand (1027) rural settlements with population above 5000 accommodating 47.4 per cent of the total population of the region .Out of these settlements 313 have the population above 10000 (potential class IV town) which can act as growth point (market town) and considering the economic base of the region such settlements can be developed as agro-industrial centre. Another 714 settlements with population between 5000-9999 can function as service centre which can serve as innovation diffusion centre and small scale processing and manufacturing industries can be developed.

There are 42 rural settlements with population above 20000 in the North East Bihar which are potential class III (medium) towns and have the capacity to serve as an important link and serve to offset the deficiencies in the number of cities as well as small towns. Surprisingly none of these rural settlements have the population density below 400 persons per sq. km. There are four settlements whose population density is above 2000 persons/sq. km, Bakhtiyarpur with the maximum density followed by Marar, Laualagan and Chausa. There are 12 settlements where the density of population is between 400-1000 persons/sq. km.

If the rural settlements with population above 20000 are considered to be urban cen-

Table 5: Rural Settlements with Population Above 5000

S.No.	Districts	Population size			No. of settlements
		5000-9999	10000-19999	20000 and above	
1.	Araria	129	45	4	178
2.	Kishanganj	57	9	0	66
3.	Purnea	120	35	6	161
4.	Saharsa	74	21	7	102
5.	Madhepura	82	44	7	133
6.	Supaul	86	46	6	138
7.	Katihar	87	30	6	123
8.	Khagaria	79	41	6	126
	North East Bihar	714	271	42	1027

Source: Respective District Census Hand Books 2011, Series 11, Part XII A

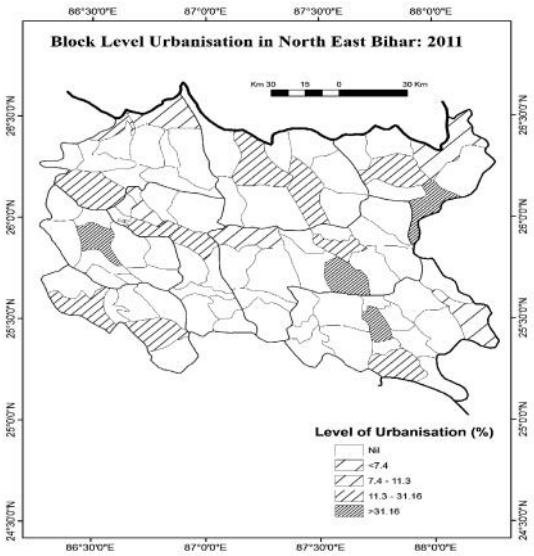

Fig. 1

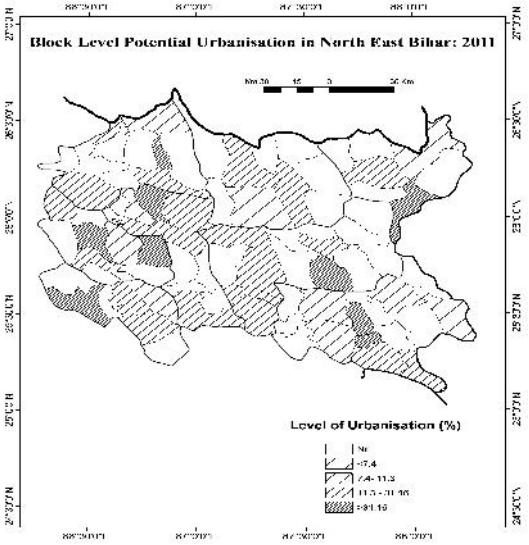

Fig. 2

tres the level of urbanisation of this region is likely to increase to 13.2 per cent (more than the state average), 40 CD blocks will have different levels of urbanisation (Fig. 2) and the average distance covered will come down.

If the level of urbanisation is an index of economic development, then economy of this region can be improved by developing these settlements and creating employment opportunities for the surrounding areas. The story of urbanisation and economic development depicts chicken-egg story where whether

Table 6: Block Level Potential Level of Urbanisation (%)

Level of Urbanisation	CD Blocks	No. Of CD Blocks
Above National Average (31.16%)	Katihar (81.4), Shankarpur (64.8), Purnea(63.4) ,Kahra(62.5), Pratapganj (48), Kishanganj (43.9), Patarghat (39.6), Khagaria(32.8)	8
Between State Average and National Average (11.3-31.16%)	Chausa(30.4), Amdabad(28.9), Forbesganj(28.5), Araria(27), Supaul(23.8), Kumarkhand(23), Madhepura (22.2), Chautham (22.1)Dhamdaha(21.9), Gogri(21.7), Rupauli(20.7), Tribeniganj (20.5), Nirmali(20.5), Alamnagar(18.5), Simri Bakhtiyarpur (18.3), Bhawanipur(17.7), Kasba(16.2), Nauhatta(15.7), Bahadurganj (14.6),Banmankhi(14.3),Manihari(13.9), Murliganj(13.4),	22
Between State Average and Regional Average (7.4-11.3%)	Kadwa(10.7), Saur Bazaar (10.5), Beldaur (10.3), Basantpur(9.9),Barari(9.3), Korha (7.5),	6
Below Regional Average (7.4%)`	Thakurganj(6.3), Raniganj (5.3), Singheshwar(3.9), Barsoi(1.8)	4

Source: Respective District Census Hand Books 2011, Series 11, Part XII A

urbanisation leads to economic development or economic development leads to urbanisation is a million dollar question. But the fact remains that rural settlements with different types of connectivity (physical,economic,digital) is likely to improve the economic condition by providing goods and services to the people of the surrounding areas. While talking about regional development and urban centres Misra et. Al. (1974) have suggested the hierarchy of settlements and formulated the hybrid concept of growth foci/development foci which is likely to perform the dual roles of generating economic growth as well as providing goods and services to the dependent population. In the proposed framework settlements with population between 10000-25000 would be considered as growth points which will be sub regional level innovative and propulsive urban centres linked with other growth points by all weather highways and other lower level service centre by local road network. Such settlements are likely to be agro industrial based on indigenously available resources and the important economic activities will be the production, handling and processing of such resources like agricultural and dairy products. The functions assigned to these settlements will lead to social, economic and cultural integration of the respective micro regions served by them. Each such settlement (growth points) should have police station, extension service centre, branch post office, banks, a permanent market place, warehousing, junior college, government as well as private medical centres handling agricultural inputs especially fertilizers, pesticides, machineries and repair shops capable of repairing tractors, lift pumps, trucks, cars and bikes etc. Bhagat(2011) remarks the recognition of a settlement as a town would have implication not only in terms of provision of urban infrastructure and civic amenities but also for re-

productive and child health services.

Indian policy makers are still following fifty year old demographic criteria of defining Census towns. Urban areas are primarily service providing centres to its hinterland. If a particular rural settlement satisfies all demographic criteria and acquires a census town status by Census of India, the question arises, why does the state government hesitate to give such towns the status of an urban local body? In fact Bihar Municipal Act has a special provision to notify famous tourist sites as statutory towns. Thus, it can be said that the state requires policy intervention for better urban governance.

Conclusion

Conventionally Bihar in general and north East Bihar in particular is least urbanised and there are multitude of factors like physical, social, cultural, economic and political factors responsible for the existing low level of urbanisation. However effect of these factors could be minimised by policy interventions at various levels. The study area has a large number of rural settlements with population above 20000 which can be developed as urban centres and nodes by creating job opportunities as well as making provisions of goods and services which will be utilised by the surrounding areas. Such settlements should be granted the status of urban centres and the level of urbanisation would increase which will create a virtuous circle of regional development.

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Urban Functions, Processes and Social Morphology of Amarkantak Town, Madhya Pradesh

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Abstract

Towns are the places of manifold functions and these functions are mostly related to the economic and social development of urban areas. Amarkantak town is a prominent historio-religious place of Central India which is located on lush green covered Maikal hills. The topographical configuration of Amarkantak is uneven and the town is situated around the origin point of the sacred river Narmada. The temples, ***kunds****, ponds,* ***ashrams****, and commercial shops are the foremost features of Amarkantak. The functions of Amarkantak town are widely influenced by the pilgrimage. The town has its importance as service centre in the peripheral villages and is connected with other, various important places. The process of urbanization and urban sprawl of Amarkantak are largely controlled by the religio-political factors. The segregated occupancy pattern of different ethnic groups in the town clearly shows the rural attribute of the town and its inclination towards the hierarchy based community system and religious aspect. The present study is an attempt to analyse and describe the urban functions, processes and social morphology of the settlement in spatio-cultural context.*

Keywords : *urban functions, processes and social morphology.*

Introduction

The urban areas are recognized as one of the complex and highly dynamic landscape on the earth's surface. The civilization of present era is characterized by rapid growth of urban areas and increase in the proportion of urban population in developed as well as developing nations. Influx of rural population in urban areas is the cause of various urban problems especially in developing nations that attract scholars of different disciplines to overcome these problems and prepare plans for its sustainable development. "The study of cities should invariably be associated with environment com-

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prising the very life of the people living there and also the involved activities performed by them" (Verma, 2008:2).

"The use of urban land and its expansion is largely determined by population growth, socio-economic and technological and historical elements" (Sharma and Mishra, 2011: 1). The study of urban functions, urbanization and urban land use in Geography is associated with the application of quantitative analysis of geographical data. The current spatial techniques such as computer added cartography and GIS became important tools to assist the spatial and quantitative analysis. The study extends to spatial dimension of society and culture like population characteristics, economic activities and organization of social space.

Study area and its nomenclature

Amarkantak town is situated in Pusprajgarh *tehsil* of Anuppur district, Madhya Pradesh. The town is developed close to origin point of holy river Narmada ($22^0$40' N latitude and $81^0$45' E longitude) and the place is at height of 1057 metres above mean sea level. 'Amarkantak' is a Sanskrit word conjoint of two words *amar* and *kantak* where *amar* literal means to "immortal" and kantak literal means "obstruction". In the Hindu mythology, it has been referred as an abode of the God but it was disturbed by the hindrance of *Rudraganas*. The great poet Kalidas had called it as 'Amrakoot' (the ridge covered by mango trees). The town is surrounded by Sal forest and tribal inhabited villages.

Amarkantak is a small town with 8,416 population and the sex ratio is 864 females per thousand male. The lower sex ratio of the town is caused by the influx of male selective population. The sex ratio among the age group 0-6 years is relatively far better (931) than the overall sex ratio. The total literacy of the town is 80% and the work participation rate is 36.6%. Among the total workers (3,081), male workers are more than two times of female workers, *i.e.*, 2,166 male and 915 female. About 84% of total workers are other workers, after big gap, it is followed by agricultural labourers 9.28% and workers in household industry (4.77%) while the lowest proportion comes under cultivation, *i.e.*, 2.20% because the town has grown as service centre and the largest source of livelihood is tertiary sector. The ethnic composition of population shows that the largest proportion of population (43%) belongs to tribal community. Almost half of the population of the town belongs jointly to scheduled tribe and scheduled caste (6.16%).

Objectives

- To study the various urban functions of the town
- To understand undergoing urban processes in shaping of urban functions, and
- To describe social morphology of the town

Data base and methodology

The present study is based on secondary sources of data while the primary work played a vital role in the study of field check of urban functions and its spatial arrangement and helped simultaneously to observe the processes of urbanization and urban sprawl. The discussion with the local people enabled to understand the social and cultural aspects of the settlement. The study of locational importance of urban functions and its spatial connections are clearly marked through the prepared map. The interpretation of geographical data, map and phenomena are based on intensive field study. The

relevant published and unpublished material is consulted and quoted. The preparation of applicable map is based on ward-wise map supplied by *Nagar panchayat* and land use map which is taken from Amarkantak development plan, 2015. The population data is taken from district census handbook and primary census abstracts of different years.

Evolution of the town

The Narmada valley and plateau platform situation provides base for the evolution of the settlement, Amarkantak while its growth is affected by the pilgrimage and its scope is enhanced by the tourism because of scenic beauty of nature and connectivity with other places. "Town's place is the product of culture of people of the region" (Verma, 2008: 55). That is why the origin of towns is related to multifarious reasons such as social, economic, cultural and political. The urban characteristics of the small settlement are primarily the result of non-primary occupation of population. The place Amarkantak and the river Narmada are mentioned in various old texts such as *Puranas, Ramayana, Mahabharata, Vashishtha Samhita* and *Shatpathabrahamana*. Amarkantak was known as *Rikshparvat* (about 6000 years back) in *puranas*. *Suryavanshi Samrat* Mandhata founded a town in the valley of *rikshaparvat* and gave name *purukutsa* and he has also given the name of Narmada to the river. Pandavas stayed here during their exile and got benefited of spirituality. Adishankarcharya (borned in 788 AD) founded the *Pataleshwar Mahadev* temple at the origin point of Narmada and the place is known as Surajkund. The Kalchuri king Karandev (1042-1072 AD) constructed many temples close to this *kund*. Before the British rule, Amarkantak was ruled by the king of Nagpur (1808).

The urban characteristics of the settlement came into being after starting of the bauxite mines by BALCO and HINDALCO in early 1960s and continued up to 2003 in Amarkantak which led to grow urban services like market, bank, postal service and transportation. The economy of the town has suddenly declined with the closing of both of the mines however it regained importance with the establishment of IGN Tribal University, Amarkantak (2008).

Urban functions

Urban areas have multi-fold functions that support the urban life and its efficiency. Urban functions include dwelling units, physical and social facilities and services with its spatial arrangements. The urban functions are grouped in two ways namely basic and non-basic. The basic functions are those functions which generate income to the town through providing the services to the surrounding settlements and the non-basic functions are those functions that fulfill needs of its own population. Geographically, the urban functions of a town are the synonym of uses of urban land into different functions. "The secondary and tertiary urban activities combine to generate the spatial configuration of a city because their requirements are sometimes functionally differentiated and spatially segregated" (Ayeni, 1979). Although urban activities and land use are sometimes spatially segregated, they functionally linked together through human patronage, human activities and time (Adedokun, 2011:409). "The pattern of the city is the way how different functions and elements of the settlement form a distributed and mixed together spatially. It can be mea-

sured by the size of its grain. Grain is fine when similar elements or functions are widely dispersed throughout the district without forming any large clusters. On the other hand, grain is coarse if different elements and functions are segregated from each other in a way that extensive areas of one thing are separated from extensive area of other things" (Lynch, 1981:265). The study focuses on urban functions which are analysed and described with given following sub heads:

Residential areas

The land, on which the dwellings are built, is marked as residential area. It is an important and largest component of urban space. Amarkantak is a small size town because of its population and urban functions and is growing out of rural settlement. The area under residential use is 22.35 ha that is very less (0.33% to the total area of *Nagar panchayat*) while it is 18.13% to the developed land. The whole residential area has a core and many groups of dwellings developed into pockets.

The spatial grouping of residential units of the town is divided into houses of rich *purohits* and businessmen, government employees, less spacious and unhygienic houses of poor peoples. *Ashrams* are the places of temporary accommodation during the pilgrimage periods while a number of saints are regular dwellers in these *ashrams*. The major concentration of residential dwellings takes place around the *kund* that form the core of the town. Besides, Tikri *tola*, Bank *tola*, Jamna dadar, Kapila *sangam*, Naka, Bandha and Barati are the other residential localities of the *Nagar panchayat*.

The spacious and modern architectural styled houses with good facilities and amenities belong to *purohits* of Narmada temple and the locality is known as *pandan mohalla* which is followed by the houses of business class that surround it. Economically weaker section of the society, the tribal and scheduled caste persons live in poor and unhygienic huts/ houses in peripheral localities of the town. The residential quarters of government employees are constructed close to police station, backside Chandrachariya hospital, and in the vicinity of Barfani *ashram*. Jwaleshwar and Baigan *tola* are inhabited by Baiga tribe and located at outskirts of *Nagar panchyat* and attributed by the pure rural characteristics.

Official building

Official set-up is generally developed in a specific area and connected with means of transportation. The administrative area such as capital, district headquarters, *tehsil* or local body governance and administrative function generally develops in moderately settled part or outskirt of the towns/cities. "The location of administrative offices is guided predominantly by accessibility, selection and availability of vast space" (Sharma and Mishra, 2011:13) Three administrative set-ups are established in Amarkantak namely police station, forest office, and *Nagar panchayat*. The police station and forest offices are located in outskirt nearby new bus stop while the office of *Nagar panchayat* is centrally located in the town and close to retail commercial area.

Retail business

'Retail commercial activities are the significant functions in a city to fulfill the basic requirements of the local people and dependents of surrounding region' (Yadava and Prasad, 2014: 34). The central business district of town is under developed and shops are mainly found

in ribbon pattern along the road from Shanti *kuti* to the circumference of the old park. The shops generally belong to kirana, general provision, cosmetics, cloths and readymade garments, photo studio, stationary and electronics along with a few restaurants. The market is centrally located in the built-up area. The single storeyed shops show lack of rush when it serves to the local people and the commuters. The location of the central business area is in the proximity to the old settled part of the town and the Narmada temple. The market got benefitted by the good location along main road and as all the commuters, tourists and pilgrimage pass from the market.

More than hundred business outlets are developed in rectangular shape in north-west of Narmada temple. Majority of shops are related with worship items, idols of God/Goddess, photos and frames, fruits, kirana, and religious literature. The tea stalls and breakfast outlets as well as some general provision shops are also developed in this area. The Narmada temple is only source to attract such business outlets.

The numbers of shops are increased rapidly along the road in the vicinity of Chandracharya hospital and the shops are mainly related to readymade garments, dairy products, home appliances, jewelry and electronics, medicine store and Indane LPG gas agency. The outlets of tea stall, refreshment, *gumati*, dry cleaner, and saloon are found on the other side of the same place. The development of shops in the area is a result of growth of population and urban sprawl and the demand of commuters also. Similar shops are found at Naka and new bus stop which are the result of the requirement of passengers and the inhabitants of the locality.

Leisure-restaurant

The spatio-cultural characteristics of Amarkantak are a combination of natural scenic beauty and the sacred places. Many people of different places especially urban areas come to recreation in all weather seasons. Few people want to enjoy with cloudy weather, some of them enjoy the snow cover on grass along the thinly Narmada valley while many of them come into spring and summer season to enjoy the natural beauty of flowering season and pleasant weather. Boating facility is available in puspkar reservoir of Narmada. The Kapildhara waterfall and sunrise point at Sonemuda are the attracting points of every tourist. Many running streams make small rapids and falls which are also attracting points named as *dharas* like Dudh *dhara*, Shambhu *dhara*, Durga *dhara*, etc. Many private and government guest houses are the places of accommodation and foods. Among them holyday homes, PWD guest house, SECL guest house, forest rest house and *Sarvodaya* lodge are very famous. The restaurants are very limited in numbers and found mainly in the area of retail market but tea stalls and small shops of breakfasts are found at every places of visit.

Education and health

The small place Amarkantak became a hub of education that attracts students from peripheral area with the establishment of four higher secondary schools, primary schools and IGN Tribal University and having hostel facilities. Apart from university, a B.Ed. college and a branch of Makhan Lal Chaturvedi *Patrakarita Vishwavidyalaya* are started at Amarkantak.

The traditional *vaidyas* of Amarkantak are famous in *ayurvedic* treatment and the *jungle* of Mekal range is the source of varieties of

medicinal plants. Many tribal people come to sell herbs in the market. The allopathic health services are very poor due to lack of hospitals in Amarkantak. Only one government primary health centre is there while Chandracharya hospital is almost dysfunctional.

Hotel and accommodation

The accommodation facility in Amarkantak is mostly provided by the *Ashrams* and *dharamsalas* that are related to many sects and religions which are located everywhere in Amarkantak. Many of them are maintained like hotels. The hotels are limited in number and most of them are associated with government departments while privately owned guest houses are functioning parallel to serve tourists.

Public facilities and other services

The land use under public and semi-public domain is 63.24 ha which occupies more than 50% of the developed area. It shows that the town is an important service centre in the surroundings. The major part of this land use falls under the religious uses as *ashrams, dharamshalas* and temples. The other land use is devoted to educational and health institutions, guest houses, burning ghats, etc.

The electric power station, water supply, *sulabh* complex, urinaries, place for periodical market are other public services and utilities. Only 37% households are getting tap water while 46% access through wells and rest got to river and springs. The 81% households of the town do not have lavatory facility. Only 20% households are having open and closet drainage facilities. The above proportion shows that the basic urban services are very poor in the town which are adversely affecting the environment of Amarkantak.

Industrial

The total land use under the industrial function is 2.81 ha which is 2.28% of the developed land. The Training-cum-Production Centre (TCPC) is located in Barati area which is established by the Government of Madhya Pradesh for the promotion of industrial activities and generation of employment. In the vicinity of Barati, there is an open cast mining area of bauxite which was mined by HINDALCO but at present, the mining is stopped. Employees have left the place while some people are still inhabiting the same locality.

Transportation and communication

Urban transportation is the single most important component instrumental in shaping urban development and urban living (Sen and Sanyal, 2013:421). The circulatory system in any settlement reflects its pattern of development in entire landscape. High density of roads shows dense population and further development of the settlement. Low density of road network of Amarkantak shows that the town is less populated. Transportation network of the town covers an area of 20.5 ha which is 16.63% of the developed area. There are two types of roads namely state highway and local municipal roads. The bus terminus is developed at Naka and the roads are radiating to the Jabalpur, Shahdol and the Narmada temple from this point.

The BSNL exchange is installed in Amarkantak to extend the communication services and internet facility. The railway signal tower is constructed close to Sonemuda.

General commercial

The commercial land use of the town is 6.55

ha which is 5.31% to the developed land. The commercial activities are the prominent function in the town as a source of livelihood for urban dwellers. The commercial function is retail in nature. The retail business lies along the streets and roads in the vicinity of Narmada temple. The vicinity of Jain temple is also attracting people for purchasing some consumer items. The restaurants and eateries are different commercial activities in the town. Apart from above business functions, petrol filling station and LPG gas agency are also developed in Amarkantak.

Financial

There is only a single banking branch in Amarkantak, *i.e.*, SBI with functioning ATM.

Generalized land use pattern of the town

"Land use pattern of a city is reflection of anthropogenic transformation of land and dynamicity of the city which is conditioned, controlled and shaped by various phases of histogenetic evolution and are guided by location, topography and accessibility" (Singh, 2010:75). "Land use in a city has a unique structure because of its interactions between spatial configurations and functions. Urban land uses differ with one another not only in their areal coverage but also in their different morphological structures. Its study becomes essential as a part of analysis of different functions" (Sharma and Mishra, 2011, p.11). Human occupancy of the land changes dynamically in space and time. This requires a scientific study of the land use related to their types, incentives and concentrations (Tiwari, Singh and Sharma, 2010, p.17).

The total planning area of Amarkantak is 6,850.41 ha (*Nagar Panchayat* covers an area of 68% of the planning area out of that 34% is purely urban). The 123.29 ha is developed while rest area (6,727.12 ha) is undeveloped and comes under the open and forest, water bodies and cultivation. The land use data clearly show the unequal development of land in the town. Only 1.8% area is developed under various urban functions especially in the vicinity of Narmada *kund*. The major concentration of buildings have been seen at Narmada *Kund* and along the main roads that connect the new bus stand and the further extension is marked along the Kapildhara road and the TCPC road of Barati.

The figure 2 shows the urban land use pattern out of the total developed land. The land under public and semi public function is larger proportion which is more than half of the developed land followed by residential (18.13%), transportation (16.63%), recreational (6.36%), commercial (5.31%) and industrial (2.28%).

Entire urban space of Amarkantak is characterized by temples, *ashrams*, *dharmsalas*, business outlets, residential units and other public services. Thus, the religious factor has played a major role in the development of the town. Another factor of its growth is connectivity with the important towns and cities by roads and the nearby railway station, *i.e.*, Pendra road.

The forest covers an area of 6,582 ha which is 97.84% of the developed area and 96.08 of the total area. The forest land is major proportion within the limit of *Nagar panchayat* and its planning area. These forests are under deterioration due to illegal Lrapid deforestation which accelerates erosion of thin layer of soil. The area under water bodies is 10.08 ha. Water bodies are other important feature of Amraknatak. The area is a source of water that caused the origin of sacred river Narmada and the river Sone. Various *kunds* (small

Table 1: Generalized Land Use Pattern of Amarkantak Town, 2011

Sl. No.	Land Use	Area ha	%age of developed land	% to total
1.	Residential	22.35	18.13	0.33
2.	Commercial	6.55	5.31	0.10
3.	Industrial	2.81	2.28	0.04
4.	Public and Semi- Public, and Public Utilities	63.24	51.29	0.92
5.	Recreational	7.84	6.36	0.11
6.	Transportation	20.50	16.63	0.30
	Total Developed Area	**123.29**	**100.00**	**1.80**
7.	Miscellaneous use	48.43		0.71
8.	Forest Area	6582.00		96.08
9.	Water Bodies	10.08		0.15
10.	Agricultural Area	86.61		1.26
	Total Undeveloped Area	**6727.12**		**98.20**
Grand Total	**6850.41**	-	**100.00**	

Source: Amarkantak Development Plan, 2015

ponds) exits in the area. Besides, major part of the *panchayat* is dried and there is crisis of water. The agricultural land is a very little in terms of total area, *i.e.*, 86.61ha which lies in marginal areas of rural localities.

Urban Processes

The urban processes are those which caused structural change in urban land use and functions. The term 'process' generally refers to the sequence of change in space and time and the logical sequence of change lead to a recognisable result on the actual ground that is the consequence of both spatial and temporal processes. "An understanding of urban development processes is crucial in urban development planning and sustainable growth and man-

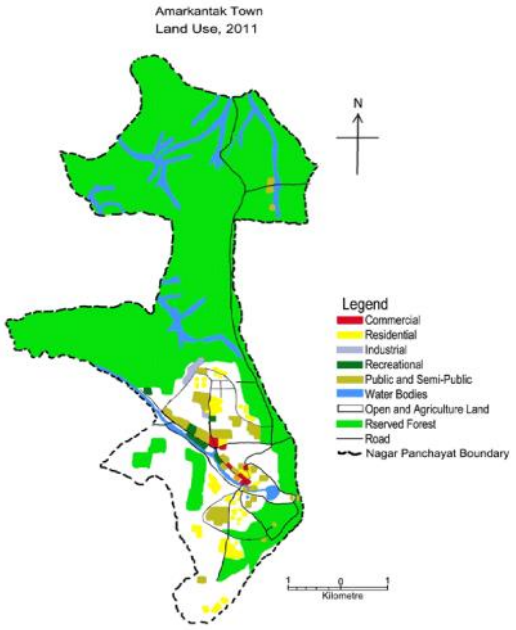

Fig. 1

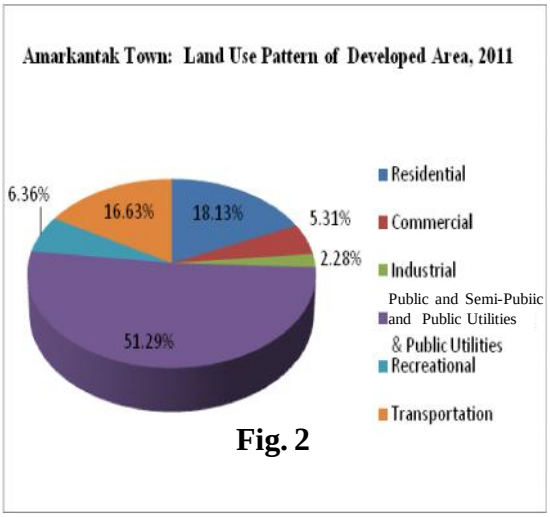

Fig. 2

agement" (Cheng, 2004: 167). Two chief urban processes namely urbanization and sprawl are discussed in the study.

Urbanization

Urbanisation is a term that refers to the clustering of population in increasingly large, dense and diverse, cities over time (Jonas et al. 2015: 11). The process of urbanisation seems to be associated with economic growth and the sectoral composition of the economy (Langeweg et al 2000: 22). The population of Amarkantak has rapidly grown 8 times in five decades from 1961 to 2011 (table 2). The trend of urbanization in Amrakantak shows increase in the size of urban population with high fluctuation. The urbanization of Amraknatak is mainly related with mining activities, education centre and people also want to live in Amarkantak to get spiritual and climatic benefits. The patches of Amarkantak are going to fill with the growth of population and urban functions. In this context, urbanization played a vital role in the changing land use pattern of the town. "The increase in the population has multiple effects on the land uses under residences as well as other uses" (Kaushik and Kaur, 2009: 35).

Urban sprawl

Sprawl is generally defined as the increased development of land in suburban and rural areas outside of their respective urban centres (Bala, 2013: 164). The typical urban sprawl is originated in Amarkantak that is associated with modern development on the one hand and on the other the construction of *Ashrams* and trusts with basic facilities and amenities in scattered mode. Both the things are affecting the development of the town in different ways and represent current and traditional culture. The sprawl of current constructions is generally taking place along the main road that joins to new bus stand from the *pandan mohalla* and the Barati area. The important thing of urbanization is the overall development marked within the limits of the local body and it is found in small pockets. The hilly location and government policies, especially forest laws are responsible for slow growth of the town as declared holy place and come in area of Achankamar biosphere reserve.

Centralization and decentralization

The maximum economic activities are encircled with the nuclei in the vicinity of Narmada temple. The residential units and business activities in the area are woven with each other due to priesthood of Brahmin community and close association with business community for mutual benefits. The magnet of the core is holy temple of Narmada that attracts people to reside here. The newly development of urban activities and residential units are taking place in outskirts along the roads radiating in different directions due to lack of space and the legally banned the new construction in the central area.

Table 2 : Growth of Population in Amarkantak town, 1961-2011

Sl. No.	Census Year	Population (figures)	Change in population figures	Decadal growth rate (%)
1.	1961	1,095	-	-
2.	1971	2,465	1,370	125
3.	1981	4,465	2,000	81
4.	1991	4,936	471	11
5.	2001	7,082	2,146	43
6.	2011	8,416	1,334	19

Source: District Census handbooks, 1961, 1971, 1981; and Primary Census Abstract, 1991, 2001 and 2011.

Social morphology

The term social morphology is used by the sociologist as the study of form and structure of society while the social geographers studied social morphology as spatial and environmental dimension of societies. It includes environmental basis of social organization and size, density and distribution of population. "The morphology or forms of the towns in India reflect faithfully ethnic and social distinctions. The social areas of third world cities are basically characterized by the degree of modernization, and consequently, there is visible in the urban landscape patches of both 'traditional' and 'modern' areas" (Verma, 2008: 132).

The occupancy pattern of social/ ethnic groups in Amarkantak is characterized by rural attributes of the settlement. The present Amarkantak is a settlement of settlements as group of many settlements of both rural and urban nature which are segregated by the hierarchical caste system and tribal localities. These tribal localities have evolved as hamlets around the main settlement. Some of them are emerged with the spatial expansion of the core settlements like tikari *tola* and bank *tola*. They came into closer contact with the connectivity and spatial spread of the settlements as growth of population and enhancement of urban activities. The core is highly compact and the other pockets are semi-compact and scattered. The nucleus of Amarkantak is inhabited by the *brahmin* society and followed by business community while the tribal people and scheduled caste people live in periphery either close to this core or grouped in the other residential pockets. The Barati area is showing mix culture of various ethnic groups. The core residential area is characterized by *pucca* double storeyed buildings and metalled roads. The buildings are constructed spacious with 4-5 rooms and having courtyards for sunshine and other socio-cultural activities. Availability of

modern facilities and amenities in the houses reflects prosperity itself. The houses of business class are also having similar characteristics. The residential areas of Tikari *tola*, Bank *tola*, Jamna dadar, Kapila *sangam*, Bandha are inhabited by economically and socially deprived tribal and scheduled caste people. The conditions of the dwellings and streets are worst and they are identified as slum. The houses are filthy and suffering from lack of space which are constructed by mud walls and thatched by tiles and grass as. The areas are far from reach of urban facilities and amenities except electricity.

Tikari *tola* is located at the margin of the core settlement and people of *pardhan*, *chaudhari*, washer man and cleaning communities are settled in the *mohalla* as to provide services to the Brahmin and business communities. It is according to the principle of social geography in hierarchical caste-based system of India. Jamuna dadar is basically inhabited by the tribal people namely Panikas, Gonds, as well as cattle rearer community, *i.e.*, Ahirs while the bank tola is inhabited by Kairwar and Gond tribes. The Kapila Sangam is having separate identity and located at the joining point of Kapila river to Narmada. Panika, Gond and Baiga people are dwelling in this locality while Bandha is basically inhabited by Manjhi, Gond and Panika communities. The Gumma ghatia is a far away settlement which is inhabited by Ahirs because vast land is available for cattle grazing. Patel, Panika and Gond communities are settled in the area of Krida Parisar while Hindalco mining area inhabited by Kol tribe. The less advantageous places are generally occupied by weaker section of society. In contrast, rich people occupied economically beneficial central place of the town.

Concluding remarks

The area of Amarkantak *Nagar panchayat* is larger than actual town and spread over vast terrain of forested and cultivated land. Amarkantak is a combination of many settlements in which core is main settlement at the same time as rest villages are having separate identity and developed in pockets at considerable distance. Some of them are having forested and cultivated land that are associated with tribal habitats. Tribal people erected their huts in either scattered mode or in groups in such localities. The core of the town is constituted of residential houses of *purohits*, business class people, main retail market and the Narmada temple group.

The evolution and development of the town is affected by its topography, climate, the Narmada valley, pilgrimage and connectivity with other places. Roughly 1/3 southern part of *Nagar Panchayat* is actually built-up area that constituted main settlement. Thus, the concentration of buildings and development of road network are commonly seen in the constructed area and the business activities predominate in this area while other parts have small rural localities with the predominance of primary economic activities as rearing of milch cattle and cultivation. A few tribal families of these localities still depend on minor forest produces. The land under public and semi-public function of the town covers a relatively better proportion of land in the context of the town while the proportion of residential land use is marked be-

low the scenario of Indian cities. The land use under transportation is relatively better with its proportion whereas its many parts are still having unmetalled road.

The water bodies are significant phenomena of the town that cause the cultural importance of the place. The entire area is naturally beautiful and attractive but recreational facilities are not properly developed by the local body governance. The growth of the town is observed along the main roads which lies towards northwest and southeast. All the new constructions and development are taking place along this road. The Barati area is a fast growing locality with the construction of residential houses. The social space and functional integration of the town still have attributes like villages of India.

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Begusarai Municipal Corporation : A study on population characteristics

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Abstract

Population characteristics include study of population density, growth rate and social compositions, and worker status. The study has been done to analyse reasons and effects of spatial and temporal distribution of population; the spatial aspects of social composition, i.e. sex ratio, literacy rate and worker's classification that were portrayed for 2011 census. The secondary sources of data of two census years 2001 and 2011 are collected to portray different population characteristics at ward level. Sex ratio is considered as an important parameter for determining the growth of population, social condition of the society, quality of life etc. Spearman's rank difference method has been used to find the coefficients of correlation between literacy and sex ratio, and literacy and working population of the city. Certain relevant and pragmatic conclusions are derived from the discussion.

Kywords : *population growth, density, social composition, sex ratio, literacy, working population, spearman's rank co-relation coefficient.*

Introduction

From the beginning, society has preferably been settled at places where natural resources were easily accessible. But, in the modern globalized world, due to swift transport facilities, advanced communication and development of service sector, the pattern of settlement of urban and rural has been changed drastically. From social scientists to geographers, all have studied different aspects of population to cope with emerging issues and challenges in both rural as well as urban society.

India is the fastest growing economy having the world's 2nd largest population. Alongwith the population pressure on the land, unplanned settlements, increasing environmental pollution, decreasing agricultural lands, growth

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of slums, urban floods are the emerging problems in our country that are appealing for a consideration of sustainable development. Therefore, to avoid the day of reckoning, we need planned developmental projects. Several factors such as population growth rate, population density, sex ratio, literacy rate, pattern of migration etc. are required to be analysed to study salient features of population of an urban settlement. A comparative study of various population indices of different census years gives vital information. Betterment of health facilities has led to increased birth rate and decreased death rates, resulting in longer life expectancy. Restrained family planning and proper education are causing burgeoning population in India. Areas having higher literacy rates have higher sex ratio. Thus, literacy is likely to prove positive bearing on the sex ratio. Migration pattern also affects population density and sex ratio of an area. Commonly central business district (CBD) has high literacy rate as well as high population density. But, due to cheaper land prices settlement of population in outskirts of the city is causing a boom in the population growth of urban areas. Begusarai Municipal Corporation (BMC) shows such trend of settlement in the city. In the nutshell, all the aspects of population are correlated to one another in one or the other way.

Study Area

Begusarai city of the state Bihar is located from $25^0$22'51" to $25^0$26'35" north latitudes and $86^0$06'19" to $86^0$09'11" east longitudes with an average elevation of 48 m above mean sea level. It is situated in middle Ganga plain with its general slope south and south-easterly. The city had played a significant role in Indian history from very ancient time. The name 'Begusarai' is said to be derived from either Muhammad Begu, who looked after the sarai situated in this region or after the Begumsarai. Buddhist literature describes this region as Anguttarapa (ang-uttar-apa), i.e. the waters to the north of Anga. Various archaeological sites show the importance of the region during Buddhist period. The Birpur excavation conducted by AIH and Archaeology Department of G.D. college Begusarai, with permission of Archaeological Survey of India unveils the History from the remains Shunga-Kushana period. Begusarai was also a centre of economic and administrative activities during the Gupta period. Begusarai is bordered by Naokothi in the north, Dandari and Balia in the east, river Ganga and Matihani in the south, Barauni and Birpur in the west. Begusarai is having its municipal corporation and acts as administrative headquarter of Begusarai district. It lies in north central Bihar, 125 km away from the state capital Patna. It assumed the district status on 2nd October 1972, prior to that it was a sub-division of Munger district. The geographical area of Municipal Corporation is 48 sq. km, that is divided into 45 wards and a population of 2.5 lakhs (2011). There are 45 wards in the municipal corporation with an average density of 5,040 persons per sq km.

Objectives

The objectives of the study are as follows:-

* To analyse the population characteristics of the city.
* To explain the co-relation between literacy rate and sex ratio, and working population and its consequences.

Data base and methodology

Secondary sources of data are used in the

study collected from Begusarai *Nagar Nigam*. The data of social composition of working and non-working population are collected from the district census handbook. A base map showing wards of the town is prepared, which is further digitized on GIS platforms. Population density, growth rate, sex-ratio, literacy rate, social composition and working population maps are prepared with the help of base map and census data. All the variables considered for the study are classed into four categories. Spearman's Rank difference method is used to find the co-relation between literacy rate with sex ratio and working population. The formula is as below:-

$$r = 1 - \frac{6\sum d^2}{n^3 - n}$$

{Where n is the number of samples}

It has been done by giving a suitable rank to the variables and further calculating correlation by using the formula as elucidated in the study. Level of significance chart is used to test the hypothesis. Tables and charts are prepared with the help of Excel data worksheet.

Population Characteristics

1. Population growth

According to 2011 census, the city had population of 2.5 lakhs out of which 1.3 lakhs were males and about 1.2 lakhs were females. The city had 88% general and other backward caste, 12% SC population and insignificant tribal population. Child (0-6 years) population constituted 16% of urban population in which 53% were male and 47% females. The urban population in the year 2001 was 2.15 lakhs, which noted a 16% rate of growth of total population. From the year 2001 to 2011 the urban population has increased to nearly 36,000. Ward no. 28 (Lohiya *Nagar*) has shown the highest population growth rate. This region is situated at the side of railway track and has large number of slum population. This region mostly comprised of rag pickers, beggars, rickshaw pullers etc. Ward no. 45 which is situated in outskirt of the municipal corporation away from the CBD, has shown highest population growth rate. Besides, cheaper land price, good infrastructures and better health facilities acted as a pull factor for the rural population to buy land and settle down in this ward. Apart from this type of migration to the outskirts, young population of the CBD also tend to migrate to other states for pursuing higher education and employment because literacy rate and awareness for education is high in these areas. This is the region for negative growth rate in ward no. 9, 11, 14, 16, 25, 27, 30, 33, and 41. Ward no. 8 and 26 hasvel also shown high growth rate because of newly emerged colonies and low prices of land. Other wards have moderate population growth rate.

There is continuous increase in the population since 1961. There was a high growth rate during 1961-81, that is due to assumption of Begusarai settlement from rural to urban one. Prior 1972, Begusarai was a subdivision of Munger district which gained the status of district in 1972 and thus Begusarai city became the administrative headquarter of the district. Therefore, the decadal growth rate of 1971-81 is highest. After that the decadal growth rate is gradually but constantly decreasing due to increase in education, and adherence to family planning norms. The growth rate of the decade 2001-2011 was 16.79%.

2. Population density

The average density of Begusarai city is

5,040 persons per sq.km. The central part of the city is densely populated whereas the outer and outskirts have low density. There are nine wards namely 42, 32, 34, 23, 24, 30, 31, 36 and 37 which have high density of population (more than 15,000 persons per km^2). The highest population density was recorded in ward no. 42. The high density wards confirm to their proximity with CBD and emerging market complexes. Moderate density (8000 to 15000 persons per km^2) is found in wards, *i.e.* 22, 33, 35, 13, 28, and 29, which existed in proximity to high density wards.

Twenty two wards of the corporation have moderately low population density (3000 to 8000 persons per km^2). Sixteen wards are spread in south eastern part of Municipal Corporation while two are located in west, two in north- west and two in northern margin of the corporation. New migrants are attracted to these areas due to cheap availability of land. Besides, households in rented quarters are in process of settling over there. There are seven wards which have very low population density (below 3000 persons per km^2) most of which are confined to western part of the municipal corporation. The wards are occasionally intercepted by moderately low density. This phenomenon may be due to its relatively more vulnerability to flood as well as their outskirt location. Outer wards are late entrant to the municipal corporation.

3. Social composition

From the very beginning social discrimination, atrocities and injustice are prevailing against the weaker sections which have hampered the unity and integrity of the city. SC/ST are the most marginalized people. They have never achieved equality in true sense. They are matted with variety of prejudice against them. Not only these classes are poorer in comparison to other classes but also suffer from high morbidity and mortality rates. The sufferings of these classes can be remedied by free and compulsory education, quality education, and change of mind set of people in society. Schemes and funds should be framed to meet exclusively for their welfare and employment.

Fig.3 shows the proportion of distribution of general and other backward class combined and SC population in the year 2011. Total general population in the city is 220,673 which included 117,226 males and 103,834 females. On the other hand total SC population is 31,057 which include (16,557 males and 14,500 females) and ST population is 279 including 141 males and 138 females. As such there is a predominance of general class and other backward class population in the city that constituted 88% of the total population with low SC population (12 percent) and ST population (0.1%). Begusarai has very few number of tribal populations as the development of this district from the beginning has never been favourable for the tribes to flourish. Tribes are food gathers, hunters, foreland cultivators, and minor forest product collectors. They lived in isolation with near to nature. Since the geographical condition of Begusarai region is good for agriculture and industries, the region has witnessed development of villages and towns from Pala period to the present day, making it favourable for settlement of population rather than tribal civilization.

4. Sex ratio

According to census 2011, Begusarai city

as a whole had 885 females per thousand males which was very low in comparison to sex ratio of urban India (926). The sex-ratio ranges from 661 to 987 in the city. Ward no. 33 recorded highest sex ratio whereas ward no. 38 recorded least. All the forty five wards are categorized into four categories to portray pattern of sex ratio. High sex ratio more than that of urban India (926) was recorded in five wards *i.e.* ward no. 8, 14, 20, 33, and 36. Wards which are in close proximity with the CBD have better urban amenities and infrastructural facilities, and have high sex ratio. This area is economically strong and has very high literacy level as well. There are seven wards, *i.e.* 9, 15, 21, 22, 30, 32 and 37 which have moderate sex ratio (900 to 925). These wards having moderate sex ratio are mainly located in the central part, intercepted by high as well as moderately low sex ratio. Moderately low sex ratio ranges between 875 and 900. There are twenty one wards, *i.e.* 1, 2, 3, 5, 10, 12, 13, 17, 23, 26, 28, 29, 31, 34, 35, 39, 41, 42, 40, 44 and 45. Highest number of wards of the municipal corporation falls under this category. Very low sex ratio (below 880) have eleven wards, *i.e.* 6, 7, 11, 16, 18, 19, 24, 25, 27, 38 and 43 while two wards of this category are located in the east, two in the south-east, four in the west, three in the north and one in the north-eastern margin of the corporation. Areas of this category are occurring in outskirts with poor infrastructure, low literacy rate and economically weaker section of the society that find it difficult to maintain their family requirements in the city.

Negative trend of child sex ratio has been seen in Begusarai city. According to 2011 census child sex ratio is 893. It has decreased by 29 from the census 2001 to 2011. This is due to sex determination of child in the womb and female foeticide. The lust for male child is one of the main reasons behind this phenomenon. The death rate of girl child below 6 years is also high due to relative negligence and ignorance in timely availing of health care facilities. Migration of female after marriage to their in-law's house is a common practice. This is also an important reason for low sex ratio. Recently crimes against women have increased at the fast rate. According to national crime bureau, in 2015 Bihar itself contributes to 4.2% of total crimes in India. Besides, there are much more crimes which go unreported. Rape, dowry death, abetment to suicide etc. are some of the main reasons for death of females. High rate of death of women during pregnancy and at the time of delivery is due to lack of awareness regarding proper sanitation and significance of availing on time health facilities.

However, the overall sex ratio has increased by nine from the year 2001 to 2011. This is due to migration of male population to other states for pursuing better education and better jobs. During the recent pace of time guardians are much aware regarding secure future of their childen and sending them for quality education in better institutions. There is a common practice of sending male child to other cities or other states while admitting female child in local school or college. This is also one of the main reasons for increase in overall sex ratio. The increased literacy rate and education has changed the mind set of

commoners against female foeticides and infanticides.

5. Literacy

The average literacy rate of Begusarai city is 76% out of which 82% literates are male and 70% are female. Thus, about 1.6 lakh people are literate including 92 thousand males and 70 thousand females. From the year 2001 to 2011 male literacy rate has decreased by 2% while female literacy rate has increased by 2 percent. The wards which are having literacy rate more than the literacy of urban India, *i.e.* 85% are included in high literacy category. There are ten wards which have high literacy rate, *i.e.* ward no. 9, 14, 15, 16, 20, 23, 28, 33, 35, 35 and 41. Ward no. 9 has recorded the highest literacy rate, 97%. Wards which are in proximity with the CBD, have better educational and other institutions are having high literacy as population in these area is economically well-off and more aware. Moderate literacy wards have literacy rate in between 75% to 85%. There are twenty one wards, *i.e.* ward no. 8, 11, 12, 13, 13, 17, 18, 21, 22, 24, 25, 30, 31, 32, 34, 36, 37, 38, 39, 40, 42, and 43. Wards of this category occupy the central and near central part of the city. Moderately low literacy rate ranges in between 65%-75%. There are eight such wards, *i.e.* 1, 2, 3, 7, 10, 26, 29 and 45. Ward with slums and in proximity with the rural areas, with low literacy rate and high population of labourers and small scale workers, has moderately low sex ratio. Very low literacy rate wards have poor performance of literacy rate (below 65%). There are six wards which have very poor literacy rate named 4, 5, 6, 19, 27, 44 and 5 that recorded the least literacy of 45% which is even lower than the literacy of rural India. These wards are located in the outskirts of the city.

6. Workers and non-workers

Working population consisted of workers who get indulged in any economic activity and earn money for their livelihood. In India, persons above the age of 15 years and below the age of 64 years are considered as working forces. According to Karl Marx, working population creates society's wealth because they do all the hard works without owning any means of production. This population group is very important for a developing country. Indian census has classified the whole population is three broad categories, *i.e.* main, marginal and non-workers. Main workers are the persons who are engaged in any economic activity, for more than 183 days whereas, marginal workers are those who don't work for at least 183 days and non-working population is the population which does not involve in any economic activity. According to census 2011, 28.7% of total population of Begusarai is classed as working population. This includes both main and marginal workers. This constitutes 72 thousand population including both male and female. Total male workers constituted 44.2% and female workers 11.1% of its respective population. Main workers are 20.6% and marginal workers are 8.1% of total working population..

All the forty five wards are grouped into

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three categories of working population, *i.e.* high, moderate and low working population. High working population (30% and above) wards are 21, 27, 45, 06, 36, 44, 8, 18, 17, 10, 37, 20 and 23. Highest working population, *i.e.* 35.9% is found in ward no. 21. Wards having high working population are situated in the outskirts of the city where agricultural and industrial workers got settled down from the rural areas. Moderate working population (26-30%) included twenty two wards of the city, *i.e.* 26, 9, 3, 22, 19, 4, 42, 25, 38, 15, 16, 39, 5, 24, 28, 11, 31, 33, 12, 1, 13 and 41. Low working population (below 26%) wards are 32, 30, 34, 14, 7, 29, 43, 35 and 2. Ward no. 2 recorded least working population, *i.e.* 21.8%. Wards in proximity with the CBD have high literacy rate, so the proportion of working population is slightly low in comparison with the outskirts.

Spearman's rank difference method is used to find out the correlation between literacy and sex ratio. It is observed that positive and moderate correlation. r=0.55 at 0.01 level of significance (single tailed). Since the value of r is>r_critical ,(r_critical = 0.35).So, the hypothesis must be rejected. Therefore, we can say that literacy increases the sex ratio. Literacy has positive bearings on sex-ratio in two major ways.

- Incidences of female foeticide and infanticide are less prevalent among the educated people resulting high birth rate of girl child.
- Migration for the purpose of education and employment is predominant among males resulting in temporary increase in number of females per thousand male.

Literacy, especially higher education reduces the proclivity of son, hence it reduces female foeticides. Therefore, it increases the sex ratio. High literacy rate is found in ward no. 9, 14, 20, 28 and 16 whereas least literacy rate is found in ward no. 5, 19, 27 and 4 etc. It has been found that the wards having least literacy rate have low sex ratio. And the wards having high literacy rate have high sex ratio. This means literacy significantly affects the number of women in the city.

Correlation between literacy and working population

Spearman's rank difference method is used to find the co-relation between literacy rate and working population. It is observed that there is a negative and very weak co-relation between Literacy and Working population. r= -0.18 at 0.05 level of significance. Since the value of r is<r_critical (r_critical = 0.25) so, the hypothesis must be accepted. Therefore, we can say that literacy reduces the proportion of working population.

People in the age group of 15-64 years are taken into consideration for calculation of working population, irrespective of their literacy, gender or nature of job. Illiterate people are contented to occupation based on physical labour whereas; literate and more specifically educated persons had wide opportunity to choose from. This is why illiterate people gets indulged as physical labourers in agricultural or other sectors at a very young age, and work up to old age till they are physically fit. On the other hand, literate people spend considerable time in gaining education and seeking proper job and occupation. Generally, they

Table : 1 Co-relation between literacy and sex-ratio

Number of Ward	Literacy rate	$Rank_1$	Sex ratio	$Rank_2$	Difference (D)	D2
0 1	69	33.00	898	14.00	19.00	361.00
02	67	35.50	888	23.50	12.00	141.00
03	65	37.50	879	29.50	8.00	64.00
0 4	60	40.50	855	40.00	0.50	0.25
0 5	45	44.00	880	28.00	16.00	256.00
06	58	42.00	856	39.00	3.00	9.00
0 7	67	35.5.0	858	38.00	-2.50	6.25
0 8	80	19.00	938	6.00	13.00	169.00
09	97	1.00	916	8.50	-7.50	56.25
10	68	34.00	892	19.50	14.50	210.25
11	79	22.50	815	43.00	-20.50	420.25
12	80	19.00	886	24.00	-5.00	25.00
13	80	19.00	877	32.00	-13.00	169.00
14	96	2.00	954	4.00	-2.00	4.00
15	87	8.50	922	7.00	-1.50	2.25
16	89	5.00	859	2.50	2.50	6.25
17	71	31.50	889	21.50	10.00	100.00
18	79	22.50	861	37.00	-14.50	210.25
19	55	43.00	874	34.00	9.00	81.00
20	91	3.00	959	2.50	0.50	0.25
21	83	16.50	916	8.50	8.00	64.00
22	77	26.00	903	12.00	14.00	196.00
23	88	6.50	893	18.00	-11.50	132.25
24	78	25.00	87	41.00	-16.00	256.00
25	76	27.50	839	42.00	-14.50	210.25
26	73	30.00	888	23.50	6.50	42.25
27	60	40.50	869	35.00	5.50	30.25
28	90	4.00	881	27.00	-23.00	523.00
29	71	31.50	897	15.00	16.50	272.25
30	84	13.00	905	11.00	2.00	4.00
31	76	27.50	879	29.50	-2.00	4.00
32	83	16.50	900	13.00	3.50	12.25
33	88	6.50	987	1.00	5.50	30.25

34	84	13.00	878	31.00	-18.00	324.00
35	86	10.00	876	33.00	-23.00	529.00
36	79	22.50	941	5.00	17.50	306.25
37	84	13.00	910	10.00	3.00	9.00
38	79	22.50	661	44.00	-21.50	462.25
39	84	13.00	884	25.00	-12.00	144.00
40	84	13.00	889	21.50	-8.50	72.25
41	87	8.50	892	19.50	-11.00	121.00
42	76	27.50	895	16.00	11.50	132.25
43	76	27.50	865	36.00	-8.50	72.25
44	61	39.00	894	17.00	22.00	484.00
45	65	37.50	883	26.00	11.50	132.25

Source: Census of India 2011 and personal calculation

also get retired around the age of 60 years. Thus, it is proved in the certitude that literate persons works for a shorter period in their lifespan, in comparison to illiterate population resulting in negative co-relation between literacy and working population as has been emanated in the study. Ward no. 21, 27, 45, 6, 36 and 44 have high working population. Besides, these wards have very low literacy rate. Average literacy rate of the above mentioned wards is 67% which is less than the average literacy of urban India, *i.e.* 85%. Thus, we can say that literacy and working population are negatively co-related.

Conclusion

For sustainable development of the country there is a need to check the burgeoning population. This is why study of population characteristics has become inevitable. Despite being the second capital and industrial capital, there is low level of literacy and low sex ratio in Begusarai and low proportion of working population. This is due to the temperament of people for not allowing their wife's and daughter to work, the willingness to pay high dowry which places a huge burden on raising a daughter. Education is lower among women than in men. The discrimination against girls is predominance in lower middle class of the society. Discrimination against lower castes is also prevailing in the society. But in recent span of time the people are changing their mind set and getting more aware. So, we can say in due course of time the city will have good and healthy environment for all. The extension of the city is increasing towards outer boundaries of the municipal corporation. This is due to infrastructural development in these areas. People used to build houses on agricultural land. The problem of construction of residential and industrial buildings on agricultural lands can be resolved by planned development and building residential apartments in the city. Several developmental and planning projects are in progress in the city, giving a ray of hope for the sustainable development of the Begusarai municipal corporation.

Table 2: Correlation between literacy and working population

Number of wards	Literacy rate	$Rank_1$	Working Population	$Rank_2$	Difference (D)	D^2
01	69	33.00	26.70	33.50	0.50	0.25
02	67	35.50	21.80	45.00	-9.50	90.25
03	65	37.50	29.10	16.00	21.50	462.25
04	60	40.50	28.50	20.00	20.50	420.25
05	45	44.00	27.50	27.50	16.50	272.25
06	58	42.00	34.40	4.00	38.00	1444.00
07	67	35.50	25.30	41.00	-5.50	30.25
08	80	19.00	31.50	7.00	12.00	144.00
09	97	1.00	29.30	15.00	-14.00	196.00
10	68	34.00	31.00	9.50	24.50	600.25
11	79	22.50	27.30	30.00	-7.50	56.25
12	80	19.00	26.70	33.50	-14.50	210.25
13	80	19.00	26.30	35.50	-16.50	272.25
14	96	2.00	25.50	40.00	-38.00	1444.00
15	87	8.50	27.90	24.00	-15.50	240.25
16	89	5.00	27.80	25.00	-20.00	400.00
17	71	31.50	31.00	9.50	22.00	484.00
18	79	22.50	31.10	8.00	14.50	210.25
19	55	43.00	28.70	18.50	24.50	600.25
20	91	3.00	30.30	12.50	-9.50	90.25
21	83	16.50	35.90	1.00	15.50	240.25
22	77	26.00	29.00	17.00	9.00	81.00
23	88	6.50	30.30	12.50	-6.00	36.00
24	78	25.00	27.50	27.50	-2.50	6.25
25	76	27.50	28.20	22.00	5.50	30.25
26	73	30.00	29.60	14.00	16.00	256.00
27	60	40.50	35.80	2.00	38.50	1482.25
28	90	4.00	27.40	29.00	-25.00	625.00
29	71	31.50	25.20	42.00	-10.50	110.25
30	84	13.00	25.60	38.50	-25.50	650.25
31	76	27.50	27.10	31.00	-3.50	12.25
32	83	16.50	25.90	37.00	-20.50	420.25
33	88	6.50	26.80	32.00	-25.50	650.25

34	84	13.00	25.60	38.50	-25.50	650.25
35	86	10.00	22.40	44.00	34.00	1156.00
36	79	22.50	33.70	5.00	17.50	306.25
37	84	13.00	30.90	11.00	2.00	4.00
38	79	22.50	28.00	23.00	-0.50	0.25
39	84	13.00	27.70	26.00	-13.00	169.00
40	84	13.00	28.70	18.00	-5.00	25.00
41	87	8.50	26.30	35.50	-27.00	729.00
42	76	27.50	28.40	21.00	6.50	42.25
43	76	27.50	24.30	43.00	-15.50	240.25
44	61	39.00	33.10	6.00	33.00	1089.00
45	65	37.50	34.50	3.00	34.50	1190.25

Source: - Census of India, 2011 and personal calculation

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Occupational Variation in Durgapur City, West Bengal

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Abstract

The occupational structure of the country implies involvement of its population in economic activities of various sectors. These are divided into a) Primary activity (agriculture, fishing, mining, quarrying), b) Secondary activity (household and manufacturing) and c) Tertiary activity (transport, trade, and other services).This paper presents the changing pattern of occupational structure in Durgapur city (West Bengal) from 1981 to 2011.The development of Durgapur city was itself a part of regional resource development plan, that comes with big bang of a new era of industrialization after independence. Since primary activity has been the base of economy for a long time along with development of secondary activities but, in recent times, it is shifting towards tertiary activities. There were 26.37% main worker, 0.33% marginal worker, and 73% non-worker in 1981 whereas in 2011 main worker reached to 26.92% and with 8% light increase in marginal worker reached to 8.21% and with decrease non-worker reached to 64.87%. There was change in percentage of occupational types during 1981 to 2011. There were 0.34% cultivator, 1.01% agricultural labour, 0.50% household and manufacturing workers and 24.79% workers in other services in 1981 which were recorded in 2011 as 0.39% cultivator, 0.82% agricultural labour, 0.80% household and manufacturing workers and 32.47% workers in other services. The analysis draws our attention towards change in occupational structure oriented to tertiary activities which is not a good sign for future development because primary and secondary activities are the base of economy and tertiary activity is only the supportive one.

Keywords : *occupational structure, industrialization, economic activities, shifting occupation.*

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Introduction

Total population of a country may be subdivided into economically active and economically inactive population. Economically active is sometime spoken as labor force or working population. It is defined as not only those men and women who are actually engaged in productive employment but also those who may be temporally unemployed (Trewartha, 1969). There are three categories under occupational structure Primary sector (Agriculture, fishing, quarrying etc of which production is based on nature directly), Secondary sector (manufacturing) and Tertiary sector (that provide services to primary and secondary activities).

The development of Durgapur city was a part of regional resource development plan at the dawn of a new era of industrialization after independence. In this way primary activities the base of economy like mining, quarrying, agriculture etc were transformed into secondary activities to develop small and large scale industries. Tertiary activities also (like, bank, school, college, mall, multi-complex, park, restaurant, hospital, administrative building, and shop etc.) were also developed to support other sectors of economy. Thus, there had been a gradual change in employment pattern of Durgapur. The share of primary and secondary activity's employment to total employment registered a slight fall during 1981 to 2011 but not in tertiary sector employment.

The diversity in occupational structure influenced precisely infrastructural, social, cultural and economic developments of the city. All types of activities are necessary to maintain a sustainable life in nature as primary activities produce resources, secondary activities manufacture them and finally, the tertiary activities access and distribute goods to people. And also more diversity in occupation is needed to bear the population pressure; national and global development. The occupation of an individual refers to his trade, profession, type of work etc. The study of occupational composition of population remains incomplete without understanding the economic prosperity and natural support of the area. Diversification in occupation is based on the above factors. World's agriculture remained as subsistence for a long time but changes came after green revolution in only agro production, therefore not much diversification experienced in this occupation. The diversification process gets further impetus from industrialization because it generates a number of varieties of work. Advancement in science and technology introduced an element of specialization in the occupational composition by creating highly specialized works. These entire developments brought a new urban culture supported with a very luxuriant life style. Occupational status of an individual is divided into two class workers and not workers. Workers are classified main workers and marginal workers. In 1971, Indian census classified the occupational structure in nine categories.- cultivation, agricultural labor, livestock, forestry, fishing, hunting, plantation, orchard, and allied industries, mining and quarrying, manufacturing, processing, servicing and repairs, construction, trade and commerce, transport and storage, other service.

Since 1981, these have been a change in the scheme of categorization and the workers were categorized into four main categories: cultivators, agricultural labor, household and manufacturing and other works. The occupa-

tional diversity of a country influences its development to a great extent. Recent developments in infrastructure, technology and economical activities have resulted in diversification of occupation. The type of occupation influences life at different levels. Moreover, the diversity in occupation checks the population pressure by giving a platform to work in many spheres of life supporting activities which is necessary for local to global development.

Many academic works have been done by the national and international scholars in the field of occupational structure of the people. Clark, C., (1968), focused on the studies for the Sao Paulo Province of Brazil were particularly valuable because they were standardized by age (offspring of men aged 50-59) and cross classified by occupation. For a given occupation that the fertility differential between capital city (the largest city of Brazil) and the rest of province was about 30 percent for non- manual and about 22 percent for manual occupation . Rutherford, J. et.al. ,(1970), argued that in contrast to advanced nations like Japan, most of the underdeveloped countries could not encourage people to shift from agriculture to manufacturing and service sectors. Singh, R.S., (1986), focused on the changes during 1961-1981 in the employment structure of male tribal workers. Chandana, R.C., (2001) pointed out that commercial use of primary resources generates diversification in occupational structure. Ahmad, A., (2010) said about a distinction between total population and manpower. Total population denotes the entire populace inhabiting the area while the manpower consists of only those people who could participate in economically gainful activities in the event of need. Economically non-active population is that part of manpower, which is engaged in activities like household duties in their own house or at the place of their relatives, retired personnel, inmates of institution, students and those living on royalties, rents, pensions, etc.

Study area

Durgapur (23.36'N-23.88'N to 87.10'E-87.20'E) is located in the Bardhman District of West Bengal (Fig.1) on the bank of river Damodar in the alluvial plain of Bengal. The topography is undulating towards southward and the G.T road connecting Delhi- Howrah mainline NH-2 (National Highway) across the city. The City Center ward exists in center of Durgapur as a CBD (Central Business District) which is studied through personal observation and survey. Durgapur city is approximately rectangular shape along the road side of national highway (NH-2). The population of Durgapur was 566517 lakh with growth rate of 14.18% in 2011 and the male was 294255, female was 272262 lakh while the sex ratio was 871 female per thousand male, literacy rate was 87.78% and density was 3670 persons per square kilometer. In the present study, population characteristics of the City Center ward in Durgapur is based on personal survey. In city center ward total population was 20745 with10513 male and 1023 female with density of 5683 persons per square kilometers, literacy rate was 87.41% and sex ratio was 973 female Per thousand male.

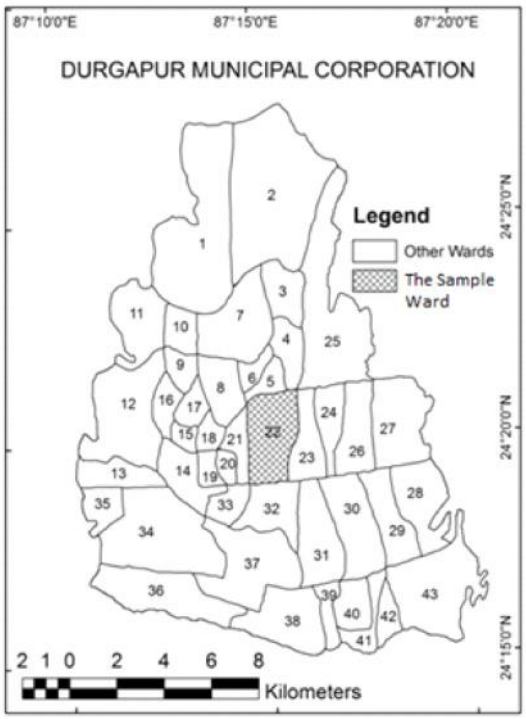


Fig. 1

Objective

To analyze the change in occupational structure in Durgapur City since 1981 to 2011,

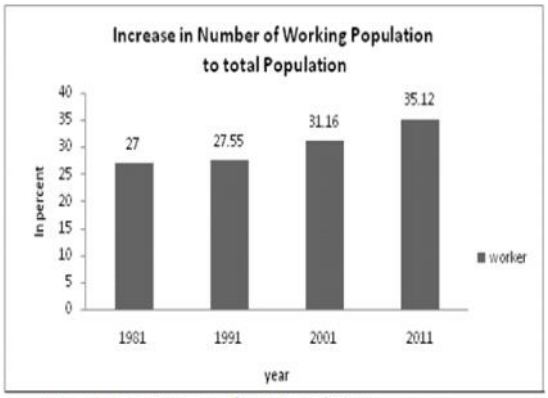
Methodology

This paper is based on the secondary and primary data. The secondary data were collected from DMC (Durgapur Municipal Corporation) and Joint Administrative Building in Salt Lake and New Secretariat Building in Kolkata. Location quotient of different occupation is used as occupational specialization index for every ward of Durgapur city that show specialization of a particular occupation in a ward. Primary data were collected from city Center Ward of Durgapur city with help of personal observational interview schedule related to occupational structure of the city. ARC GIS software is used for analyzing data and preparation of maps.

Change in occupational structure in Durgapur

The shifting is seen from primary activity to low productive manufacturing and service related activities. Between 1981- 2011, in Durgapur city the above change seen with the help of under follows table and showing the percentage of these categories.

In 2011 main workers were 152499 and marginal workers were 46514. According to Census of 1981, total population was 211000 and total worker was 56970 that means 27% people joined various works whereas in 1991, worker was 27.55% which increased up to 31.14% in 2001 and 35.13% in 2011.



Source:Economic Census of West Bengal,2011

Fig. 2

There are several reasons which caused the change in particular occupational activities during this time period.

Cultivator

The cultivators were 0.37% in 1981 and 0.79% in 1991 it means increasing trend of cultivators was recorded before the inception of new industrial policy. After incorporation of

new industrial policy a drastic change occurred in Durgapur where cultivators decrease upto 0.33% in 2001 0.39% in 2011 remained only.

Agricultural labor

The agricultural labour's condition remained same as cultivators. Rice cultivation covered large area of Durgapur and large number of population engaged in agricultural activity. Burdwan district (West Bengal) stand first in rice production in West Bengal, Durgapur is also part of the district. In 1981 agricultural labor is 1.01% which increased upto 1.37% in 1991 but after effect of liberalization in economy through new industrial policy, it dropped to 0.91% in 2001 and 0.82% in 2011.

Household and manufacturing

Table 1: Workforce in Different Activities

Year	Cultivator	Agricultural	Household and manufacturing	Other services
1981	0.37	1.01	0.50	24.79
1991	0.79	1.37	0.32	24.79
2001	0.33	0.91	0.52	29.37
2011	0.39	0.82	0.80	32.47

Source: Economic Census of West Bengal, 2011.

In spite of set up of Durgapur Steel Plant (1958) and Damodar Valley Corporation (1948) the share of household and manufacturing worker decreased from 0.50% in 1981 to 0.32% in 1991 but it was affected by liberalization and globalization policy and increased upto 0.52% in 2001 0.80% in 2011.

Other workers

It had opposite condition from the above sectors. The people engaged in other services were 24.79% in 1981 and 24.79% in 1991 because people were seeking traditional livelihood like agriculture, fishing etc but in 2001 other workers increased up to 29.37% and 2011 it further increased upto 32.47% due to technological advancement in industrial sector.

Occupational specialization

Location quotient has been used as occupational size variation index for every ward which was specialized in a particular occupation.

Ward number 2 is highly specialized by cultivators followed by ward number1, 12, 18, 33and 43 due to presence of cultivated field in outer part of the city. Ward number 2, 28 have also high participation in agricultural labors and moderately inward number 36, 38, 41, 43and also remaining wards have low participation due to presence of labour class people whose life style is poor and live in outskirts of the city.

Now focused on the participation of workforce in household. Ward number 40 is highly specialized in household manufacturing followed by 41, 42 and 43 due to presence of many industrial patches near the wards. All other ward except number 2 followed by 1, 40, 41, 42, 43 and 28 are highly specialized in other workers, that means the situation is just opposite in comparison to the above three occupation in each ward. Thus the data shows that maximum parts and peoples of Durgapur city are highly urbanized and developed.

Durgapur city is equipped with highly de-

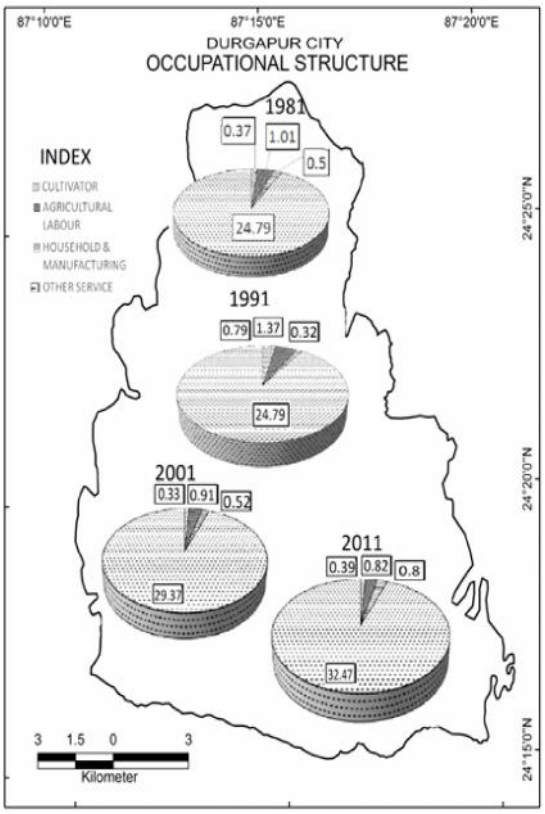
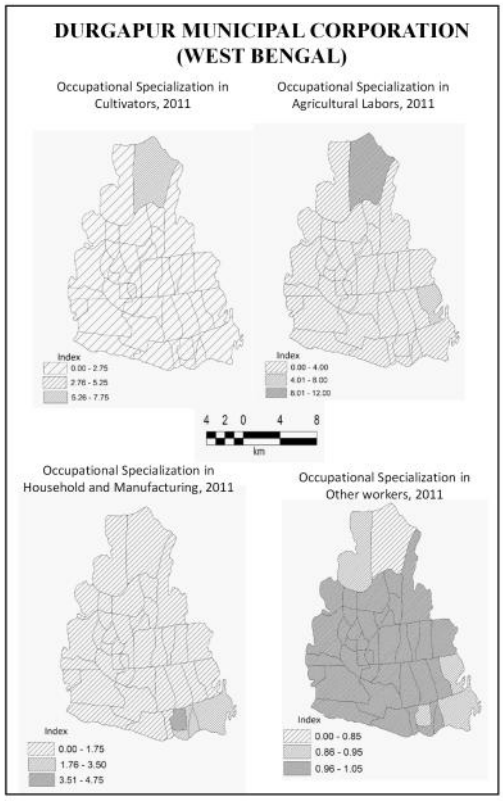


Fig. 3



Source: Calculated from District Census Handbook, 2011

Fig. 4

veloped infrastructure, big multi-complexes, parks, apartment, restaurant, malls, school, hospital, bank, roads with greenery etc. People mostly join the tertiary and quaternary sectors because they are highly educated (87.70% literacy rate) awakened and free from conventional and traditional thinking. Finally, the life style of people of Durgapur city is very modern and luxuriant.

Occupational structure in city center ward: A case study

The economy of Durgapur city is based on the tertiary and quarternary sectors which is proved observations in ward number 22(city center) in Durgapur. Here, people participation as cultivator was 3.0%, as agricultural labor was 7.0%, in the household and manufacturing 14.5% and in other services it was 76.5%.

Total person engaged in primary sector was 10.0%, in secondary sector 14.50%, and in tertiary sector it was 76.5% (table no.2). That means people are adopting luxurious life style.

Problems and remedies

The rapidly shifting occupational structure is not good scenario for future development because the agriculture, mining, quarrying, fishing, and industries in secondary activity are replaced by tertiary activities but primary and secondary activities are the base of economy.

The Durgapur city is facing low productiv-

Table 2: Types of Economy and People Engaged

Type of Activity	Sub group	Total Persons	Percentage
Primary Activity	Cultivators	6	3.0
	Agricultural Labors	14	7.0
Secondary Activity	Household labor and manufacturing	27	13.5
Tertiary Activity	Other Workers	153	76.5

Source: Personal Survey, 2014

ity of agricultural land. Therefore, people are shifting their occupation towards secondary tertiary sectors which create great disparity in life style between the primary based people and service sectors based people.

The migrated people from Bihar, Uttar Pradesh, Jharkhand, Orissa etc are engaged in primary and secondary activities, and thus, their economic status are low and they make fringe zone surrounding the city where they live as slum dwellers and degrade the city's environment.

Though a UK based survey had ranked Durgapur-Asansol subdivision 42nd among the 100 fastest growing cities of the world (Asansol Durgapur Development Authority) due to increasing per capita income but Durgapur city also has been included in 22 most polluted cities of India due to small and large new agglomerations of factories, openly producing pollution without following suitable industrial norms. Traffic Jam on roads and over crowd in market in whole city is another problem.

As remedies of problems, few favorable steps may be recommended to check pollution and improve the quality of urban life. Two steps are urgently needed: first to plant trees at every vacant space in the city and second, there should be balance among primary, secondary and tertiary activities, because the rice cultivation in the Burdwan district of West Bengal is ranked first in India.

Conclusion

Durgapur is the planned city in which male and female work participation is high in tertiary sector with the passing is which proof the development of city but side by side few steps are needed to resolve the problems like congestion, pollution, traffic, female delinquency, etc and also try to overcome the problems in the mining, quarrying, and agricultural activities of nearly areas. On the other hand it is also needed to support the Durgapur Steel Plant and other industries to follow ednvironmental norms. In spite of all above, it is seen few positive signs like, education development, immprovement in female status, cultural advancement, social attainment in any programmed etc, which gave a better quality of life in Durgapur city.

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Table 3: Occupational Specialization Index

	Cultivator	Agricultural labor	Household and Manufacturing	Other worker
Durgapur (M.Crop.)				
Ward no.1	2.435	2.212	1.134	0.958
Ward no.2	7.616	11.662	0.429	0.747
Ward no.3	1.032	0.473	0.399	1.023
Ward no.4	1.279	0.280	1.041	1.008
Ward no.5	0.461	0.311	0.474	1.031
Ward no.6	0.275	0.231	0.529	1.033
Ward no.7	0.373	0.252	0.675	1.028
Ward no.8	0.49	0.259	0.852	1.022
Ward no.9	0.633	0.226	1.072	1.016
Ward no.10	0.36	0.358	0.612	1.028
Ward no.11	1.065	0.658	0.573	1.015
Ward no.12	2.442	0.974	0.917	0.985
Ward no.13	0.286	0.179	1.291	1.015
Ward no.14	1.204	0.510	0.792	1.011
Ward no.15	0.372	0.264	0.555	1.030
Ward no.16	0.709	0.384	1.006	1.014
Ward no.17	0.463	0.992	1.380	0.997
Ward no.18	0.386	0.165	1.169	1.017
Ward no.19	0.837	0.148	1.500	1.004
Ward no.20	3.101	0.185	0.601	0.998
Ward no.21	0.909	0.393	1.465	1.000
Ward no.22	0.324	0.210	0.279	1.039
Ward no.23	0.685	0.264	0.467	1.029
Ward no.24	0.589	0.340	0.979	1.016
Ward no.25	1.131	0.762	0.290	1.019
Ward no.26	0.474	0.110	0.642	1.030
Ward no.27	0.691	0.261	0.761	1.022
Ward no.28	0.602	7.280	1.684	0.878
Ward no.29	0.479	1.415	0.305	1.015
Ward no.30	0.321	0.189	1.561	1.008
Ward no.31	0.200	0.273	1.005	1.021
Ward no.32	1.122	1.014	0.577	1.008
Ward no.33	2.079	0.772	1.032	0.990
Ward no.34	0.971	0.404	0.823	1.015
Ward no.35	0.764	0.335	0.474	1.027
Ward no.36	1.362	1.797	0.862	0.984
Ward no.37	0.455	0.414	0.531	1.027
Ward no.38	0.755	2.079	0.916	0.985

Ward no.39	0.431	0.582	0.858	1.017	
Ward no.40	0.421	0.284	4.603	0.933	
Ward no.41	0.974	1.352	2.172	0.966	
Ward no.42	1.434	0.374	2.321	0.974	
Ward no.43	1.774	2.866	1.973	0.934	

Source: Calculated from District Statistical Handbook, 2011.

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Analysis of Carrying Capacity and Population Food Balance of Drought - Prone Tahsils in Jalgaon District, Maharashtra

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Abstract

The idea of carrying capacity of land is closely related to sustainable development, because both refer to the need for survival rather than capital. However, in future, it is recommended to bring down the population pressure so as to avoid any decline in the carrying capacity of the land. The analysis of carrying capacity of land, and population food balance in drought- prone Tahsils in Jalgaon district is an attempt to understand the man and land relationship. The carrying capacity of agricultural land is worked out by applying Jasbir Singh, (1972) using secondary data of population and cropping data of 9 tahsils of 31 years collected from Census Handbook of Jalgaon district. This study helps in finding out the relative population pressure on the available arable land in different tahsils of the study region. The increasing pressure of population on the available resources is a matter of great concern to the present academicians, planners and policy makers. Geographers are spatially and temporarily concerned with deteriorating man and land relationship (Gharge, 2011). The results of the present study indicate that the carrying capacity of land is 1231 persons / sq.km and food crop density is 1062 persons / sq.km.

Keywords : *carrying capacity, population food balance, food crop density, surplus and deficit population food balance.*

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Introduction

Agricultural land is the most valuable resource for food production. Early civilisations started in deltas and valleys endowed with rich and fertile soils that enabled agriculture development and food production. Thus, agriculture has been the mainstay of livelihood for thousands of years. The rapid increase in population mainly after industrial revolution has put pressure on the land resources for increasing food production. The continuous cultivation of crops affected the carrying capacity of land and promoted land degradation. In India since the inception of the Green Revolution, the cereal production increased only fivefold, while fertilisers consumption increased 322 times between 1950-51 and 2007-08 (Prasad, 2009). Overuse of fertilizers has posed a serious problem before the governments, planners and scientists to feed more than 1200 million people of India. It is, therefore necessary to take all measures to ensure that the carrying capacity of land does not get depleted and enough can be produced to feed the teeming millions and also to have a safe buffer stock.

The study of carrying capacity of agricultural land in study region is an attempt to understand the man and land relationship which would help in finding out the relative population pressure on the available arable land in different *tahsils* of the study region.

As stated earlier there is a close relationship between the numbers of heads and the carrying capacity of the land, particularly in an agrarian society where land is only the sole support of the growing population. The availability of agricultural land is almost fixed in are al extent while population is increasing rapidly.

Objective

To measure the carrying capacity of agricultural land in relation to population pressure.

To find out the present and projected surplus / deficit population of food balance.

The Study area

The study area is located in the drought-prone *tahsils* of Jalgaon district of Maharashtra state. These drought prone *tahsils* are identified by V Subramaniam Review Committee (1987), appointed by the Maharashtra State Government. The *tahsils* are Amalner, Dharangaon, Erandol, Parola, Chalisgaon, Bhadgaon, Jamner and Muktainagar. There are 09 *tahsils* which are selected for the present study which cover an area 6994.54 sq.km. The area under study is located in the south of the Tapi river in Jalgaon district; in the East, the area is bordered by the Buldhana and Jalna district; to South lies the Hatti, Ajanta, Satmala ranges and Chandor hills that form a natural boundary between the study area and the district of Aurangabad and Nasik. The west is surrounded by Dhule district to the North, Tapi river. It lies between 2011' to 2113' North latitudes and $74^0$46' to $76^0$24' East longitudes (Fig. 1). Most of the study area is covered by the plateau and less area is covered by alluvial deposits of Girna, Waghur, Tittur, Anjani, Bori and Purna rivers. The study region experiences the sub humid monsoon climate (Singh, 1971).

Tools and methods

The spatial patterns of carrying capacity of agricultural land are worked out by applying of Jasbir Singh, (1972) formula. For the estimation of carrying capacity of 9 major food crops in the study area covering more than one percent of the cultivated area taken in to ac-

count. The selected crops are, Jowar, Bajara, Pulses, Oilseeds, Onion, Corn, Fruits, Sugarcane and Vegetables. However, the fruits and vegetables are excluded. Further, triennium averages of the data for the years2007-08, 2008-09 and 2009-10 are taken to calculate the carrying capacity in different tahsils of the study area. Similarly weighted average standard nutrition unit for ingestion in calories / person / annum for all the tahsils of the study region are calculated on the basis of scale recommended by Indian Council of Medical Research (ICMR), Hyderabad. The carrying capacity (Cp) is calculated using the following expression.

$$C\,p = \frac{Co}{Sn}$$

Where:

C_p = Carrying capacity

Co = Caloric output available for ingestion per unit area for the selected crops.

Sn = Weighted average standard nutrition for ingestion in calories / person / annum

Food Crop Density (FCD) is defined as the density of population per unit area under food crop. The pressure of population on land in generally measured on the basis of the density of population. In the present study *tahsil* wise population projected on 2001 census data for 2009-10 was divided by the area under food crops in the respective *tahsils* and the values so obtained are used for the *tahsil* level analysis of the spatial pattern of food crop density (FCD) in the study region. The algorithm used for the calculation of FCD is:

$$\text{Food Crop Density} = \frac{\text{Pupulation of the tahsil}}{\text{Area under Crops in the Tahsil}}$$

Population-Food Balance is worked out on *Tahsil* level to identify the areas of surplus and deficit carrying capacity using the following formulae.

Population Food Balance = Carrying Capacity - Food Crop Density

Projected Population Food Balance is calculated by considering the present population growth rate projected for the period of 32 years from 2010 to 2041 while the carrying capacity is considered as constant at the current level of agricultural productivity and use of present technology. It is calculated by using the formula given below:

Projected Population Food Balance = Carrying Capacity - Projected Food Crop Density

Pattern of carrying capacity

The average carrying capacity of agricultural land in the study region for 2009-10 has been calculated as 1231 persons per square km, while at the *Tahsil* level it shows significant variation. Some *tahsils* has recorded a very high carrying capacity (Dharangaon 1451, Pachora 1410 carrying capacity person / sq. km), while others have shown very low (Parola 1004, Jamner 1027 and Amalner 1056 carrying capacity person / sq. km). The spatial pattern of carrying capacity of agricultural land has been analyse by categorizing viz. very low, low, medium, high and very high. Table 1 and Figure 2 shows the distribution pattern of Carrying Capacity of land in the study area.

Very low carrying capacity

The category of very low carrying capacity is determined by less than 1062 persons / Sq. km. The three least carrying capacity *tahsils* are 1004 persons / sq. km in Parola

tahsil, 1090 in Erandol *tahsil* and 1056 in Amalner *tahsil* lying in the western part of the study region (Table 1 and Fig.2). It covers only 25% area under Land Capability Class - I (LCC). It is very less in comparison to other *tahsils* and it has 45 % area under LCC - II, 13 % area under LCC - III and 16% area under LCC - IV. 39% area of these *tahsils* is covered by coarse shallow soil, barren hills and it also receives low rainfall.

Low carrying capacity

The Low carrying capacity is recorded within the range of 726 to 980 persons / sq. km. In this category only one *tahsil* namely Jamner with a carrying capacity of (970) is observed. This *tahsil* covers 35% area under Land Capability Class I, 8% area under LCC-II, 10% area under LCC-III and 3.50 % area under LCC-IV. It is mainly due to the low Farm Yard Manure (FYM) consumption and low area under Farm Yard Manure (FYM) and green manure crops and low fertile soils, low rainfall which seems to be responsible for low carrying capacity.

Medium carrying capacity

The category of the medium carrying capacity ranges 981 to 1235 persons / sq kmt and has been recorded in Bhadgaon *tahsil* only having a carrying capacity of 1138 persons / sq. km. The *tahsil* has moderate Farm Yard Manure (FYM) consumption. It covers 19 % area under LCC-I, 3% area under LCC-II, 55% area under LCC -III and

Table 1: Study Area: Tahsil level Carrying Capacity and Population Food Balance 2009-10

Tahsil	Carrying Capacity Person / sq. km	Population	Area under food crop sq.km	Food crop Density Persons per sq./km	Population Food Balance person / sq. km.
Chalisgaon	1299	394600	350	1127	172
Bhadgaon	1420	157226	130	1209	211
Pachora	1410	278588	240	1161	249
Parola	1004	187916	180	1044	-40
Erandol	1090	163802	198	827	263
Dharangaon	1451	177712	140	1269	182
Amalner	1056	290328	320	907	149
Jamner	1027	319393	290	1101	-74
Muktainagar	1323	152267	150	1015	308
Region	1231	2121832	1998	1062	169

Source: Computed by the researcher, 2016

33 % under LCC - IV. The main reason for medium carrying capacity is lack of irrigation facility and low rainfall.

High carrying capacity

This category of carrying capacity ranges between 1236 and 1490 persons / Sq. Km. It includes three *tahsils* of the study region namely Chalisgaon, Pachora and Muktainagar with a carrying capacity of 1459, 1386 and 1323 persons / sq. Km. These *tahsils* have rich black soil and most of the area of these *tahsils* falls in the Land Capability Class- I, and very less area falls under LCC - III and IV. Around 75 % areas of these *tahsils* is covered by LCC-I, 20 % by LCC - II by LCC-II, 2 % by LCC-III and only 1.25 % area come under LCC - IV. These *tahsils* have very high level of agricultural mechanization and FYM consumption as well as noticeable area under FYM and green manure crops and high rainfall. Fertile soils seems to be the drivers of high carrying capacity of these *tahsils*.

Very high carrying capacity

The category of Very high carrying capacity is recorded with more than 1491 persons / sq. km. The *tahsil* Dharangaon 1628 person / sq. km falls into this category (Table 1 and Fig. 2). This *tahsil* lies within the northern part of the study region. This *tahsil* has high fertility and most of the area falls in the Land capability class - I. While a very small area falls under LCC - IV. Around 80 % area of this *tahsil* is covered by LCC - I, 12 % by LCC - II, 2.10 % by LCC -III and only 1.65 % area comes under LCC - IV. This *tahsil* has very high levels of agricultural mechanization and Farm Yard Manure (FYM) consumption as well as very large area under FYM and green manure crops, very fertile soils, high rainfall and developed irrigation facility. There are plausible causes for very high carrying capacity of this *tahsil*.

From the above analysis it is found that southwestern part of the study region has very low Carrying Capacity (724 persons / sq. km) and it increseases *towords* northern part. The highest carrying capacity is found along the Girna river surrounding banks of the study region like Dharangaon, Chalisgaon and Pachora *tahsils*. Five *tahsils* namely Parola, Erandol, Jamner, Bhadgaon and Amalner *tahsils* have Carrying Capacity less than the study areas average of 1160 persons / sq. km. The remaining four *tahsils*, Chalisgaon, Pachora, Dharangaon and Muktainagar have a more carrying capacity than the study area average. It is found that the *tahsils* which have the maximum Farm Yard Manure (FYM) consumption and sufficient acreage under FYM and green manure crops has maximum carrying capacity, while the *tahsils* that have low FYM consumption as well as less acreage under FYM and green manure crops have a very low carrying capacity.

Food crop density

The food crop density has been measured to study the sustainability of agricultural land, and it is found that average food crop density of the whole study area is 728 persons / sq. km. The total population of the study region in the year 2009-10 was 2121832, persons and the total area under the major selected crops was 2915 sq. km. The pressure of population on land is measured in terms of the density of population. In this study only the area under the major selected crops is considered to measure the population pressure, *i.e.* population burden on agricultural land. So the food crop density is defined as the density of population per unit area under food crops (Nayak, 2009).

Hence, man - land ratio is an important element in studying the population pressure.

Significant variations are found in food crop density at *tahsil* level. Table 1 and Fig. 2 show *tahsil* level distribution of the food crop density in 2009-10. It has been recorded to be high in the *tahsils* of Dharangaon (1015), Chalisgaon (940) and Pachora (856) due to high population concentration in these *tahsils*. The very low food crop density is recorded in the *tahsils* of Parola (537), Erandol (550) and Amalner (680). Low population concentration and large area under food crops in these tahsils have resulted in very low food crop density.

Population food balance

Ecologist and population biologist have used the logistic model of population dynamics as a way to understand the cause and effect relationship between carrying capacity and population size (Wilson and Bossert, 1971; Gotelli, 1998). There is a deep relationship between carrying capacity and population. If an area has the highest carrying capacity and high pressure of population than its carrying capacity then the food balance would lead to decline. It helps in identifying the areas with surplus and deficit carrying capacity.

The Table 1 shows that in 2009-2010 the carrying capacity of the study area was 1160 persons / sq. km. Therefore, the average population food balance of the study area calculated was 432 persons / sq. km. It shows that the study region is enjoying surplus carrying

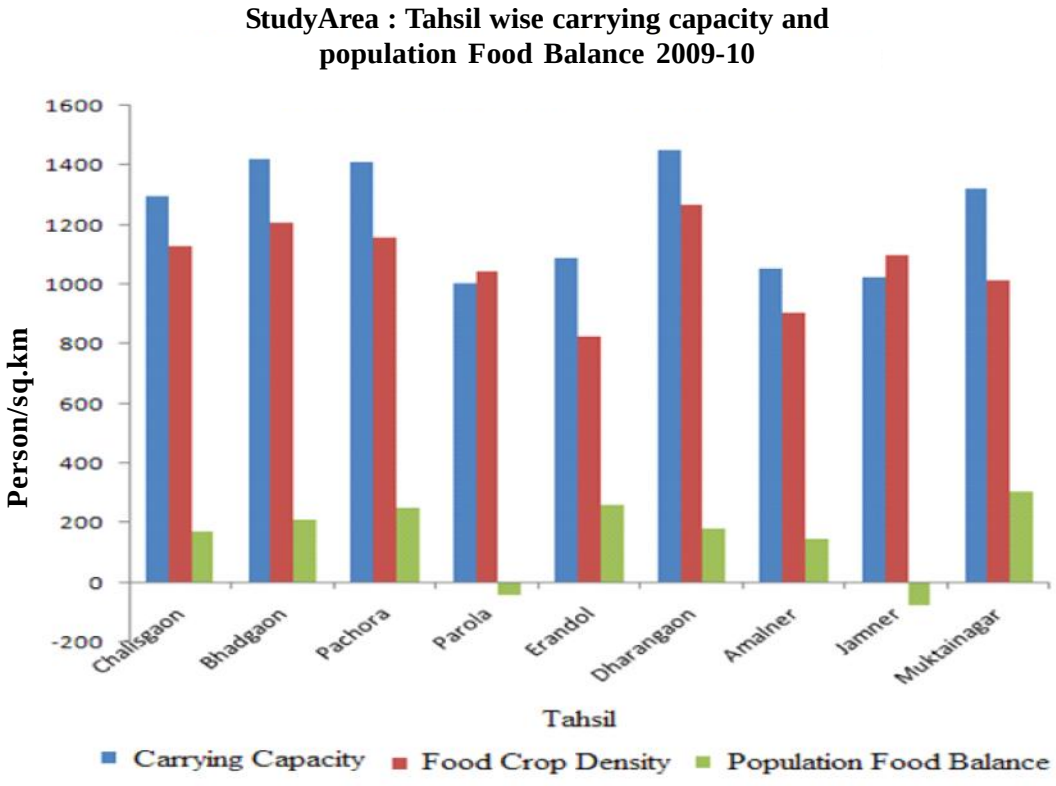

Fig. 1

capacity of 432 persons / sq.km. Fig. 1 shows the *tahsil* levels variations in food balance where out of the 9 *tahsils* two suffer from food deficit. The carrying capacity of the cultivated land at the present level of technology as reported in 2009-10 in Parola and Jamner *tahsils* was experiencing population pressure more than its capacity. The Jamner *tahsil* is experiencing an extra pressure of 81 persons /sq. km while in the case of Parola it is 40 persons / sq. km of cultivated land.

The remaining *tahsils* of the study region in comfortable position and are experiencing lesser population pressure on the existing cultivated land. It means that per sq.km cultivated land in these *tahsils* can support the food requirements of more populations. It varies between 123 persons to 308 persons / sq. km. The food balance status of all the *tahsils* of the study area presented in Table 1. These variations have been classified into very low, low, medium, high and very high categories.

The very low population - food balance is identified by less than 84 persons / sq. km. It is found in Parola and Jamner *tahsils*. The population food balance is recorded least in Jamner *tahsil* where its value is - 74 persons /sq. km Parola follows Jamner *tahsil* and suffers from food deficiency to an extent of - 40 persons / sq. km. The carrying capacity of the Jamner block was 1027 persons /sq. km in 2009-10, while the food crop density was high i.e. 1101 persons / sq. km hence, the population food balance was recorded very low. It shows that this *tahsil* is experiencing a deficit in population food balance in the study region. Chalisgaon, Pachora, Amalner and Parola *tahsils* have urban area which attracts migrants from the nearby rural areas. The carrying capacity of the Parola *tahsil* was 1004 persons / sq. km in 2009-10, while the food crop density was high *i.e.* 1044 persons / sq. km that is why in Dharangaon *tahsil* the population food balance was also recorded very low.

The category of low population food balance is lying between 151 to 175 persons / sq. km which are found only in Chalisgaon. Chalisgaon *tahsil* has food balance of 172 persons / sq. km. Chalisgaon, Dharangaon, Pachora and Bhadgaon *tahsils* have the carrying capacity range 1299 and 1451 persons / sq.km, and food crop density range 1127 and 1269 persons / sq.km. These *tahsils* having high population concentration are self sufficient and can feed extra 172 to 308 persons/sq. km respectively.

The medium category of population food balance is found between 176 to 200 persons / sq.km in Dharangaon with an additional population that can be feeded as 182 persons/sq. km. Dharangaon is presently self sufficient and has a surplus carrying capacity. This tahsil surrounded industrial area of Jalgaon city,also has relatively high population concentration which perhaps define medium carrying capacity of this *tahsil*.

The category of high population food balance recorded within the range of 201 to 225 persons/sq. km, in Bhadgaon *tahsil* with a surplus population food balance of 211 persons / per sq. km. This tahsil has an average carrying capacity of 1420 persons / sq. km and the average food crop density of 1209 persons/sq. km. This *tahsil* is presently self sufficient in food availability with a surplus carrying capacity.

The very high population food balance is identified by more than 226 persons /sq. km. This category includes two *tahsils* namely Pachora (249) and Muktainagar (308) persons / sq. km. The average carrying capacity of this category is 1367 persons / sq.km. The average food crop density for this category is measured as 1100 persons / sq. km. The average

population food balance for this category has been estimated at 279 persons / sq. km. So all *tahsils* have low concentration of population. They are self sufficient to feed their population.

Projected surplus and deficit population food balance

The present level of carrying capacity of the agricultural land of the study area is sufficiently high. However, there is a need to compute that the correct level of carrying capacity how long and to find out it is sustainable for the growing population of the study region. For finding out the projected population figures, the growth rate of population is calculated for the period between 2010 and 2040. At the current level of agricultural technology and carrying capacity of agricultural land it is found that the food crop density would continuously increase due to increasing population resulting in a declining level of Population Food Balance. It is stressed that the population of the study region in 2001 was 1918687 persons which increased to 2121832 persons in 2011 with a growth rate of 1.19 % per annum. The projected figure of population for 2041 at the current growth rate has been estimated as 2601563 persons. Hence, the food crop density of the study region is expected to reach at 1275 persons / sq. km. Therefore, in a period of 32 years food balance is expected to decline at - 44 persons / sq. km resulting in deficit population food balance.

Figure 2 and Table 2, presents a *tahsil* level declining population food balance. The carrying capacity of agricultural land is considered as constant at the present level of technology, and the food crop density is increasing due to fast growing population, whereas the graph lines of these two variables intersect each other ahead of the population food balance is register in negative. In other words at that point of time the study region would reach its maximum food crop density, balancing carrying capacity and beyond which the study region would be unable to feed the additional population.

The population food balance of the study region in 2009-10 was 169 persons / sq. km for 2036 the projected population food balance of the study area has been estimated at only six persons / sq. km. It means that by 2038- If the carrying capacity of the study region remains constant and the food crop density continues to increase in situ of the current rate of population growth will be able just to feed its population.

In 2038 the population food balance scores would be recorded in negative figures, and an alarming condition would be registered. In 2040 the population food balance would be - 44 persons / sq. km. Hence, a study area which is food surplus at present would turn into a food deficit area after 2036. So, study area would be self - sufficient to feed its population till 2038. This study is carried out to identify those tahsils which are showing projected deficit food balance in future like Parola and Jamner. It would be self sufficient to feed its population only till 2038. This exercise has been conducted in order to isolate those blocks which are showing a serious projected deficit food balance figures like Parola and Jamner. The *tahsils* showing deficit Population Food Balance should be given proper attention and effective planning strategy should be formulated and implemented in advance so that their declining food balance can restore. Distinguished strategies should be divided for those *tahsils* which are not showing deficit food balance 2038, so that such *tahsils* can

Table 2 : Study Area: Projected Population Food Balance, Persons/sq. km, 2009-10 -2041

Years	Carrying	Population capacity	Food Crop Density	Population Food Balance
2010	1231	2,121,832	730	501
2012	1231	2,140,611	750	481
2014	1231	2,180,523	790	441
2016	1231	2,200,142	800	431
2018	1231	2,240,653	835	396
2020	1231	2,280,452	875	356
2022	1231	2,320,145	890	341
2024	1231	2,340,123	920	311
2026	1231	2,380,256	960	271
2028	1231	2,420,145	980	251
2030	1231	2,460,123	1000	231
2032	1231	2,490,412	1090	141
2034	1231	2,510,123	1150	81
2036	1231	2,530,142	1225	6
2038	1231	2,560,123	1250	-19
2040	1231	2,614,201	1275	-44

Source: Computed by the researcher, 2016

Table 3 : Study Area: Projected Population Food Balance 2010-2040

Tahsil	Carrying capacity Person / Sq. km 2009-10	Food Crop Density Persons /sq km.	Population Food Balance Persons/Sq. Km 2041
Chalisgaon	1299	1240	59
Bhadgaon	1420	1385	35
Pachora	1410	1395	15
Parola	1004	1298	-294
Erandol	1090	1085	5
Dharangaon	1451	1498	-47
Amalner	1056	1230	-174
Jamner	1027	1320	-293
Muktainagar	1323	1310	13
Region	1231	1310	-79

Source: Computed by the researcher, 2016

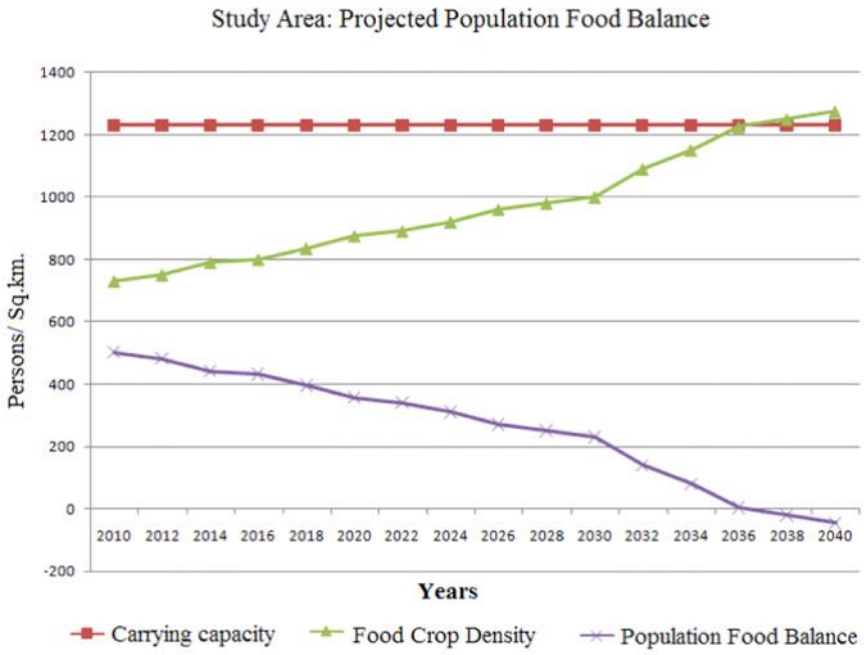
Study Area: Projected Population Food Balance
Persons/ Sq.km.
1400
1200
1000
800
600
400
200
0
-200
2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040
Years
Carrying capacity
Food Crop Density
Population Food Balance

Fig. 2

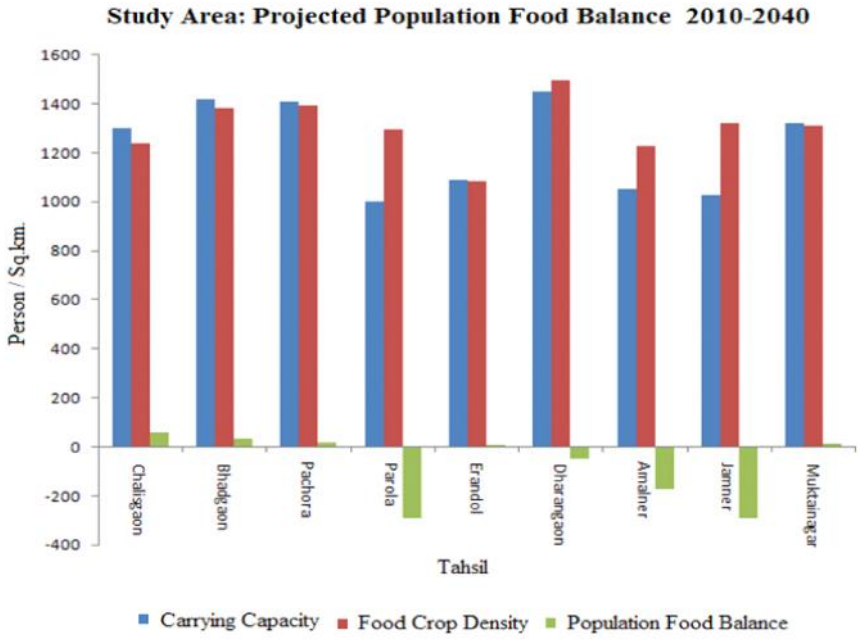
Study Area: Projected Population Food Balance 2010-2040
Person / Sq.km.
1600
1400
1200
1000
800
600
400
200
0
-200
-400
Chalisgaon
Bhadgaon
Pachora
Parola
Erandol
Dharangaon
Amalner
Jamner
Muktainagar
Tahsil
Carrying Capacity
Food Crop Density
Population Food Balance

Fig. 3

produce the surplus to feed the population of other *tahsils* which would be unable to feed their population by 2038. The *tahsil* level projected population food balance is presented in Table 3 and Figure 3. It is found that by 2040, out of nine *tahsils* (Table - 3) 5 *tahsils* are in food deficit condition.

The *tahsils* which would suffer from declining population food balance are Parola and Jamner. Parola and Jamner are still food deficit *tahsils* with a population food balance of -40 and -74 persons / sq. km respectively in 2040. The food crop density of Dharangaon tahsil would reach from 1269 to 1498 persons / sq.km from 2009-10 to 2041. Likewise, food crop density of Amalner *tahsil* would also reach from 907 to 1230 persons / sq. km. The *tahsils* of Dharangaon and Amalner which are presently food surplus *tahsils* would also become food deficit tahsils by 2040 to the extent of -47 and -174 persons / sq. km respectively. So, with the current population growth and a constant carrying capacity the food crop density is tend to increase, and consequently, the population food balance would decline resulting in a deficit carrying capacity.

The remaining 7 *tahsils* like Chalisgaon, Bhadgaon, Pachora, Erandol, Amalner and Muktainagar are supposed to remain positive population food balance category. These *tahsils* would experience surplus carrying capacity of 169 persons / sq. km for Chalisgaon 59, Bhadgaon 35, Pachora 15 and Erandol 5 persons / sq. km.

Conclusion

The present carrying capacity of the study region is 1231 persons / sq.km which is sufficiently high and it may feed its current population. However, the population of the study region is continuously increasing while the carrying capacity of agricultural land is considered to remain constant at the current level of agricultural technology. The food crop density is 1062 persons / sq. km. It is continuously increased on account of continuously increasing population resulting in the declining levels of population food balance. The food balance is 169 persons / sq. km.

To maintain the carrying capacity and high production, it is suggested to increase the agricultural efficiency using sustainable agricultural practices like cropping in parity with the land suitability classes and controlling the population growth. Special attention is required in the *tahsils* of Parola and Jamner which are already recording a negative trend of carrying capacity.

By the year 2041, the food crop density of the study region is expected to reach at the level of 1310 persons / sq. km. Hence, in a period of 32 years from 2009-10 onward population food balance of the study region as a whole is expected to reach - 44 persons / sq. km, *i.e.* from surplus to deficit population food balance. The calculated population food balance of the study region in 2009-10 was 501 persons / sq. km which the projected value for 2038 is estimated to be only -19 persons / sq. km. It means thet if the carrying capacity of agricultural land remains constant and the food crop density continue to increase at the same rate than the study area would be able to feed the surplus population. After 2036, the population food balance would be negative figures. By 2041 the population food balance would reach - 44 persons / sq. km which will further decline with the passage of time.

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Assessment of Drinking Water Quality of Renukoot Industrial Area in District Sonbhadra, Uttar Pradesh

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Abstract

The drinking water quality of Renukoot Industrial Area of Sonbhadra district of state Uttar Pradesh in India has been studied. For this study, the ground water samples were collected from the selected locations of the study area with the identification of their longitude and latitude. The GIS locations of the sampling sites are shown in map. Further, the samples were analyzed as per guidelines of BIS for 14 drinking water quality parameters like pH, Total Hardness, Alkalinity, Chloride, TDS, Sulfate, Nitrate, etc. in analytical laboratory. The results are compared with Indian Standard Drinking Water specification IS: 10500-2012. The study reveals that the concentration of major constituents in the water samples is well within the permissible limits of the drinking water except in few cases where concentration of one or more parameters are high which indicates that the water of the study area is fit for drinking purposes in most of the places except few sites. Further, correlation coefficient values indicate the presence of NaCl and KCl salts in such ground waters and high values of TDS are mainly due to presence of NaCl and KCl.

Keywords : *parameters, drinking water, BIS, correlation co-efficient.*

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Introduction

Population growth indicates the higher rate of urbanization all over the world. The quantity of surface water is decreasing day by day due to construction of houses, buildings, commercial areas, industrial areas etc. This leads to the more demand for ground water for human consumption, irrigation and many other purposes. The production of drinking water occurs by alluvial aquifers that are hydraulically associated with a water system. Currently, the surface water quality as well as ground water quality has become serious problem due to several factors like rapid increase in population, urbanization, deforestation, industrialization, etc. in the plain areas of the state (Sharma, et al., 2016). During the past decades, careless and unscientific patterns of disposal of industrial, agricultural, and domestic wastes have enlarged the problem of pollutants which are contaminating not only the surface waters but

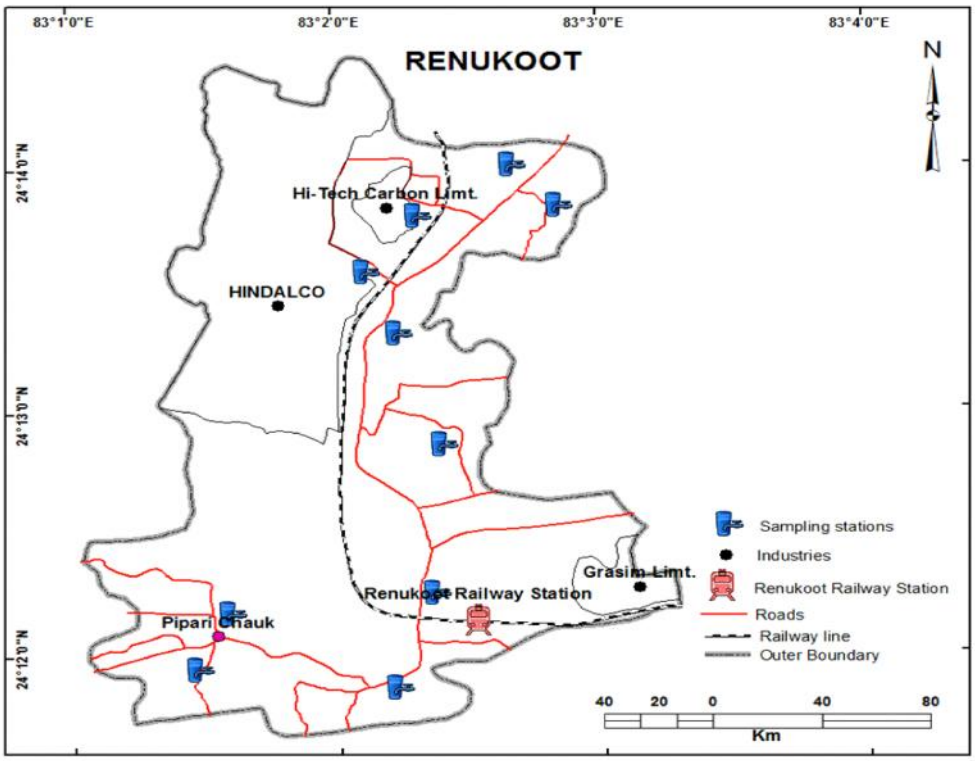

Fig 1. Location of the study area and water sampling sites

with Mr. Kothari of HINDALCO and Ray Fullerton of Kaiser as executive engineers.Other major factories within the suburbs of the Renukoot city include Aditya Birla Chemicals plant (now Grasim Industries limited) and Hi-Tech Carbon unit of Aditya Birla Nuvo's Birla Carbon.Most of the economy of Renukoot revolves around HINDALCO. Maximum people live in HINDALCO colony and almost all of the businesses depend on these people.

groundwater sources also (Lacorte, 2005).Water quality of any area can be monitored by its physical, chemical and biological characteristics. Moreover the landfill sites and mining waste dumps are some factors of metal pollution in drinking water. Chemical analysis forms the basis of interpretation of the quality of water in relation to source, geology, climate and use (Kanwar, 2014). The values of these parameters are harmful for human health if they found more than permissible limits. Characterization of water quality is necessary to study about the existing water quality. The assessment of water quality includes sampling, analyzing, and characterization of drinking water samples obtained from sources on continuous basis, which explains the quality of water after comparing with water quality standards (CGWB, 2016).In Sonbhadra district, an industrial estate is developed at Renukoot. The impact of industrial development on natural resources especially on drinking water resource has become necessary to study. Therefore, it has been decided to study the drinking water quality.

Objectives

- To analyze the physico-chemical parameters of drinking water of Renukoot industrial area.
- To assess the quality of groundwater for drinking as per standard value given by BIS (Bureau of Indian Standard).

Study area

The study area Renukoot is situated in Sonbhadra district in eastern Uttar Pradesh of India. Sonbhadra is the only district in India which borders four states, namely Madhya Pradesh, Chhattisgarh, Jharkhand and Bihar. The study area having extension from 24° 11' 42" N to 24° 14' 06" N and 83° 01' 30" E to 83° 03' 45" E. Renukoot is an industrial town. It is well known for the HINDALCO aluminium plant and Rihand Dam. As of the 2011 census, Renukoot had a population of 347524. Renukoot had an average literacy rate of 73 percent, higher than the national average of 59.50 percent. Renukoot lies in one of the most important industrial belts of India, which consists of the cement, aluminium, and chemical industries, as well as hydropower and thermal power projects. One is HINDALCO, India's largest aluminium company. The aluminium mill was built in 1963 and 1964 as a joint venture between HINDALCO (Hindustan Aluminium Co.) and Kaiser Engineers of Oakland, California, USA,

Database and methodology

The present study comprises primary as well as secondary source of data. Secondary data has been collected from BIS (bureau of Indian standard) while primary data is collected through sample survey. Water samples were collected during post-monsoon period(23-26 November) 2015from bore hand pumps of different locations of Renukoot after flushing water for 10-15 minutes to remove the stagnant water. The sampling container were washed, rinsed with distilled water and dried before use. Groundwater samples were collected from the India *Desi* and India Mark-ii hand pumps.

All samples were immediately transported to the laboratory. The ten samples were analyzed for physico- chemical parameters like pH, EC (electrical conductivity), TA (Total Alkalinity), TH (Total Hardness), TDS (total dis-

Sample code No.	Locations of different sampling sites	Longitude	Latitude
X1	Near Rihand Dam	83° 01' 26" E	24° 11' 56" N
X2	PipariChauk	83° 01' 34" E	24° 12' 09" N
X3	Bus Stand Renukoot	83° 02' 12" E	24° 11' 52" N
X4	Near Nirmala Convent School	83° 02' 21" E	24° 12' 15" N
X5	Behind of Ramleela Field	83° 02' 23" E	24° 12' 52" N
X6	Near Shiv Mandir	83° 02' 13" E	24° 13' 19" N
X7	Jokahi	83° 02' 06" E	24° 13' 34" N
X8	Near High-Tech Carbon Plant	83° 02' 17" E	24° 13' 47" N
X9	Murdhava	83° 02' 49" E	24° 13' 50" N
X10	Near Radha Krishna Temple	83° 02' 38" E	24° 13' 59" N

Source: Locations taken by Research scholar

solve solids) Ca2+, Mg2+, So42- , Na+,K+, CO32-, HCO3-, Cl-, and Nitrate (NO3-) by following the standard methods prescribed as per Bureau of Indian Standard (BIS 10500-2012) for drinking water.

Result and discussion

General parameters

The physico-chemical characteristics along with their mean are presented in Table 1. The pH values vary from 7.34 to 7.68 (mean, 7.54), indicating alkaline nature of groundwater samples. All pH values are within the permissible limit (6.5-8.5) of Bureau of Indian Standards (BIS, 2012).The electrical conductivity (EC) varies from 2422.54 to 3078.8 µS/cm (mean,2661.50µS/cm) (Table 1). EC exceeds the BIS permissible limit (BIS,2012) of 3,000 µS/cm in one sample (X7).The alkalinity is referred to as the acid neutralizing capacity (ANC) of the water. This is expression of buffering capacity. The basic species responsible for alkalinity in water are bicarbonate ions [HCO3-], carbonate ions [CO32-] and hydroxide ions (OH). The total alkalinity values vary from 482 to 905 mg/l (mean, 630 mg/l). About 50 percent of the samples exceed the BIS permissible limit of 600 mg/l (BIS,2012).In natural waters, dissolved solids mainly consist of carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of calcium, magnesium, sodium and potassium with traces of iron, manganese and other minerals. Organic matter and various dissolved gases are also present in small amount (Jain et al. 2010).

The TDS values have been found between 1689 and 2627 mg/l (mean, 2013.80 mg/l). About 40% samples exceed the permissible limit of 2,000 mg/l (BIS, 2012). Water having high TDS values if used for drinking purposes may induce an unfavorable physiological reaction in the transient consumer and gastrointestinal irritation (Shankar et al., 2008).In the water

Table 1: Physical and Chemical properties of water samples in Renukoot,

Parameters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	Mean
pH	7.52	7.34	7.68	7.62	7.48	7.55	7.58	7.65	7.55	7.45	7.54
Electrical Conductivity (µS/cm)	2634.26	2422.54	2627.66	2543.38	2721.42	2668.73	3078 8.8	2745.28	2645.43	2527.51	2661 0
Total alkalinity (mg/L)	741	546	482	490	637	684	905	786	539	493	630.30
Total dissolved	1760	2122	1920	2068	2627	2032	1689	1780	2409	1731	2013.80
Total Suspended Solids (mg/L)	194	136	155	286	211	168	318	147	189	148	195.20
Total hardness(mg/L)	223	445	262	423	534	218	326	297	286	178	319.20
Calcium (Ca2+)(mg/L)	96	153	34	86	137	78	68	62	78	73	86.50
Magnesium (Mg2+)(mg/L)	31	39	14	21	45	19	7.6	8.1	7.2	7.7	19.96
Sodium (Na+) (mg/L)	29	40	35	42	33	37	29	27	32	31	33.50
Potassium (K+) (mg/L)	6.8	8.2	7	8.5	11	9	6.7	7.1	6.7	6.9	7.79
Chloride (Cl-)(mg/L)	326	288	146	280	266	238	195	176	197	189	230.10
Sulphate (SO42-)(mg/L)	143	168	72	110	190	136	69	70	63	78	109.90
Nitrate (NO3-) (mg/L)	9	13.5	ND	6.4	8	12	10	13	18	9.2	11.01
HCO3 - (mg/l)	130	364	260	312	91	65	143	208	260	156	198.90

Source: Water samples analyzed in Chemistry lab (Prof. M.C Chattopadyay) University of Allahabadwith the help of Research Scholar

Table 2: Water quality parameters of groundwater of Renukoot with BIS standard

Water Quality Parameters	Range of Samples			BIS Standard	
	Minimum	Maximum	Mean Value	Desirable Limit (mg/1)	Permissible Limit (mg/1)
pH	7.34	7.68	7.54	6.5	8.5
Electrical Conductivity (µS/cm)	2422.54	3078.8	2661.5	300	3000
Total alkalinity (mg/L)	482	905	630.3	200	600
Total dissolved solids (mg/L)	1689	2627	2013.8	500	2000
Total Suspended Solids (mg/L)	136	318	195.2	-	-
Total hardness (mg/L)	178	445	319.2	200	600
Calcium (Ca2+) (mg/L)	34	153	86.5	75	200
Magnesium (Mg2+) (mg/L)	7.2	45	19.96	30	100
Sodium (Na+) (mg/L)	27	42	33.5	50	200
Potassium (K+) (mg/L)	6.7	11	7.79	10	12
Chloride (Cl-) (mg/L)	146	326	230.1	200	1000
Sulphate (SO42-) (mg/L)	63	190	109.9	200	400
Nitrate (NO3-) (mg/L)	0	18	11.01	45	No Relaxation
HCO3- (mg/l)	65	364	198.9	300	600

Source: Computed by Authors and standard taken from De, A.K. Environmental Chemistry

samples, the total suspended solids are in the range between 136 to 318 mg/l. X-7 has highest TSS value while that of X-2 is lowest. Total suspended solids in all the water samples are well within the desirable and permissible limit. The value of total hardness for the ten ground water samples are in the range 178-534 mg/l (table 1). X-5 has highest value of total hardness (534 mg/l) while that of X-10 is the lowest one (178 mg/l). The total hardness value X-10 is below the acceptable limit (200mg/l) whereas remaining samples X-1 to X-9 have their value below the permissible limit (600 mg/l) of BIS standard for drinking water. Further, it is clearly seen from the table that the water samples belong to hard water category (150-300 mg/l).

Cation parameters

The major cations present in most of the ground waters have highest concentration of calcium, magnesium, sodium and potassium (Younger, 2007). The concentrations of various cations analyzed in groundwater samples are presented in Table 1. Calcium and magnesium concentrations vary from 34 to 153 mg/l

(mean, 86.50 mg/l) and 7.20 to 45.0 mg/l (mean, 19.96 mg/l), respectively. None of the samples exceeds the calcium and magnesium BIS permissible limit (BIS, 2012) 200 mg/l and 100 mg/l respectively. Sodium and potassium concentrations vary from 27 to 42 mg/l (mean, 33.50 mg/l) and 6.7 to 11 mg/l (mean, 7.79 mg/l), respectively. All the water sample have their concentration of Na+ below the threshold limit (200 mg/l) of BIS. Only one location *i.e.* X-5 has a greater amount of K+. Rest of the values of 9 samples fall under the BIS limit (10 mg/l) prescribed for Potassium. Low concentration of calcium versus sodium in groundwater samples indicate the absence of readily soluble calcium minerals, whereby calcium present in ground water samples has been exchanged by sodium due to base- exchange reaction (Sharma and Rao, 1997). High Ca2+, Mg2+, Na+ and K+ concentrations are mainly due to their mineralogical origin in the soils.

Anion Parameters

The major anions having highest concentration present in majority of groundwaters are chloride, sulfate, Nitrate and bicarbonate. The concentration of various anions analyzed in groundwater samples are presented in Table 1. For the ten ground water samples (X-1 to X-10), the concentration of chloride (Cl-) ranges from 146 mg/l to 326 mg/l. Approximately 40% of water sample exceeds desirable limit of 250 mg/l recommended by BIS for chloride in drinking water supply. It is added through activities carried out in agricultural area, industrial waste, sewage, and trade wastes. The Sulphate in groundwater generally is present as calcium, magnesium, and sodium soluble salts. Significant change in the Sulphate concentration takes place with time during rainfall infiltration and groundwater recharge (Jain et al., 2010). The Sulphate concentrations in the samples vary from 63 to 190 mg/ l which is below the permissible limit of 400 mg/l (BIS, 2012). Sulphate when present alone may not cause any adverse health effects while presence of Sulphate in excess of >400 mg/l with sodium or magnesium may lead to gastrointestinal irritations (Shankar et al., 2008).High nitrate concentration in the groundwater are reported in many parts of India because of intensive agricultural practices which utilize nitrogen fertilizers that are changing the natural drainage patterns. Nitrate concentration >45 mg/l in drinking water has adverse health effects on human resulting methemoglobinemia commonly known as blue baby syndrome which generally affects the infants (Jain et al., 2010) and gastric carcinoma (Tank and Chandel, 2010). The nitrate concentration ranging from ND to 18.0 mg/l (mean, 11.01 mg/l) in all the samples are within the BIS permissible limit of 45 mg/l. Carbonate is almost absent or beyond detectable limit. Therefore, total alkalinity for different ground water samples is due to the presence of Bicarbonate (HCO3-) ions only. The concentration of HCO3- for different ground water range from 65 mg/l to 364 mg/l and all the stations have HCO3- content less than 500 mg/l. Bicarbonate affects alkalinity and hardness of water. The weathering of rocks add bicarbonate content in water.

Statistical analysis on the basis of correlation co-efficient

Correlation coefficient is a statistical mea-

sure of interdependence of two or more random variables. Correlation analysis measures the closeness and the degree of linear association between independent and dependent variables. The correlation analysis of the analyzed parameters was performed and the correlation coefficient is presented by correlation matrix in Table 3.The values of correlation co-efficient (r) of different variable pairs of physico-chemical parameters for the ten ground water samples (X-1 to X-10), are shown in table -3 given below. From table-3, it is clearly seen that positive correlation (r=0.25) is there between TDS and electrical conductivity (EC). Both Ca2+ and Mg2+ show strong positive correlation with total hardness (TH) having r values 0.69 and 0.67 respectively, establishing the fact that high concentrations of Ca2+ and Mg2+ attribute to more hardness of different waters. The negative correlation (r = -0.26) between pH and total hardness, indicates that with increase of pH, the total hardness for different ground water samples decreases and vice-versa. Cl- shows positive correlation with both Na+ and K+ having r values 0.35 and 0.41 respectively showing that both Na+ and K+ exist as chlorides in the different ground waters represented by X-1 to X-10. Further, Na+, K+ and Cl- show strong positive correlations with TDS having r values equal to 0.36, 0.70 and 0.23 respectively. Similarly, Na+, K+ and Cl- show strong positive correlation with EC (r=0.58, 0.15 and 0.33 respectively).

The above strong positive correlation of Na+, K+ and Cl- with TDS and EC respectively, establishes the fact that high values of TDS (and hence EC) are due to presence of NaCland KCl salts mainly in the different ground waters represented by X-1 to X-10.The high correlation between EC and TDS is due to the fact that conductivity depends on total dissolved solids and the main constituents of TDS in water are these ionic species. The pH was negatively correlated with most of the physico chemical parameters. Nitrate was positively and significantly correlated with Cl-, alkalinity, TDS, EC and Ca2+.Sulphate is positively correlated with most of the physico-chemical parameters.

Hydrochemical Facies

Hydrochemical facies concept has been used to explain the distribution and genesis of principal types of groundwater in the study area. Back and Hanshaw (1965) have suggested two main types of facies: cation facies and anion facies. The overall water chemical character is determined by both cation and anion facies. Groundwater aquifer hydrochemistry in the study area is summarized using the trilinear plots (Fig.2). The trilinear plot of cations expresses abundance of each species (Ca2+, Mg+, Na++K+) as a percentage of their sum. Similarly, trilinear plot of anions expresses abundance of each species (HCO3-, SO42-, and Cl-) as a percentage of their sum.

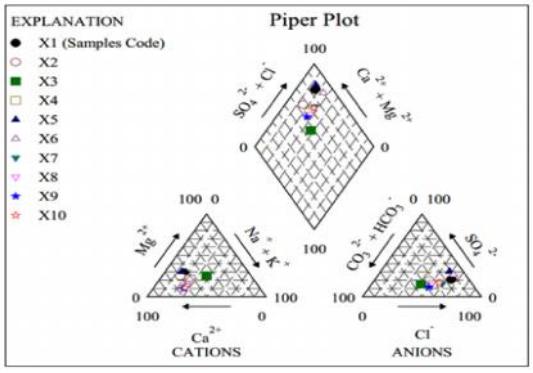

Fig 2. Piper trilinear diagram for ground water samples

Table 3: Correlation co-efficient (r) values between different variable pairs of physico-chemical parameters for different ground water sample.

Parameters	pH	EC (µS/cm)	Total alkalinity (mg/L.)	TDS (mg/L)	TSS (mg/L)	TH (mg/L)	Ca2+ (mg/L)	Mg2+ (mg/L)	Na+ (mg/L)	K+ (mg/L)	Cl- (mg/L)	SO42- (mg/L)	NO3- (mg/L)	HCO3- (mg/l)
pH	1.00													
EC(µS/cm)	0.43	1.00												
Total alkalinity	0.16	0.73	1.00											
(mg/L) TDS (mg/L)	-0.25	0.22	-0.33	1.00										
TSS (mg/L)	-0.09	0.09	-0.16	0.67	1.00									
TH (mg/L)	-0.26	-0.03	-0.09	0.66	0.86	1.00								
Ca2+ (mg/L)	-0.82	-0.35	-0.03	0.54	0.49	0.69	1.00							
Mg2+ (mg/L)	-0.56	-0.34	-0.04	0.53	0.49	0.67	0.85	1.00						
Na+ (mg/L)	-0.21	0.58	-0.64	0.36	0.43	0.41	0.35	0.39	1.00					
K+ (mg/L)	-0.27	0.14	-0.07	0.70	0.75	0.70	0.61	0.73	0.45	1.00				
Cl- (mg/L)	-0.52	0.33	0.09	0.23	0.33	0.38	0.75	0.77	0.35	0.41	1.00			
SO42-(mg/L)	-0.61	-0.33	0.03	0.50	0.45	0.58	0.85	0.97	0.39	0.79	0.79	1.00		
NO3-(mg/L)	-0.40	0.01	0.28	0.21	-0.12	-0.02	0.33	-0.11	-0.19	-0.10	0.13	-0.01	1.00	
HCO3 - (mg/l)	-0.06	-0.51	-0.56	0.07	0.04	0.29	0.12	-0.01	0.51	-0.25	-0.01	-0.16	0.03	1

Source: Data processed in excel by authors

These trilinear diagrams are useful in establishing the chemical relationships among groundwater samples in more definite terms than any other possible methods. The diamond shaped field of Piper diagram can be further classified into (1) Ca2+-Mg2+-Cl--SO42-, (2) Na+- K+-Cl--SO42-, (3) Na+-K+-HCO3- and (4) Ca2+- Mg2+-HCO3-. The trilinear plots of the major cations and anions in the groundwater samples of the study area are shown in Fig.2.A look of the hydrochemical facies (Fig.2) indicates that in the groundwater, monovalent cations (Na+ and K+) predominate the Ca2+ and Mg2+.Among the anions, chloride is dominant over other anions. It is evident from Fig2. , most of the samples belongto the non-carbonate hardness (secondary salinity) exceeding 50 percent, which means the Na+ and K+ concentrations in the analyzed groundwater samples may be due to the weathering of sodium-potassium bearing minerals and/or some cation-exchange processes and industrial/agricultural activities in and around study area (Singh et al., 2006). Sodium and potassium exchange by calcium and magnesium adsorbed on the clay mineral surfaces may be responsible for the high sodium and potassium concentration.

Conclusion

The water quality of Renukoot industrial area of Sonbhadra has been studied for 14 selected drinking water quality parameters as per BIS. The analysis of water samples collected from the different stations of Renukoot industrial area, Sonbhadra district reveals that almost all water quality parameters i.e. (pH, electrical conductivity, total hardness, calcium, magnesium, chloride, nitrate etc.) comply with BIS standard. However most of them are within the standard limits. Results of the water samples suggest that only the total alkalinity is greater than BIS permissible limit. To determine the water types the concentration of major ionic constituents of water samples were plotted in the Piper trilinear diagram. Most of the water samples were Ca2+-Mg2+-Cl--SO42-types which indicate that the water samples are non-carbonate hardness (secondary salinity) exceeding 50 percent. This is because most hardness and alkalinity come from limestone and dolomite sources in nature. Limestone is the calcium carbonate, and dolomite is the combination of calcium carbonate and magnesium carbonate. Water passes through the rocks in the ground and picks up minerals on the way. When the limestone and dolomite dissolve in water one half of the molecule is calcium or magnesium (hardness) and other half is the carbonate (the alkalinity). Major process controlling the water quality is the silicate weathering, minerals dissolution, because of hard rock structure of the study area. Topographical undulations and the groundwater flow were identified as the other supporting factors for the hydro-chemical processes and also to anthropogenic influences of infiltration and percolation during monsoon season. High values from desirable value of chloride, alkalinity, bicarbonates, sodium and potassium were found in most of the groundwater samples in Renukoot, district Sonbhadra.

- High values were found of Electrical conductivity, Total Alkalinity in X-7 sample, Total Dissolved solids in X-5 sample, Calcium and HCO3- in X-2 sample in Renukoot area. These high concentration might be due to mineral solutions that change under redox condition.

- However, some suitable treatments are necessary so as to keep the high values of the following parameters below the corresponding acceptable limits of BIS standard for drinking water: Treatment of high values of EC and total alkalinity, for X-7 sample.
- Strong positive correlation of So42- with Ca+ and Mg+respectively, shows the presence of Magnesium Sulphate (MgSo42-) salts in the different waters and further these two salts are mainly responsible for high values of TDS (and consequently high values of EC) of the different water sample.

Further the quality of water varies in every sample. It is recommended that the shallow hand pump must be replaced by deep bore pumps.

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Road Accidents in a Himalayan State of India: A Spatio-Temporal Analysis of Fatality and Severity in Himachal Pradesh

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Abstract

Present paper is an effort to analyze the fatality in road accidents and to understand the different factors responsible for accidents in Himachal Pradesh. The factors have been studied under four broad categories and occurrence of accidents at different time periods has been also described. The present analysis also reveals that in urban areas the majority accidents occurred during 6:00pm-10:00pm and in rural areas 10:00am-2:00pm. There are number of weather conditions which are responsible for vehicle accidents yet larger number of accidents occurred in fine conditions because there are more number of vehicles on the road during that time. Surprisingly more accidents occurred in the open areas as a result of negligence. It has been also noted that the cars and jeeps was the main segment of vehicle that was found more often involved the in road accidents.

Keywords : *road accidents,fatality, ramification, exposure, recommendations*

Introduction

Road accidents are a human tragedy, which involve high human suffering. They impose a huge socio-economic cost in terms of untimely deaths, injuries and loss of potential income. The ramifications of road accidents can be colossal and its negative impact is felt not only on individuals, their health and welfare, but also on the economy (Govt. of India, Ministry of Road Transport and Highways, New Delhi, 2011). Consequently, road safety has become an issue of National concern. Occurrence of accident is an outcome of interplay of a number of factors, which among others include

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length of road network, vehicle population, human population and adherence as well as enforcement of road safety regulations etc. Higher exposure to road accident risk may be mitigated by behavioral standards (adherence to road safety regulations) and policy intervention (Govt. of India, Ministry of Road Transport and Highways, New Delhi, 2013). Expansion in the road network, surge in motorization and a rising population of a country contribute towards increasing numbers of road accidents, road accident injuries and road accident fatalities. A case study done in Calcutta, India, reported that there are some host (human) factors and seasonal factors (weather and time) that contribute to fatal road traffic accidents (Zhang et al., 1998). Most accidents occurred on main roads (highways) and in the majority of cases pedestrians were found to be at fault during crossing the roads (Majumdar et al., 1996). Studies done worldwide have shown that road traffic accidents are the leading cause of deaths of many adolescents and young adults (Balogun et al., 1992 and Odero et al., 1997).There is evidence that using minimum safety standards, crash worthiness improvement in vehicle, enforcement of wearing seat belts and strict ban on alcoholic driving can substantially reduce deaths on the road (Leon, 1996).

Rational of the study

Govt. of India, Ministry of Road Transport and Highways, 2010 states that during the year 2010 there were around 5 lakhs accidents, which resulted in deaths of 1,34,513 people and injured more than 5 lakhs persons in India. These numbers translated into 1 road accident every minute, and 1 road accident death every four minutes. The rate of accidental deaths per thousand registered vehicles has made Himachal Pradesh the third highest accident hotspot in the country as per the report released on accidental deaths by National Crime Record Bureau (NCRB). A report said that during last 10 years till 2015, state Himachal Pradesh has witnessed around 29,555 road accidents. During the period of 2011 to 2015 state had recorded 15,047 accidents in which 5,612 people have been killed and 26,580 others injured. Data recorded by police shows that on an average around 3,000 road accidents are taking place in the state in which around 1,000 people being killed and 5,000 others are being injured each year. Road accidents in Himachal Pradesh have been rampant and in 2016 alone state have recorded 2,096 accidents in which 780 people have been killed and 3,919 others injured.

Himachal Pradesh is one of the hilly states of India. The changing scenario of roads and traffics in Himachal Pradesh creates many problems. The study area has a rigid topography due to which construction and expansion of roads are difficult. There are many villages which are not connected to the roads even today and some others are having only *kuchcha* roads and very few areas having *pukka* roads to connect with main centers. The conditions of roads give rise to the road accidents. There are very deep gorges in Himachal Pradesh therefore, in majority of cases accidents occur in terms of rolling down the slopes resulting not only the economic loss but also the loss of life. The climates of Himachal Pradesh also give rise to the road accidents. The climatic conditions like dense fog, heavy rainfall, strong wind, and cold climatic conditions etc are responsible for the road accidents. The transportation in Himachal Pradesh solely depends on roads

because the expansions of railways are neither physically nor economically viable. The blasting rocks in order to construct the roads have been given rise to road accidents. The present study aims at presenting the spatio-temporal distribution and examines the pattern of regional variations in road accidents in Himachal Pradesh. The study also tries to investigate the major causes and impact of topography on road accidents.

Data sase and methodology

The present study is based entirely on the secondary sources of data that include the published and unpublished records of Himachal Pradesh Government, vigilance head quarter, vehicle crime record Bureau, Traffic Police Office, S.P. Office, Census Reports, Police Headquarter, Statistical outlines of Himachal Pradesh and newspapers etc. In order to assess the spatio-temporal changes in number of total accidents, person injured and killed has been computed. Severity index and injury index is also calculated which shows the seriousness of an accident and it is defined as the number of person killed/ injured per 100 accidents. Spatial and temporal distribution and variation among road accidents during different years in the study area is shown through the line graphs and maps which are prepared by ArcGIS software.

Study area

The state of Himachal Pradesh forms the study area of present analysis. Himachal Pradesh is a hilly state of India. Himachal Pradesh is situated in lower Himalayan region with numerous mountain ranges and rich natural resources. The elevation in the state varies between 450 meters to 6,500 meters above sea level. The region forms an extension from Shivalik range of mountains. There is an increase in elevation as we go from north to south and east to west. Its length from the northwestern Chamba to the southeastern tip of Kinnaur ranging 355 kms and maximum breadth from Kangra to Kinnaur in the near north-east 270 kms. It lies between 30°22' 44" to 33° 12' 40" north latitude and 75°47'55" to 79°04' 20" east longitude. Administratively, Himachal Pradesh is divided into 12 districts. It experiences pleasant climate throughout the year. The winter month brings enormous snowfalls in the region due to its close proximity to Himalayas. The normal weather of various regions in the state varies as per altitude levels. The ideal time to explore the state is from September to March. The state is divided into three physiographic divisions from South to North *i.e.* The Great Himalayas, the lesser Himalayas, and the outer Himalayas. The Great Himalayan range is region which fall between an altitude range of above 5000 to 6000 mts. The Zanskar Range which is the easternmost range separates Kinnaur region from Spiti, then from Tibet. The lesser Himalayas are identified by steady increase in height beginning from Dhauladhar towards Pir Panjal ranges. The Shivalik range is situated on lower elevation regions in the state. It is located at an elevation of 600 mts above sea level. The hills of these regions contain rock and soil which are prone to erosion and deforestation.

Himachal Pradesh is divided into four zones on the basis of roads named as South Zone or Shimla Zone, Hamirpur Zone, Kangra Zone, and Mandi Zone. There are 12 National Highways which pass through the state covering a total length of about1552km. There are 18 State Highways covering approximately

1529km and about 31 District roads covering the length of about 1,328kms.

Objectives

The major objectives of this study are:

- To examine the pattern of regional variations in road accidents in Himachal Pradesh.
- To analyse the fatalities of road accidents in Himachal Pradesh.

Analysis and discussion

Pattern of regional variation in Himachal Pradesh Table 1. explained the regional variation of total road accidents in Himachal Pradesh. The number of total accidents in last decade have observed positive change means the number of accidents increases every year but in some districts like Chamba, Kinnaur, Kullu, Mandi and Sirmaur the change remain negative means the number decreased after 2009. Overall the number of accidents in last decade increases but in the year 2012 the number slightly decreases in comparison to previous years. The total number of accidents are highest in Kangra and lowest in Lauhal and Spiti. The reasons of this difference in highest and lowest number of accidents are the road network that is not much developed in upper parts of Himachal Pradesh and the maximum accidents occurred due to natural reasons rather than road accidents due to rigid climatic conditions and topography, the frequency of vehicles and some of the human faults etc.

Table 1: Regional Variation of Total Road Accidents from 2002 to 2012

Sr.no.	Districts	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	Bilaspur	226	219	241	216	253	242	207	247	240	274	235
2	Chamba	137	129	119	111	103	144	104	150	123	121	97
3	Hamirpur	134	146	152	176	148	144	119	133	159	126	128
4	Kangra	487	505	506	473	501	485	448	584	579	627	569
5	Kinnaur	42	38	42	26	31	38	46	66	58	44	44
6	Kullu	157	162	171	183	162	173	196	204	185	196	157
7	Lahul& Spiti	11	20	15	11	13	22	12	12	19	12	19
8	Mandi	316	350	381	363	378	463	394	404	356	360	378
9	Shimla	364	410	444	417	358	378	377	373	437	450	380
10	Sirmaur	193	154	190	211	219	243	256	270	231	201	248
11	Solan	277	330	357	344	320	366	359	334	388	427	405
12	Una	217	228	192	213	262	257	238	274	294	257	238
	Total	2561	2691	2810	2744	2748	2955	2756	3051	3069	3095	2898

Source: District Police Headquarter (H.P.)

Table 2 deals with the regional variation of persons died in road accidents from 2002-2012. The total number of persons died in road accidents increases in last decade. The fluctuations are observed in the last decade in the number of person died. There is positive and negative change in every district. Before 2009 most of the districts observed positive change

and after that some districts follow negative change means the number of died person will decreased in comparison to previous years. The districts are Chamba, Hamirpur, Kangra, Kullu, Mandi, Shimla, Solan and Una and others have positive change. The overall change is not much it was going to increase every year accept 2011 and 2012. There are many reasons which are responsible for this negative change like the increase in health facilities,hospitals in every region, awareness, driving skills, providing ambulance services like 108 which is every helful to save the people etc.

Table : 2 Regional Variation of Person Died in Road Accidents 2002-2012

SR. No.	District	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	Bilaspur	62	42	52	54	67	76	36	74	59	77	69
2	Chamba	56	87	85	55	58	81	82	143	87	134	111
3	Hamirpur	46	52	55	45	27	22	27	36	26	31	35
4	Kangra	87	84	75	141	121	120	72	165	100	129	162
5	Kinnaur	74	30	37	32	37	40	38	42	98	57	72
6	Kullu	88	50	76	60	85	77	79	91	55	72	68
7	Lahul& Spiti	11	31	18	10	15	18	4	11	14	19	14
8	Mandi	65	60	92	76	96	113	127	155	156	113	117
9	Shimla	114	147	172	129	126	162	166	153	244	149	186
10	Sirmaur	74	32	75	67	73	104	68	78	81	92	107
11	Salon	88	54	68	106	102	110	139	150	117	118	52
12	Una	68	53	52	46	63	56	59	67	76	85	57
	Total	833	722	857	821	870	979	897	1165	1113	1076	1050

Source: District Police Head Quarter (H.P.)

Table 3 shows the spatial distribution of injuries in road accidents. In last decade there is a very little change observed in the number of person injured in road accidents. The number of injuries remains allmost same in the last decade only in 2011 and 2012 the number of injuries observed the little change. In some districts the number of injured persons is increased and in others the number of injured persons in decreased. The total number of injured in road accidents in Himachal Pradesh increased accept in 2012. The reason are improvement in transportation, to improve the driving skills the driving schools were opened at different places, traffic rules and regulations followed by people,the road and vehicle conditions etc. Road traffic injuries in Al-Ain City (Bener, et al. 1992) and A perspective on road fatalities in Jeddah (Bener and Jadaan,1992) these are the earlier studies in which the road injuries or fatalities were discussed.

Table 3: Regional Variation of Road Accident Injuries 2002-2012

Sr. No.	District	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	Bilaspur	332	364	355	255	510	363	294	471	376	454	413
2	Chamba	186	209	206	182	175	225	185	335	253	253	202
3	Hamirpur	261	348	325	252	317	245	234	184	260	220	334
4	Kangra	619	795	842	997	781	974	794	1120	1025	1019	1029
5	Kinnaur	92	41	83	29	51	40	74	101	72	50	78
6	Kullu	232	241	309	305	267	375	294	345	296	410	240
7	Lahul& Spiti	23	31	23	31	27	12	10	26	30	56	33
8	Mandi	543	594	756	703	876	963	887	791	681	774	794
9	Shimla	564	641	771	724	717	713	689	672	837	740	663
10	Simaur	259	218	353	346	335	454	422	480	351	271	468
11	Solan	436	527	601	577	474	520	459	518	576	772	558
12	Una	364	449	308	286	428	448	372	536	568	442	436
	Total	3911	4458	4932	4687	4958	5332	4714	5579	5325	5461	5248

Source : District Police Head Quarter (H.P.)

Accident severity index

The accident severity index measures the seriousness of an accident. It is defined as the number of persons killed per 100 accidents. Table 4 presents the district wise accident severity index for Himachal Pradesh during the period 2009 to 2012. It is observed that in 2009 the severity index was 38.18% but in 2010 and 2011 it decrease to 36.26% and 34.76% repectively. The average severity index of 2009, 2010,2011, 2012 is 46.50%,49.34%, 61.25%, 53.33% respectively and Kinnaur, Chamba, Lahul and Spiti, Shimla Hamirpur have higher S.I. than the average. The districts have observed less number of accidents but the severity index is high because the number of killed persons is higher than other districts. These districts have hilly terrain and when the accident takes place the number of fatalities are higher than the injuries so the index is high.

Injury index

The accident injury index is defined as the number of persons injured per 100 accidents. The table 5 shows that index is high in some of the districts where severity index is low because the number of deaths is less than the number of injuries. The index is high in Lahul and Spiti, Kinnaur, Kullu, Sirmour, Chamba and Solan because the number of injuries is higher than the killed persons. These districts observed the index higher than 200. On the state highway and other roads the severity is greater than

300 while on National Highways it comes down to about 200.

Fatalities of road accidents in Himachal Pradesh

The data of the fatal accidents with casualties, and involved vehicles, by road environment and class; by location (city-non-city, division and district); by type of collision and junction; by time hours; and by mode of travel has been analyzed using a range of statistical methods utilizing a selection of predictor explanatory variables. The present paper has been analyse under four broad headings:

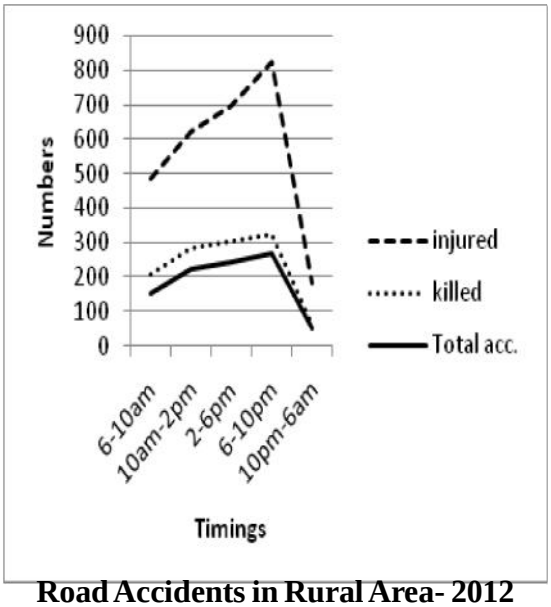
1) Road accidents in urban and rural areas
2) Road accidents in different weather conditions
3) Road accidents on different locations
4) Type of vehicle involved in accident

1) Road Accidentsin Ruban and Rural Areas:

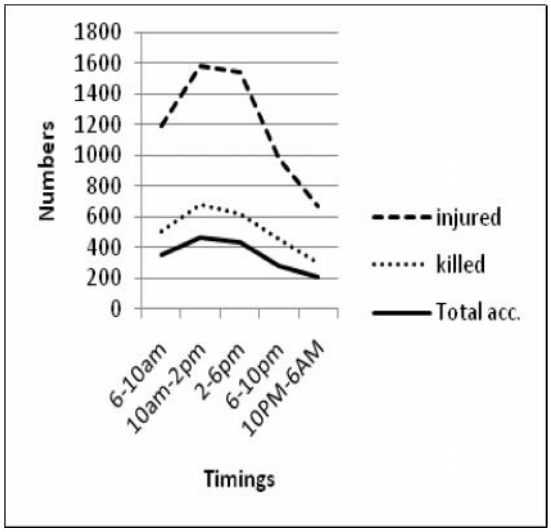
It means that the accidents take place in urban areas. Urban roads are the roads within the limits of the area of municipality, military cantonment, and port or railway authority. Most of the accidents occurred in day time in comparison to night.

The occurrence of road accidents at different time period has been described. The 24 hours of a day has been divided into five time periods and on the basis of this, the occurrence of accidents have been studied district wise. Time periods have been divided as 6:00am-10:00am, 10:00am-2:00pm, 2:00pm-6:00pm, 6:00pm-10:00pm, and after 10:00pm. The frequency of accidents is described under these time periods of different districts in urban and rural areas. The importance of time in accident is explained in "Space, time and people" (Srinivasan, 2000).

Road Accidents in Urban Area- 2012



Road Accidents in Rural Area- 2012



2. Weather conditions responsible for accidents:

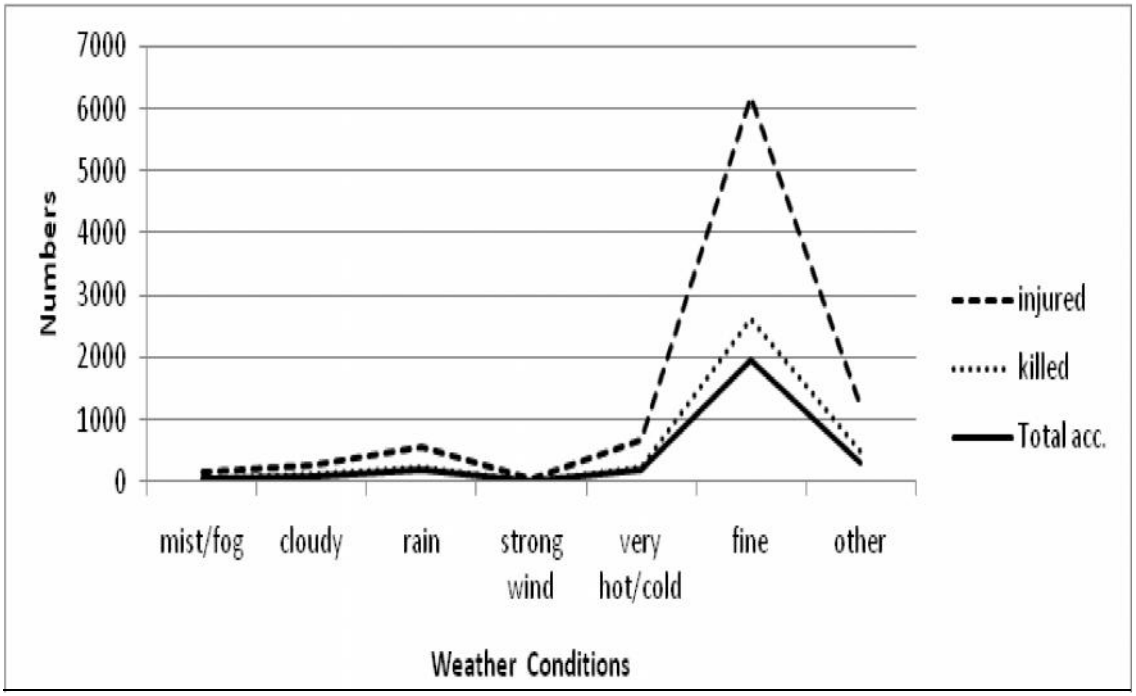
Weather conditions of any region also play an important role in the occurrence of road ac-

cidents. The present study tries to analyse the role of some of the climatic conditions like mist/ fog, clouds, strong wind, very hot/cold climate, fine /normal climate and other extra ordinary conditions which leads to accidents. The figure presents an overview of road accidents under different climatic conditions and the highest number of accidents are under fine climatic conditions. The significance of environment also explained in earlier study "Transport, the environment and economic policy" (Button,1993) which support present study.

3. Location of Road Accidents:

Though there can not be any specificity about the location of road accidents yet it may be confidently said that location also plays an

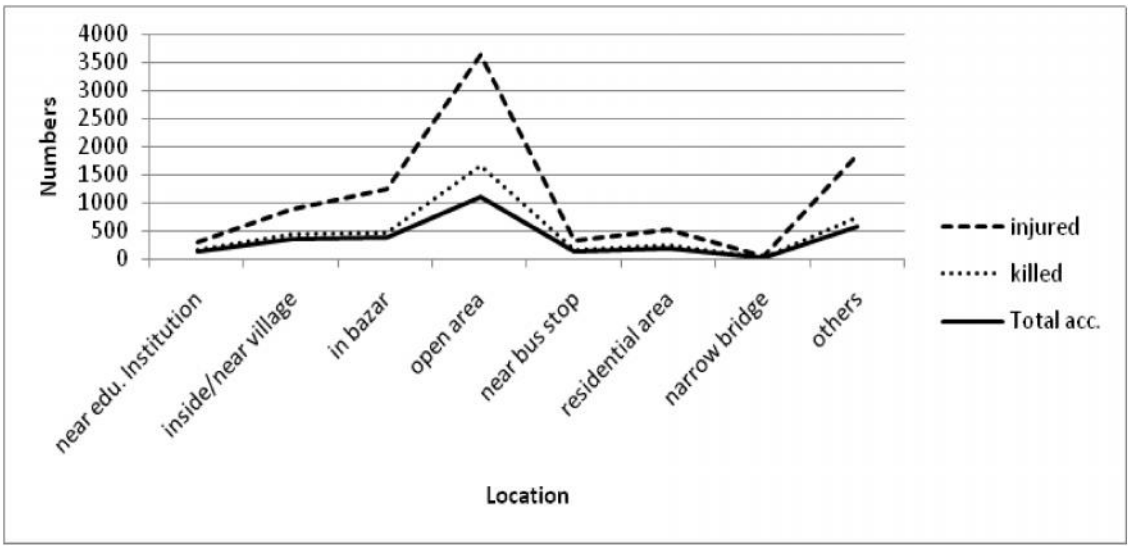
Road Accidents in different Weather Conditions-2012



important role in road accidents. Location is a place where accident take place and it is necessary that when a road accident occurred the location is identified. In simple words the name of place where accident occurred is location of accident. It has been realised that most accidents occur around some specific places. They may be broadly grouped into following few catagories like near educational institution, inside/near the village, in bazar, open area, near bus stop, residential area, narrow bridges and other places. In earlier study the location is not divided but the comprehenssively studied in "Space, time and the people (Srinivasan, 2000).

Figure shows the invovement of vehicles in road accidents in 2012.The highest accidents occurred due to car/taxi/jeep. And the maximum number of persons killed and injured are also due to car/taxi/jeep in year 2012.In 2012

Location of Road Accidents: 2012



4. Type of vehicle involved in road accidents

Type of vehicle means that which vehicle invoved in accident or the involvement of any vehicle in accident example; scooter, byke, car, autoriksha,truck, tempo etc. Here the vehicles have been grouped under five catagories like two wheeler, three wheeler, car/taxi, bus, trucks and others.

Type of Vehicle involved in Road Accidents 2012

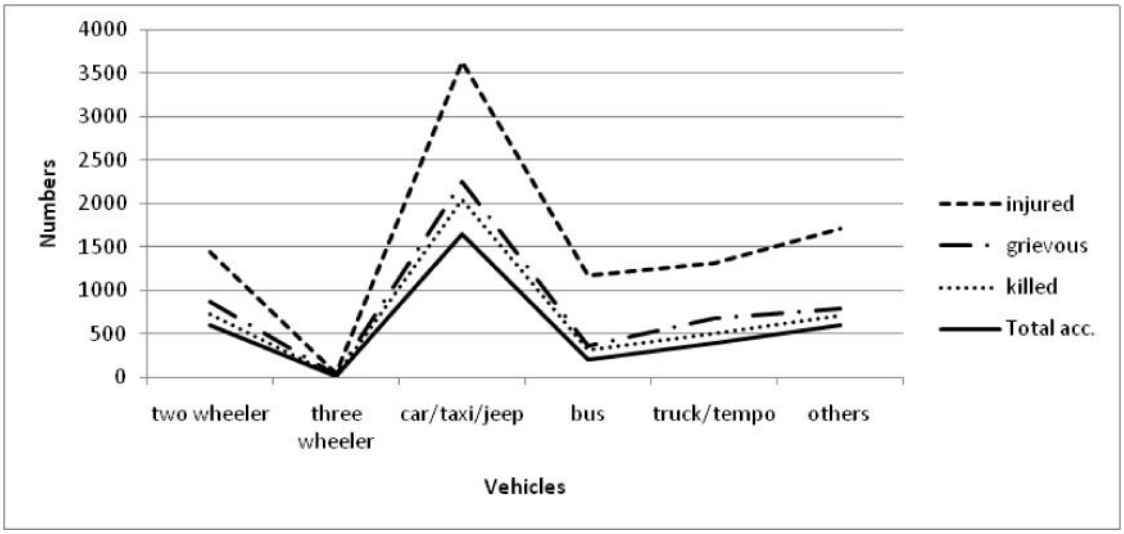


Table 4: Severity Index (2009-2012)

Sr.no	Districts	2009			2010			2011			2012		
		A	K	S.I.	A	K	S.I.	A	K	S.I.	A	K	S.I.
1	Bilaspur	247	74	29.95	240	59	24.58	274	77	28.10	235	69	29.36
2	Chamba	150	143	95.33	123	87	70.73	121	134	110.74	97	111	114.43
3	Hamirpur	133	36	27.06	159	26	16.35	126	31	103.96	128	35	27.34
4	Kangra	584	165	28.25	579	100	17.27	627	129	20.57	569	162	28.47
5	Kinnaur	66	42	63.63	58	98	168.96	44	57	129.54	44	72	163.64
6	Kullu	204	91	44.60	185	55	29.73	196	72	36.73	157	68	43.31
7	Lahul& Spiti	12	11	91.66	19	14	73.68	12	19	158.33	19	14	73.68
8	Mandi	404	155	38.36	356	156	43.82	360	113	31.39	378	117	30.95
9	Shimla	373	153	41.01	437	244	55.83	450	149	33.11	380	186	48.95
10	Sirmaur	270	78	28.88	231	81	35.06	201	92	45.77	248	107	43.14
11	Solan	334	150	44.91	388	117	30.15	427	118	27.63	405	52	12.83
12	Una	274	67	24.45	294	76	25.85	257	85	9.14	238	57	23.95
	Total	3051	1165	38.18	3069	1113	36.26	3095	1076	34.76	2898	1050	36.23

A= Number of Accidents

K= Number of Person Killed

S.I. = Severity Index

Table: 5. Injury index 2011- 2012

Districts	Years	National Highways					State Highways					Other roads				
		A	K	SI.	I	ii	A	K	SI.	I	ii	A	K	SI.	I	ii
Bilaspur	2011	179	27	15.08	268	149.72	21	06	28.57	07	33.33	74	44	59.45	151	204.05
	2012	146	38	26.03	266	182.19	13	04	30.76	15	115.38	59	27	45.76	132	223.72
Chamba	2011	-	-	-	-	-	59	40	67.80	145	245.76	62	94	151.61	108	174.19
	2012	-	-	-	-	-	40	28	70	62	155.00	57	84	147.36	154	270.17
Hamirpur	2011	40	10	25	46	115.00	26	06	23.07	33	126.92	60	15	25.00	141	235.00
	2012	55	16	29.11	131	238.18	21	05	23.81	56	266.66	52	14	26.92	177	340.38
Kangra	2011	260	54	20.77	403	155.00	137	20	14.59	263	191.97	230	55	23.91	353	153.47
	2012	243	69	28.45	436	179.42	82	12	14.63	139	169.51	244	81	33.19	454	186.06
Kinnaur	2011	25	35	140	18	72.00	-	-	- -	-	-	19	23	121.05	32	168.42
	2012	22	52	236.36	42	190.90	-	-	- -	-	-	22	20	90.90	40	181.81
Kullu	2011	54	12	22.22	97	179.62	55	09	16.36	122	221.81	87	51	58.62	191	219.54
	2012	70	19	27.14	118	168.57	38	13	34.21	37	97.36	49	36	73.46	85	173.46
Lahul& Spiti	2011	08	18	225	31	387.50	03	01	33.33	20	666.66	01	-	-	05	500.00
	2012	09	05	55.55	10	111.11	09	08	88.88	23	255.55	01	01	100	-	-
Mandi	2011	187	28	14.97	244	130.48	78	23	29.48	198	253	95	62	65.26	332	349.47
	2012	164	15	44.12	262	159.75	91	29	31.86	204	224.17	120	73	60.83	328	273.33
Shimla	2011	162	39	24.07	247	152.46	50	28	56	111	222.00	238	82	34.45	382	160.50
	2012	125	31	24.80	204	163.20	62	13	20.96	89	143.54	193	142	73.57	370	191.70
Sirmaur	2011	51	22	43.14	63	123.52	64	33	51.56	51	79.68	86	37	43.02	107	124.41
	2012	112	25	22.32	215	191.96	13	07	53.84	35	269.23	123	75	60.97	218	177.23
Solan	2011	196	40	20.41	416	212.24	45	12	26.66	85	188.88	34	07	20.58	78	229.41
	2012	125	31	24.80	179	143.20	26	08	37.76	36	138.46	62	13	20.96	126	203.22
Una	2011	157	23	14.64	207	131.84	103	32	31.06	190	184.46	44	21	47.72	81	184.09
	2012	20	08	40	36	180.00	148	27	18.24	270	182.43	70	22	31.42	130	185.71
Total		2410	617	25.60	3939	267.13	1184	364	30.74	2191	185.05	2082	1079	51.82	4175	200.52

A= Number of Total Accidents
I = Number of Injured Persons
S. I. = Severity Index
I. I. = Injury Index
K= Number of Killed Person

the involvement of car/taxi/jeep is also higher than other vehicles. The involvement of three wheeler is increased in 2012 in comparison to 2011.The involvement of two wheeler is also increased in 2012. The importance of type of vehicle involved in road accidents was also explained in the "Model of road accidents" (Abane, 1993).

Conclusions

In the present study the changing senario of road accidents in Himachal Pradesh is explained. In this it is analysed that the traffic accidents, injuries and fatalities are a serious problem all over the state. By studying the different aspects of road accident some conclusions are drawn which are: The majority of accidents occurred in urban areas in comparison to rural areas because of the higher frequency of vehicles in these areas and dependency of people on transportation system.The four wheeler are more often involved in accidents because of their higher number and also because of the unskilled drivers and other human errors. This is follwed by private buses due to lack of awareness and poor mantenance of vehicles. The number of accidents as well as the number of people injured and killed have been growing during the last two decades as the number of vehicles and the frequency of movement has also increased.The higher number of accidents occurred away from the human settlements and city locations because the drivers are carefree and are not bothered to follow the traffic rules. Though the Climatic conditions of any area may be an important fact in road accidents, yet it has been analysed that the higher number of accidents occurred in fine climatic conditions. Similarly the higher number of accidents took place during the day in comparison to the night time.

Recommendations and policy imperatives:

On the basis of present study some of the suggestions or recommendations are given below to prevent the road accidents. These are :

- The people has responsibity to obey the traffic rules set by the government and other authorities. The proper use of helmet for two wheeler riders and the use of seat belts for other vehicles needs to be strictly followed.
- The speed limits needs to be enforced and the offenders be punished under law.
- Government needs to raise the level of information to the community about traffic safety. Traffic safety topic to be more salient and sensitize the audience to the other forms of communications.
- Road users should change their behavior regarding laws and respect traffic rules and regulations also give their liable contribution to improve them.
- Local government authority and community needs to work together for planning and implementation of road traffic measures in the state to reduce the accidents.
- Government should place different road sign boards and also make speed breakers in the markets to avoid accidents.

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