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Assessing Availability and Consumption of Water Resource Dynamics in Selected Districts of Bihar, India

RASHMI RANI ANAND[1], SWATI RAJPUT[1], SHUBHAM KUMAR SANU[*2] AND PRATYUSH SINHA[1]

[1]*Department of Geography, Shaheed Bhagat Singh College, University of Delhi-110017, Delhi, India.*
[2]*Department of Geography, Delhi School of Economics, University of Delhi -110007, Delhi, India.*
E-mail: rashmiranianandjnu@gmail.com, swatisush@yahoo.com, sk.sanu26@gmail.com, sinhapratyush76@gmail.com
***Corresponding author**

ABSTRACT

Bihar is well known as third most populous and least urbanized State of India. Bihar is lagging far behind in process of urbanization with 11.3% of people living in urban areas. The major share of urban population lives as urban poor with either no access or limited access to basic amenities like safe drinking water. In Bihar, only 4.4% of households have access to tap water connection. As high as 89.6% households of the state depend on hand pump/tube well/bore hole for drinking water. Though, urban reforms were introduced a long ago but their implementation and impact on urban areas are too slow which makes conditions of urban Bihar worse. The present research study is based on primary data. The study carries out critical evaluation of urban infrastructure with special reference to safe drinking water in selected districts of Bihar. The study also analyzes role of urban local bodies, local governance and other related agencies in providing safe drinking water in Bihar. Findings of the study show that liters/capita/day consumption of water is lower than the levels recommended by Bureau of Indian Standards (BIS). Further, the major population of seven districts of Bihar consumes water in range between 50-135 liters per capita per day. Overall people perception about the quality of water is satisfactory but with increasing pressure on drinking water resource its quality has deteriorated over the years and proper management of water resource is required.

Key words: Water, urban poor, urban reforms, drinking water, consumption pattern of water, source of drinking water

INTRODUCTION

The adequate water supply plays major role in smooth functioning of economic, education and health sectors. In nature, water is major component of hydrological cycle and provides various ecological services. The current survival and future of human race can't be imagined in the absence of water (Pal et al. 2014). Climate (evaporation process), culture (importance and value based), food habits (consumption level), work and working conditions (agriculture, industries like leather tanning), development level (infrastructure) and physiography are some factors which determines the need of water in any town/city/society (Chenoweth 2012). But when the basic nature of this essential commodity is altered by the pollutants like industrial waste, chemicals, sewage then it can result in 70 % diseases affecting human health adversely (Cabelli 1983). The social and economic productive time deteriorates (specifically in backward and water deficit) in the absence of efficient water supply infrastructure as children and adults waste major part of daytime in collection of water (Yaqoob and Musavi 2019). Moreover, meagre savings/resources of poor/ economically backward/marginalized sector get wasted in treating water borne diseases like diarrhoea. The Bureau of Indian Standards (BIS) has issued direction/guidelines in order to ensure provision of 200 liters per capita per day (lpcd) water supply for domestic chores. In similar fashion, the World Health Organization (WHO) gives four different categories based on water supply and accessibility. The classification includes i) no access (water availability below 5 lpcd), ii) basic access (average approximately 20 lpcd), iii) inter-mediate access (average approximately 50 lpcd), iv) optimal access (average of 100-200 lpcd). Though the water requirement is perceived differently by different agencies but overall situation is too much chaotic and majority of population is meeting its daily requirement by using impure and unhygienic water.

In developing country like India, it becomes necessary to make provisions for clean, adequate and regular water supply for all sections of society.

The recent Shimla water crisis (2018) points towards alarming situation of water availability in India (India Today 2019). As per authority based reports, 20 cities of India (including four major metropolitan cities) are at the verge to face critical water crisis in near future (NITI AAYOG 2021). Over exploitation of water resources is the result of increased population, agricultural and industrial sector (Sharma et al. 2021). The prevailing scarcity of water have given rise to number of issues like sustainable use, water equity, conflict between states over command of water resources (Gulati and Banergee 2016). In addition to this, pricing, governance and management yet other issues which need to be considered in order to insure uniform and equitable distribution of water resources (Gangwar 2013).

The present study investigates quantity of water consumption at the domestic front and in various socioeconomic groups, sources of water supply. The study also explores the scenario of municipal corporation in water supply and maintenance of water quality and provide a comprehensive outlook about the condition of water supply in Bihar, addressing the major areas of concern and strategies for sustainable management of water resource.

STUDY AREA

Seven districts of Bihar namely Patna, Purnia, Darbhanga, Muzaffarpur, Bhagalpur, Munger and Gaya have been selected as the study area (Fig. 1). The State of Bihar is well known for its rural background and prevailing poverty while the problem of water scarcity/water crisis adds fuel to the fire. The sustainable development goal (SDG) number six talks about clean water and its equitable

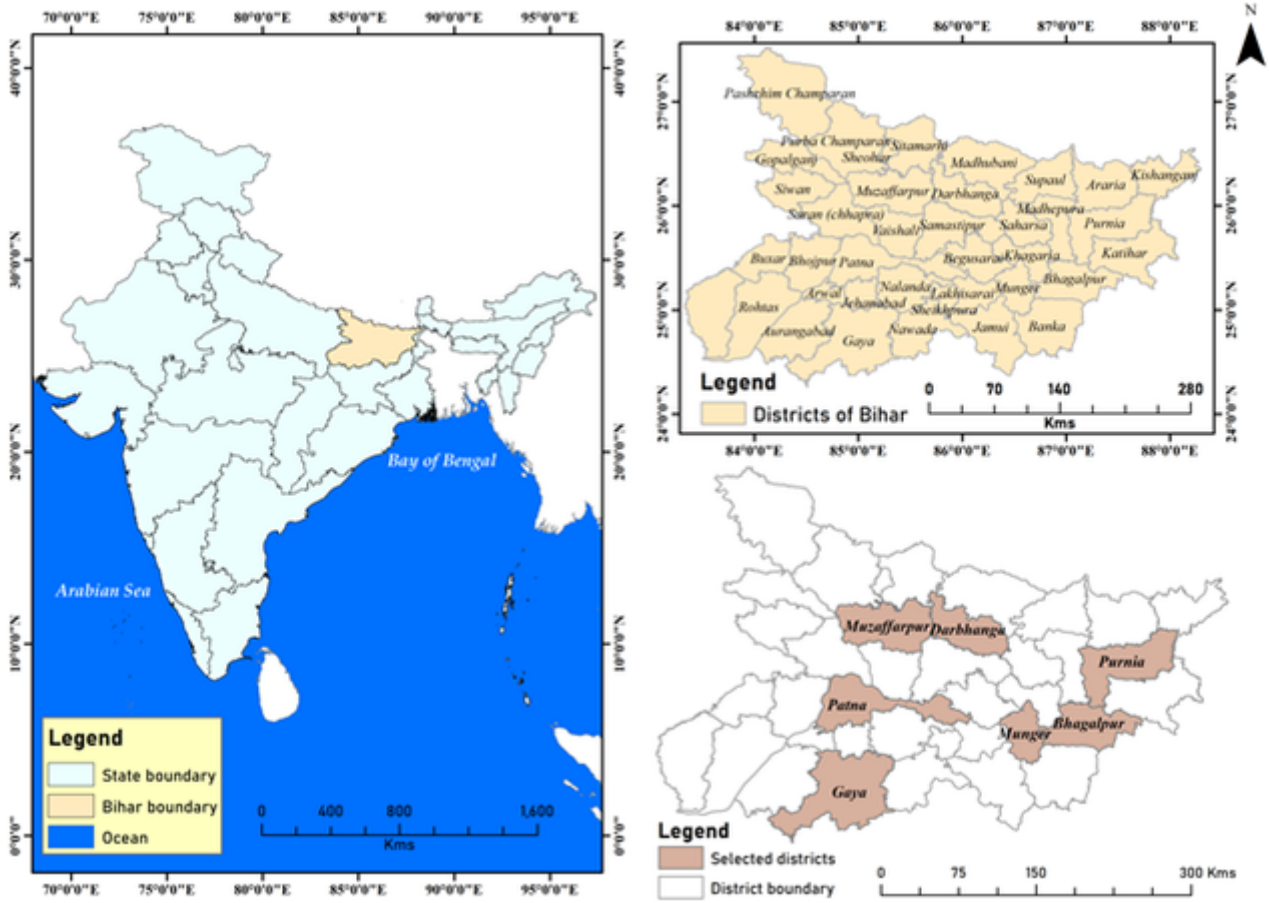

Figure 1. Location map of study area

distribution among the inhabitants. The water scenario in the State of Bihar specifically above mentioned seven districts is posing a serious problem for human survival and other infrastructural developmental activities. The percentage of urban population is quite high in the above mentioned district.

DATABASE AND METHODOLOGY

The present study is based on information collected through field survey conducted during the year 2019. For this field survey, seven districts of Bihar viz. Patna, Purnia, Darbhanga, Muzaffarpur, Bhagalpur, Munger, Gaya were selected. The field survey was restricted to the urban region of the above mentioned districts of Bihar. During field survey, 500 households were investigated from each district making total of 3500 households (7 X 500 = 3500). The information collected about the demographic attributes of households, and other parameters viz. domestic consumption (bathing, washing clothes, cleaning house, cleaning utensils, toilets etc.), liters per capita per day, water supply scenario (municipal water supply, ground water supply, tanker, canal/ rivers, packaged water/mineral water), safety level and consumption in various income groups (upper income group, upper middle class, lower middle class, slums and mixed). The pathway of methodology adopted for the field survey is depicted in the Figure 2. The secondary sources like journals, magazines, newspaper articles, books; reports

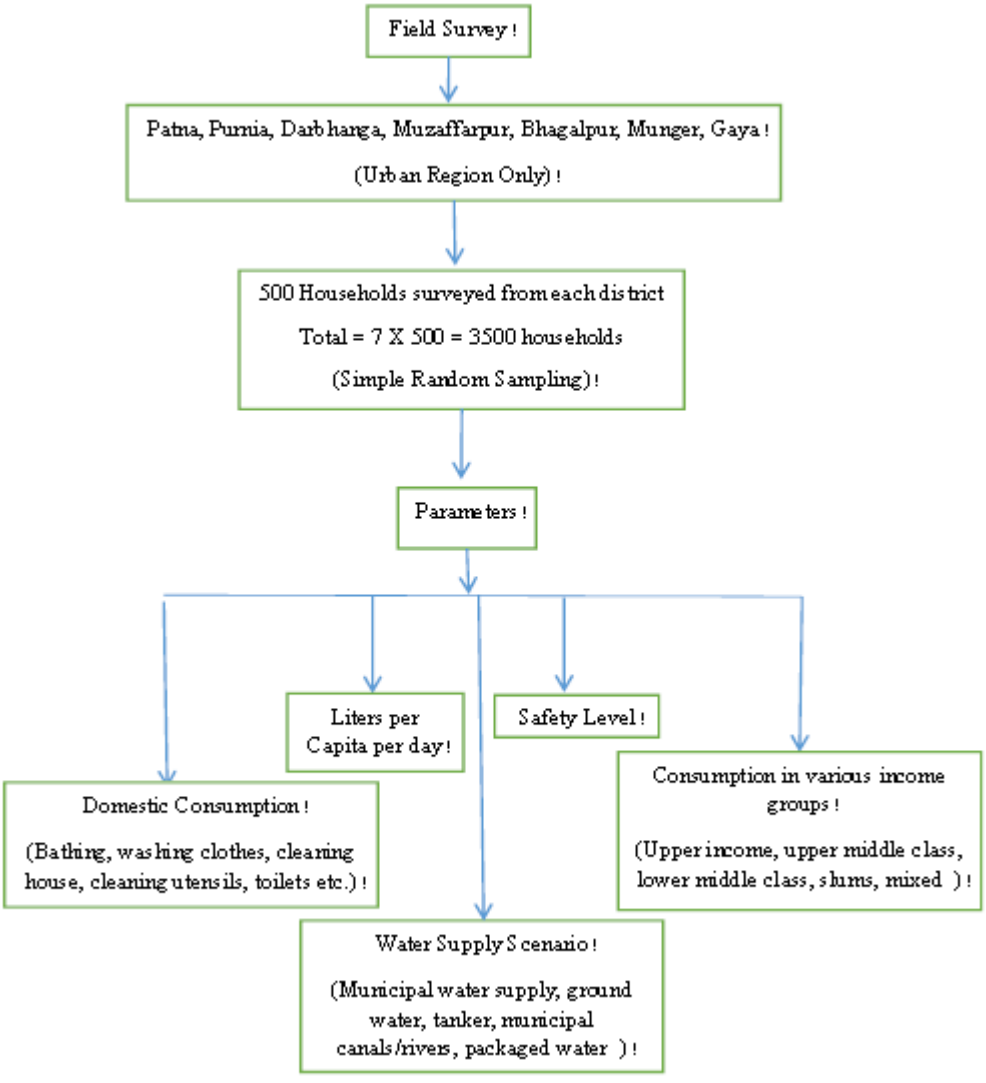

Figure 2. Pathway of methodology adopted for primary survey

(governmental and non-governmental agencies) were consulted in order to understand the background of the study. The collected data were tabulated, represented with the help of Arc GIS and interpreted. Figure 2. Pathway of methodology adopted for primary survey

RESULTS AND DISCUSSION

Demographic attributes of surveyed households

Out of the total sample population of 3500, males (2019) were larger in number as compared to females (1481). The male-female composition (Table 1) in seven districts can be summarized as Patna [males (58.6%), females (41.4%)], Purnia [male (55.6%), female (44.4%)], Darbangha [male (56.0%), female (44.0%)], Muzaffarpur [male (57.2%), female (42.8%)], Bhagalpur [male (59.2%), female (40.8%)], Munger [male (57.4%), female (42.6%)] and Gaya [male (59.8%), female (40.2%)] (Fig. 3).

Domestic Consumption of Water

The domestic consumption covers routine activities viz. bathing, washing clothes, drinking, cooking, toilets, cleaning house, washing utensils etc. The domestic activity of bathing uses major share of water supply and accounts for about 28% of the total water at domestic level. The total consumption in other domestic activities includes 20% (toilets), 18.6% (washing clothes) and 16.3% (washing utensils). The surprising fact was that less than 10% of total water at domestic level is consumed for drinking and cooking (Fig. 4).

District-wise analysis shows that highest proportion of consumption for bathing purpose was 37.1% in Darbhanga. This was followed by 31.7% in Patna, 29.1% in Bhgalpur, 26.6% in Gaya, 25.6% in Muzzafarpur, 23.7% in Purnea and 22.8% in Munger (Table 2). The second category of domestic activities which shows higher consumption of water is use for toilets. The use of water in toilets includes flushing (both half/full flush) and the highest proportion was 25.7% in Gaya followed by 24.1% in Muzzafarpur, 21.6% in Purnea, 20.1% in Bhopal, 19.1% in Munger, 16.5% in Patna, 15.9% in Darbhanga. The third category of domestic activities which consumes major portion of water is washing clothes. The highest consumption was 24.3% in Purnea, 21.4% in Munger, 20.9% in Muzzafarpur,

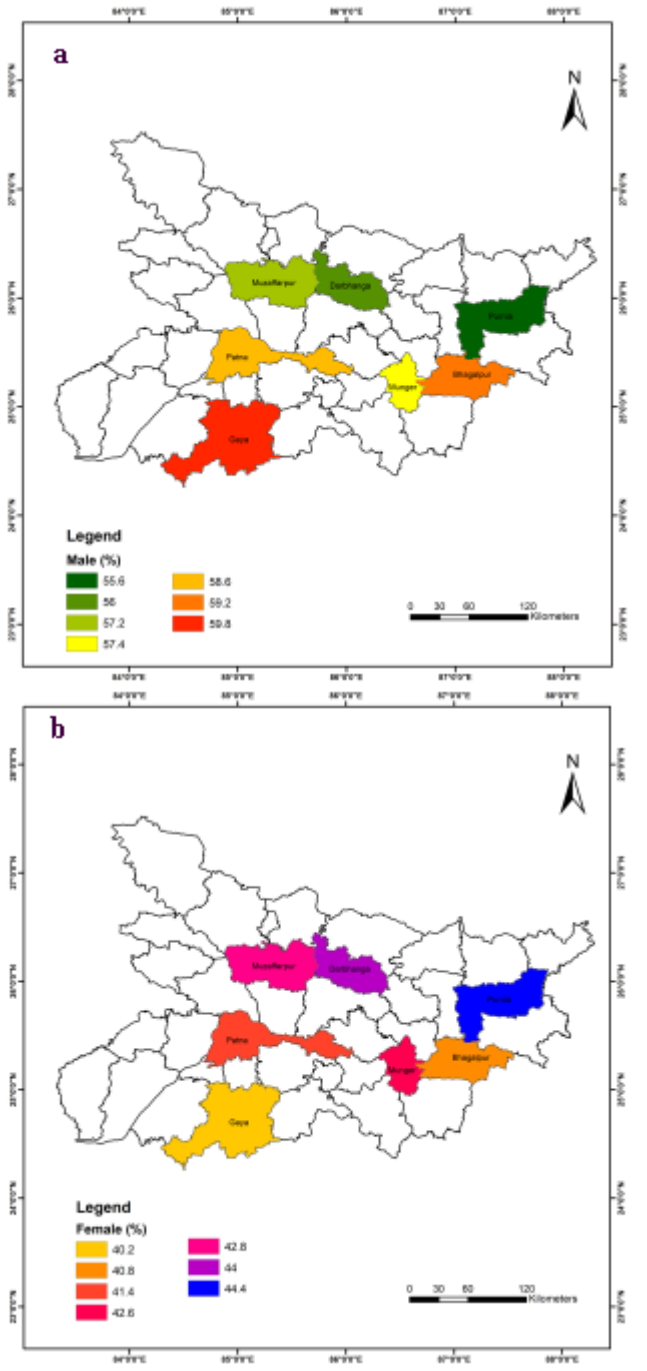

Figure 3. Demographic composition (a) sampled male population (b) sampled female population

16.3% in Bhopal, 14.2% in Patna and 14.0% in Darbhanga. The last category of domestic activities which consumes major portion of water supply is 'washing utensils'. The highest consumption was of 17.4% in Purnea followed by 16.5% in Patna and Muzzafarpur, 16.1% in Darbhanga and Gaya, 15.4% in Bhagalpur and 15.2% in Munger.

The per capita consumption of water in the seven districts of Bihar is lower than the levels

Table 1. Demographic attributes of sample population

Locations	Male		Female		Total
	No.	%	No.	%	
Patna	293	58.6	207	41.4	500
Purnia	278	55.6	222	44.4	500
Darbangha	280	56.0	220	44.0	500
Muzaffarpur	286	57.2	214	42.8	500
Bhagalpur	296	59.2	204	40.8	500
Munger	287	57.4	213	42.6	500
Gaya	299	59.8	201	40.2	500
Total	**2019**	**57.7**	**1481**	**42.3**	**3500**

recommended by Bureau of Indian Standards (BIS) (Table 3). The water consumption is not based on demand but on the basis of supply. The major population of seven districts of Bihar consumes water in range between 50-135 lcpd. The highest percentage of population consuming below 50 lpcd was 29.8 % in Patna and 33.7% in Bhagalpur. The highest percentage of population consuming between 50-75 lpcd was 29.4% in Purnea, 26.4% in Madurai, 24.4% in Bhagalpur. The highest percentage of population consuming between 75-100 lpcd was 34.2% in Purnea, 32.4% in Muzaffarpur, 26.0% in Gaya. The highest percentage of population consuming between 100-135 lpcd was 24.3% in Darbangha, 23.6% in Purnea. The highest percentage of population consuming between 135-175 lpcd was 15.0% in Darbangha, 12.7% in Munger. The highest percentage of population consuming between 175-200 lpcd was 4.8% in Darbangha which also have the highest percentage of population consuming above 200 lpcd (Fig. 5).

Water Supply Scenario

The sources of water supply in the seven districts of Bihar were municipal water supply (community tap and municipal tap water), groundwater (tube wells and hand-pumps; well/open well), tanker, river/canal/ tank, packaged/mineral water and others (railways, broken pipeline, mills, compounds etc.) (Table 4).

Table 2. Domestic activity based consumption of water (%)

Activity	Total	Patna	Purnia	Darbhanga	Muzzafarpur	Bhagalpur	Munger	Gaya
Bathing	28.2	31.7	23.7	37.1	25.6	29.1	22.8	26.6
Washing clothes	18.6	14.2	24.3	14.0	20.9	16.3	21.4	18.9
Drinking	4.2	5.0	4.2	2.6	4.3	3.8	4.9	4.9
Cooking	3.0	3.7	1.7	2.3	3.1	3.2	3.3	4.2
Toilets	20.0	16.5	21.6	15.9	24.1	20.1	19.1	25.7
Cleaning house	7.3	7.0	6.6	11.7	3.5	5.7	12.4	1.9
Washing utensils	16.3	16.5	17.4	16.1	16.5	15.4	15.2	16.1
Others	2.4	5.6	0.5	0.3	2.0	6.3	0.9	1.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 3. 'Litres Per Capita Per Day' consumption of water, Bihar, India

Litres/capita/day	Total	Patna	Purnia	Darbhanga	Muzzafarpur	Bhagalpur	Munger	Gaya
Below 50	17.5	29.8	5.4	11.8	9.0	33.7	19.4	17.0
50 to 75	22.6	22.1	29.4	13.5	21.6	24.4	20.8	26.4
75 to 100	25.3	20.7	34.2	22.0	32.4	17.2	21.9	26.0
100 to 135	20.2	17.2	23.6	24.3	23.4	14.2	18.8	17.4
135 to 175	8.7	5.3	5.0	15.0	8.3	6.9	12.7	10.2
175 to 200	2.2	2.2	1.4	4.8	2.3	1.3	2.2	0.8
Above 200	3.4	2.8	1.0	8.8	3.0	2.3	4.2	2.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

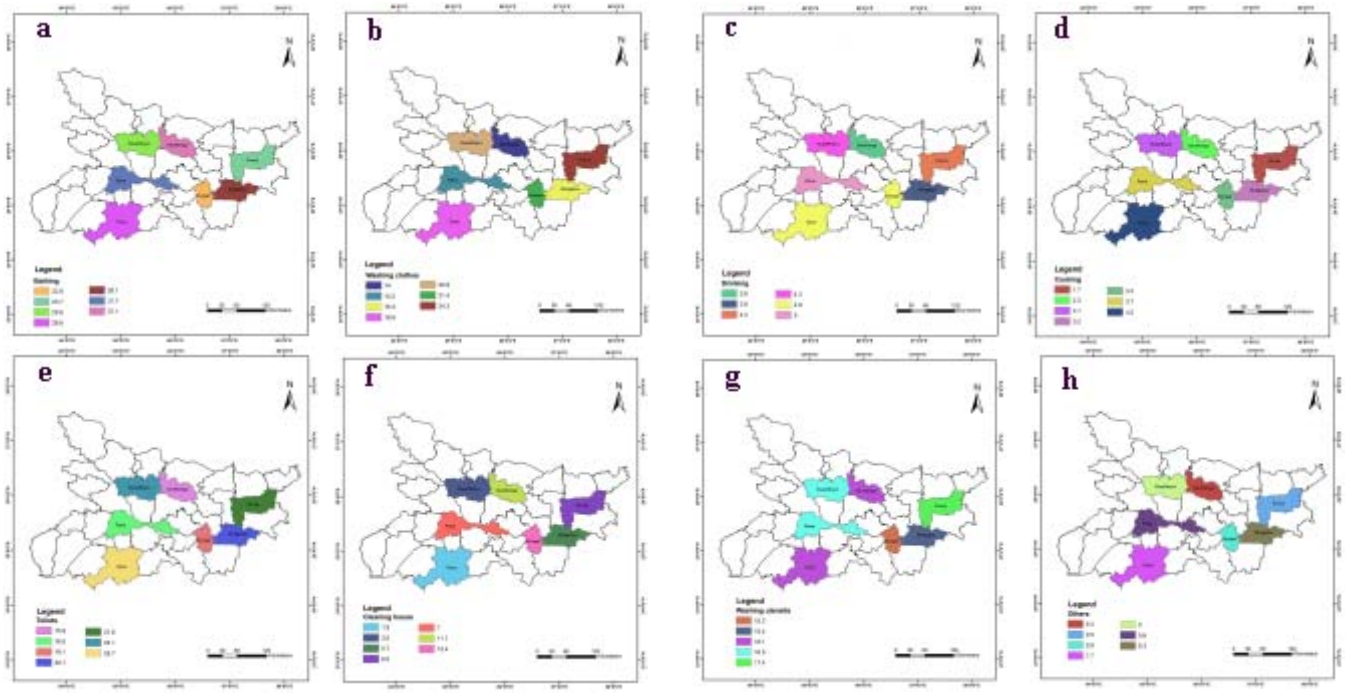

Figure 4. Consumption of water (a) bathing, (b) washing clothes, (c) drinking water, (d) cooking, (e) toilets, (f) cleaning house, (g) washing utensils, (h) others

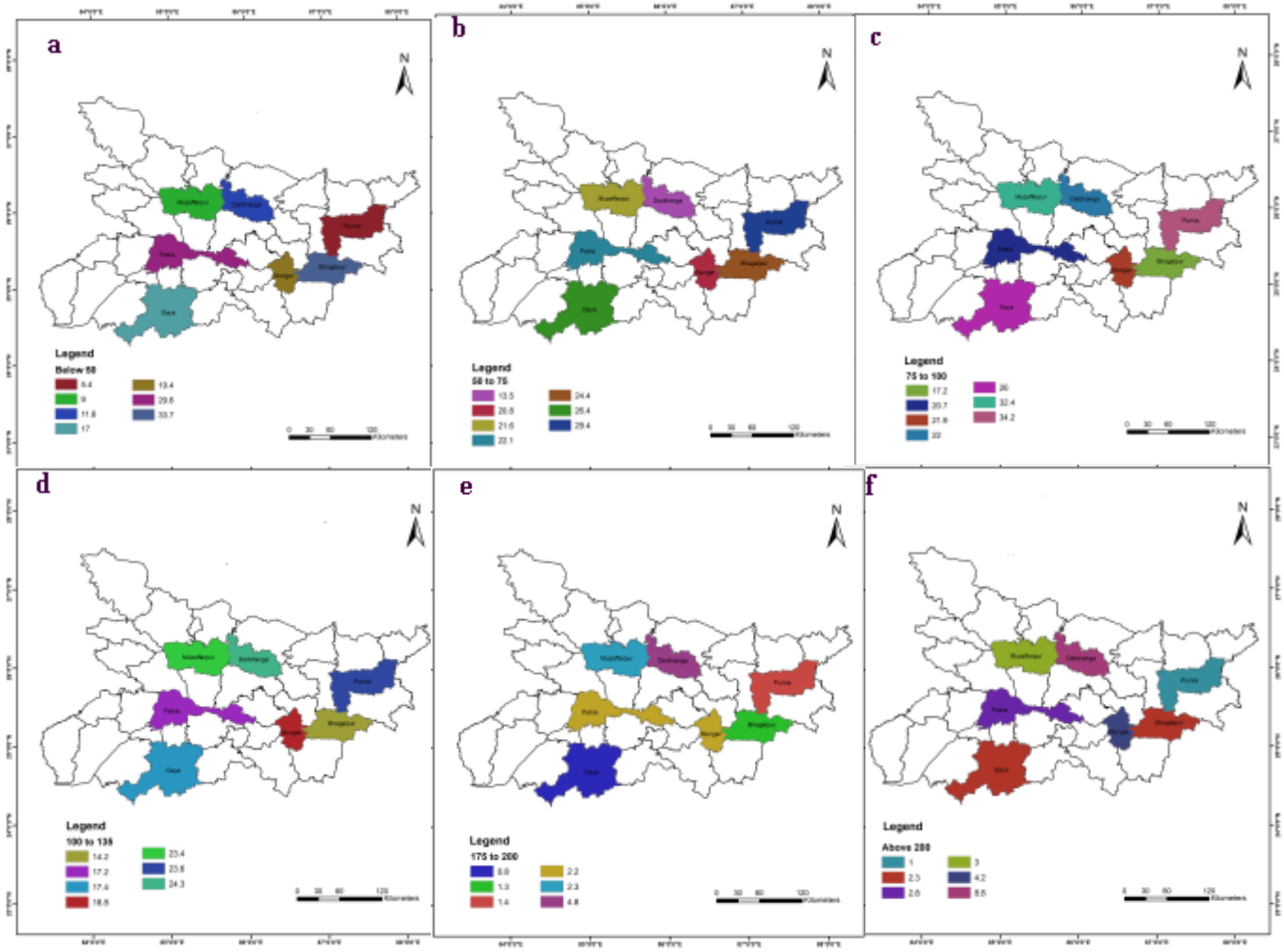

Figure 5. Consumption (lpcd) of water (a) Below 50, (b) 50-75, (c) 75-100, (d) 100-135, (e) 175-200, (f) above 200

The overall water supply scenario in selected seven districts shows that municipal water supply accounts for about 92% and out of this, community tap accounts for 9.5% and municipal tap water stands for 57.6%. Contrary to this, groundwater extraction was lower, about 38.1% (tube wells/hand pumps) and 1.0% (well/open well). The water supply sources like tanker (2.1%), municipal tankers (59.3%), river/canal/tank (0.45%), packaged/mineral water (0.8%) and others (1.1%). The category of 'others' include railways supply, broken pipes, mill compounds etc. The district-wise analysis shows that Muzzafarnagar accounts for highest supply of municipal water supply (99.7%) followed by Darbhanga (98.8%), Purnea (98.6%), Gaya (98.5%), Munger (94.2%), Patna (91.9%) and Bhagalpur (54.1%). The provision of community tap water was more prevalent in Bhagalpur (45.9%) followed by Munger (20%), Patna (8.1%), Darbhanga (1.9%), Purnea (1.5%), Muzaffarnagar (0.3%). In contrary to this, people in all seven districts were more dependent on municipal tap water with Purnea (94.4%) on top followed by Patna (71.4%), Darbhanga (68.5%), Munger (59.6%), Muzaffarnagar (39.7%), Gaya (17.7%), Bhagalpur (15.5%). The ground water extraction is done through tube wells/hand-pumps/open wells. The dependence on groundwater (extracted through tube wells and hand-pumps) was about 38.1% and was much less (1.0 %) on groundwater extracted through wells/open wells. The dependence on tube wells/hand pumps was highest in Gaya (81.1%) followed by Bhagalpur (79.2%), Muzaffarnagar (48.5%), Munger (38.5%), Darbhanga (27.8%), Patna (24.5%), Purnea (3.6%). On the other hand, use of ground water through well/open wells was 3.3% in Muzaffarnagar, followed by 2.8% in Darbhanga, 0.6% in Purnea, 0.2% in Patna. The water supply sources like tanker were more prevalent in

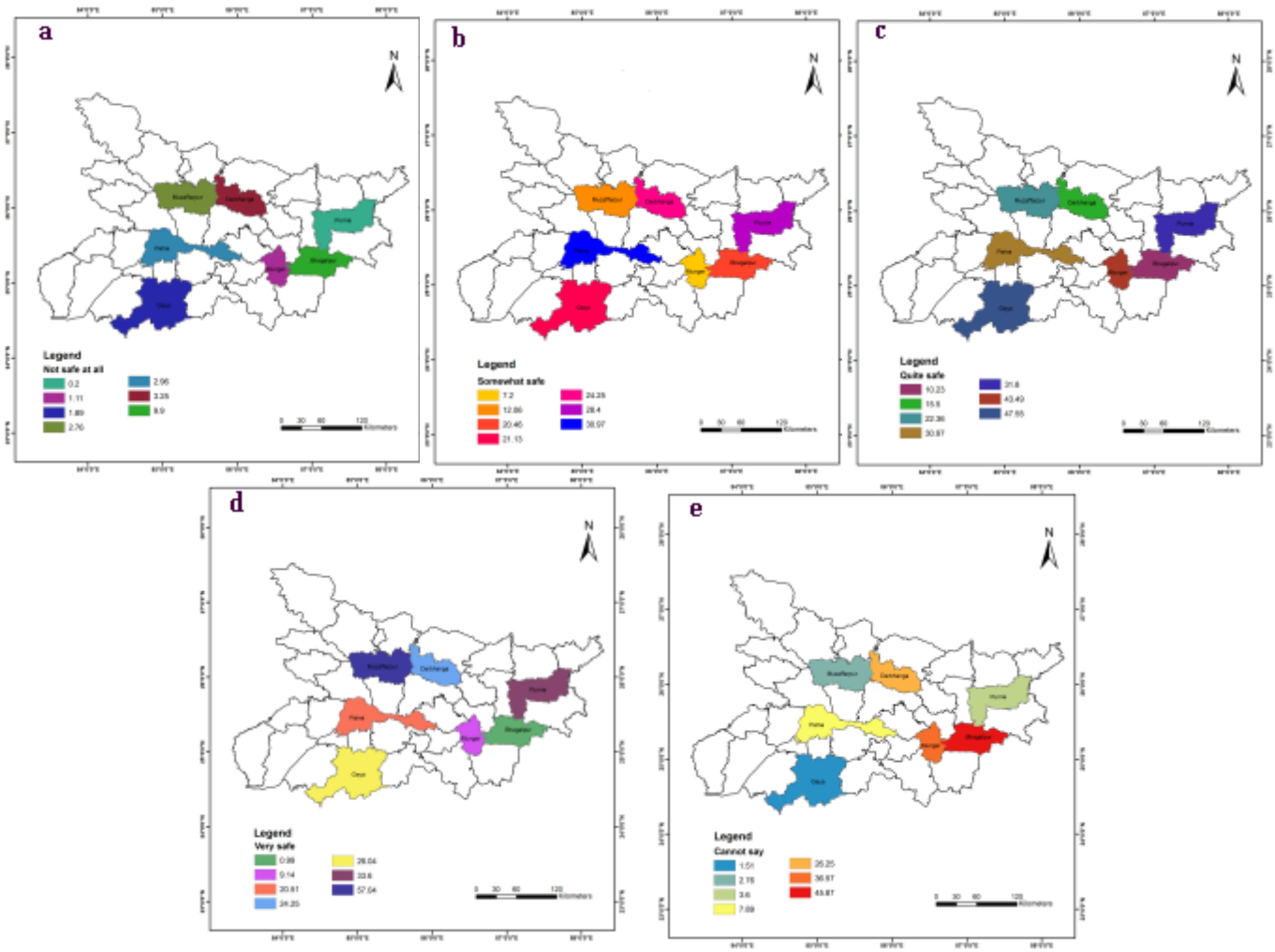

Figure 6. Safety level of water (a) Not safe at all, (b) somewhat safe, (c) Quite safe, (d) Very safe, (e) Cannot say

Table 4. Scenario of water supply (%) in Bihar

Water Source	Specification	Patna	Purnia	Darbhanga	Muzzafarpur	Bhagalpur	Munger	Gaya	Total
Municipal water supply	Total	91.9	98.6	98.8	99.7	54.1	94.2	98.5	92.0
	Community tap water	8.1	1.5	1.9	0.3	45.9	20.0	1.5	9.5
	Municipal tap water	71.4	94.4	68.5	39.7	15.5	59.6	17.7	57.6
Groundwater	Tube well/ hand-pumps	24.5	3.6	27.8	48.5	79.2	38.5	81.1	38.1
	Well/open well (Only Groundwater)	0.2	0.6	2.8	3.3	—	—	5.0	1.0
Tanker	Total	2.0	—	0.5	10.6	—	—	—	2.1
	Municipal tankers	60.0	—	100.0	54.5	—	—	—	59.3
River/Canal /Tank		—	—	2.8	—	—	—	—	0.4
Packaged/ Mineral Water		2.2	1.0	—	0.5	0.3	0.3	0.2	0.8
Others	Railways supply, broken pipes, mill compounds etc.	0.2	0.6	—	—	5.3	5.3	2.5	1.1

Table 5. Safety level of water (%) in Bihar

Safety Level	**Total**	**Patna**	**Purnia**	**Darbhanga**	**Muzzafarpur**	**Bhagalpur**	**Munger**	**Gaya**
Not safe at all	2.9	2.96	0.20	3.25	2.76	9.90	1.11	1.89
Not so safe	5.0	6.71	2.40	6.50	3.02	12.54	2.49	1.89
Somewhat safe	21.5	30.97	28.40	24.25	12.06	20.46	7.20	21.13
Quite safe	28.6	30.97	31.80	15.50	22.36	10.23	43.49	47.55
Very safe	25.6	20.51	33.60	24.25	57.04	0.99	9.14	26.04
Cannot say	16.8	7.89	3.60	26.25	2.76	45.87	36.57	1.51

Table 6 Income group based consumption of water in Bihar

Income class	**Total**	**Patna**	**Purnia**	**Darbhanga**	**Muzzafarpur**	**Bhagalpur**	**Munger**	**Gaya**
Upper Class	57.3	68.4	48.8	39.8	64.6	75.0	42.5	66.7
Upper Middle Class	64.6	78.1	69.2	42.1	61.7	66.1	56.3	76.8
Lower Middle Class	67.4	71.7	76.2	55.7	61.7	70.2	69.2	66.7
Slums	72.5	72.4	74.1	58.1	65.4	82.1	86.1	70.0
Mixed	65.5	72.0	73.1	40.5	62.0	82.8	57.8	67.3
Total	**65.4**	**72.6**	**69.0**	**47.3**	**63.1**	**75.2**	**62.0**	**69.4**

Muzaffarnagar (10.6%) and river/canal/tank in Darbhanga (2.8%). The use of packaged drinking water was dominant in Patna (2.2%).

Degree of safety of water supplied

The people in all seven selected districts were not sure about the question 'How much is safe their drinking water? To examine the aspect of safe drinking water, six broad categories were designed to collect responses of people viz. 'not safe at all', 'not so safe', 'somewhat safe', 'quite safe', 'very safe', 'cannot say'. In totality, people were not sure about the safety of drinking water and gave responses as somewhat safe (21.5%), quite safe (28.6%), very safe (25.6%) (Table 5). On the other hand, 16.8% respondents refused to express their opinion, only 5% considered it as unsafe for drinking purpose while 2.9% considered it as not safe at all. The district-wise analysis shows that people of Patna expressed their opinion for regular water supply for drinking purpose in the order somewhat safe (30.97%)=quite safe (30.97%)<very safe (25.6%). Only 6.71% people considered it as unsafe for drinking while 2.96% as not at all safe to drink. Around 7.89% respondents refrained to express their opinion (Fig. 6). The trend of responses from people from Purnea district was also more or less similar. The responses were in the order of as somewhat safe (28.4%)>quite safe (31.8%)>very safe (33.6%). Only 2.40% considered it as unsafe for drinking while 0.2% as not fit for drinking. Around 3.60% respondents refused to express their opinion on the matter. The responses of people varied in districts namely Drabhanga, Muzaffarnagar, Bhagalpur, Munger and Gaya. In Darbhanga, percentage of people expressing more or less positive opinion about the drinking water were comparatively less. The responses were in the order of as somewhat safe (24.25%)= very safe (24.25%)<quite safe (15.50%). The percentage of people not expressing their opinion was much higher (26.25%) as compared to Patna and Purnea. The responses 'not so safe' (6.50%) and not safe at all (2.76%) were similar as was in Patna and Purnea. The district of Muzaffarnagar had highest percentage of people considering regular water as safe for drinking (57.04%). The responses somewhat safe (12.06%) and quite safe (22.36%) were less. Only 2.76% refrained to express their opinion. While 3.02% considered it as not safe for drinking purpose, only 2.76% considered it as not at all safe. The district of Bhagalpur showed entirely different scenario with 45.78% people refused to express their opinion. While people with opinion of somewhat safe (20.46%), quite safe (10.23%), very safe (0.99%) were less as compared to other districts, people considering it as unsafe for drinking (12.54%) and not safe at all (9.90%) were quite high in Bhagalpur. The district of Munger had 43.49% respondents considered it as safe for drinking while 36.57% of people refused to express their opinion about the safety of drinking water. Only 9.14% of people considered it as very safe for drinking and 7.20% considered it as somewhat safe for drinking. The district of Gaya had 47.55% of people who consider it as quite safe for drinking purpose and 26.04% as very safe. Around 21.13% considered it as somewhat safe for drinking purpose.

Income based analysis of water used

The income based analysis include the categories viz. upper class (above two lakh per month), upper middle class (1,50,001-1,99,999 per month), lower middle class (1,00,001-1,49,999 per month), slums (21,000-39,999), mixed (11,000-20,000 per month). In totality, share of consumption of water was 65.4% for all the above mentioned income groups in the selected seven districts (Table 7). The highest share in water consumption was by slums (72.5%) followed by lower middle class (67.4%), upper middle class (64.6%), mixed (65.5%), and upper class (57.3%). The district-wise analysis shows that the share of water consumption of Patna was about 72.6%. Out of which, the higher percentage of water consumption was by upper middle class (78.1%) followed by slums (72.5%), mixed (72.0%), lower middle class (71.7%) and upper class (68.4%). The water consumption share was 69% in Purnia district. The highest water consumption share was of lower middle class (76.2%) followed by slums (74.1%), mixed (73.1%), upper middle class (69.2%) and lowest percentage is shown by upper class (48.8%). The district of Darbhanga had much lower percentage share in water consumption in all the income classes. The highest percentage is shown by slums (58.1%) followed by lower middle class (55.7%), upper middle class (42.1%), mixed (40.5%), upper class (39.8%). The district of Muzaffarnagar had slightly increased water consumption in all the income

classes. The highest percentage was by slums (65.4%) followed by upper class (64.6%), mixed (62%), upper middle class (61.7%), lower middle class (61.7%). The Bhagalpur district had higher water consumption in mixed (82.8%) and slums (82.1%). This was followed by upper class (75%), lower middle class (70.2%), upper middle class (66.1%). The district of Munger had highest consumption of water in slums (86.1%). This was followed by lower middle class (69.2%), mixed (57.8%), upper middle class (56.3%), and upper class (42.5%). The district of Gaya had water consumption as upper middle class (76.8%), lower middle class (66.7%), slums (70%) and mixed (67.3%) (Fig 7).

Issues of water sector in the State of Bihar

1.Uncertainty in availability of water is the major concern of the population. In summer season the situation become problematic and maximum proportion of population have to use impure water.

2.Low operational efficiency of water resources systems - The problem of limited water availability is further aggravated by low operational efficiency. Two major users of water namely, drinking and irrigation both show avoidable losses. This situation calls for immediate remedial measures.

3.Depleting ground water resources and deteriorating quality of water - With increasing dependence on ground water, the ground water resources are depleting at an alarming rate. Over exploitation of ground water has progressively deteriorated water quality affecting human health. High fluoride, arsenic and other chemical contamination is a cause of worry.

4.High cost of service, low cost recovery and low level of expenditure on Operational and Maintenance (O&M) - There is a need to rationalize the O&M charges to move towards full recovery

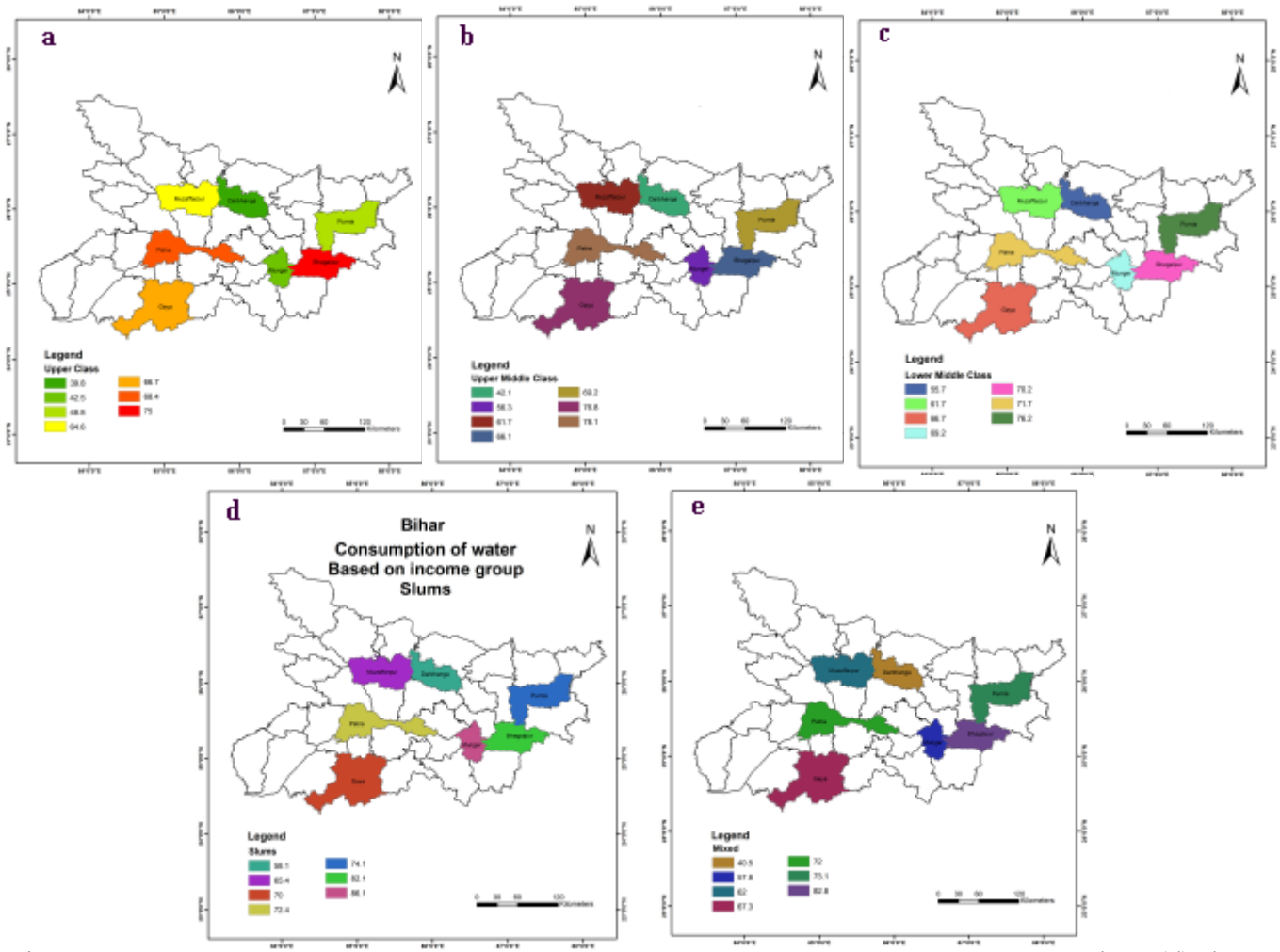

Figure 7. Consumption of water (a) Upper class, (b) Middle upper class, (c) Lower middle class, (d) slums, (e) Mixed

of O&M charges for sustainable development of water resources.

5. Lack of ownership among the stakeholders - The construction and management in the water resources sector is the responsibility of the Government but with the inadequate resources, it is imperative that stakeholders are involved in construction, maintenance, revenue collection and O & M for sustainable results.

CONCLUSION

Water is regenerated in nature through hydro-logical cycle but still, it plays really very crucial role in sustenance of every form of life form on the planet earth. The ever increasing demographic pressure and excessive consumption of water in various economic activities have resulted in unnecessary pressure on water sector leading to water crisis sort of conditions. Unsustainable use of water at domestic front and commercial front has accelerated the rate of exhaustion of this reversible natural resource. The urban population also put undue pressure on water resources of rural areas. Though the consumption of water in seven districts of Bihar is much lower than the prescribed standards but still it poses threat to natural resource. Further findings of the study show that consumption of water from municipal sources like tap, hand pump etc. is high among urban poor which can further lead to ground water depletion. At the domestic front households consume water below than the prescribed standards but are also more or less satisfied with the safety issue of supply water. The domestic activities like bathing, toilets (half and full flush), cleaning utensils etc. consume water more than the other activities. In addition to this, mode of supply of water also varies from one district to another depending upon the infrastructure, topography and physiography of region. Water supply scenario gives mix picture in the seven districts of Bihar. The supply of water by municipal corporation meet out the major part of water demand. To conclude, water supply scenario will face threat as major states have started facing acute shortage of water. The economic sectors like tourism, hotel industry, and food industry require more water and thus creating pressure on water supply in the study area. Overall for sustainable management of water resource in the area of research there is requirement of a comprehensive strategy based on local need and local people participation with effective cooperation of concerned government authorities.

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