3 Vulnerability Assessment of the Agro-Based Households to Climate Change in the Bundelkhand Region and Suggesting Adaptation Strategies

Meeta Gupta, Jyoti P. Patil, and V. C. Goyal

Abstract

Natural disasters like droughts have worsened the conditions of the villages of Bundelkhand region, India. Droughts have caused a diverse impact on the economic, environmental and social conditions of the districts. Therefore, in order to identify the variability of vulnerability, Livelihood Vulnerability Index (LVI) was calculated to assess the vulnerability, with the purpose of identifying relevant adaptation response mechanisms. The index is applied in a comparative study of four selected watersheds of Bundelkhand region, that is Ur watershed (Tikamgarh district, Madhya Pradesh), Kathan watershed (Chhatarpur–Sagar district, Madhya Pradesh), Patrahi–Lakheri watershed (Jhansi district, Uttar Pradesh) and Sajnam watershed (Lalitpur district, Uttar Pradesh). The sub-watershed-based classification was used to assess the vulnerability of people, livelihood and ecosystem to climate change, using primary and secondary data, to identify highly vulnerable sub-watersheds within a watershed, and a comparative analysis was done amongst the four districts. The LVI–IPCC approach was used to reflect the vulnerability based on 39 environmental and socio-economic sub-indicators, through IPCC-identified components: exposure, sensitivity and adaptive capacity. The overall vulnerability results reveal that the Ur watershed in Tikamgarh district was the most vulnerable to climate change than the rest due to high sensitivity and less adaptive capacity. The findings helped in suggesting sector specific as well as overall drought management and adaptation strategies to cope up with the climate change. These can be implemented by the state government and the local bodies to reduce the vulnerability and enhance adaptive capacity of all the four drought-prone districts.

Keywords

Climate change · Adaptation · Bundelkhand · Drought · LVI–IPCC · Watershed

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Abbreviations

BPL	Below poverty line
FGD	Focused group discussion
IMR	Infant mortality rate
IPCC	Intergovernmental Panel on Climate Change
LVI	Livelihood Vulnerability Index
MoWR	Ministry of Water Resources
MP	Madhya Pradesh
MPCST	Madhya Pradesh Council of Science and Technology
NIH	National Institute of Hydrology
NP	Nagar Panchayat
PDS	Public distribution shop
SC	Scheduled Castes
SHG	Self-help group
SRR	Seed replacement rate
ST	Scheduled Tribes
SW	Sub-watershed
TIFAC	Technology Information, Forecasting and Assessment Council
UP	Uttar Pradesh
UPRSAC	Remote Sensing Application Centre, Uttar Pradesh

3.1 Introduction

The Bundelkhand region of Central India is comprised of 13 districts: six districts in Madhya Pradesh (MP) and seven in Uttar Pradesh (UP). The region comes under the semi-arid zone and is significantly sensitive to climate change and prone to droughts. The region is known for its socio-economic backwardness (Development Alternatives 2007). The Planning Commission (Government of India) has identified most of the districts of the region as "the poorest districts of the country" (Development Alternatives 2007).

The region faces a variable climate condition that has been worsened due to irregular rainfall, high evapotranspiration losses, increased run-off and poor soil water retention and large areas of barren and uncultivable land (Chandramauli 2016). The population of Bundelkhand is primarily dependent on agriculture and farm activities for livelihood. Agriculture, livestock rearing and seasonal out-migration provide more than 90% of the rural income in the Bundelkhand region (Samra 2008). Irrigation activities are heavily depended on the water availability. The issues like gradual disappearance of "traditional water management practices" and inadequate "water-harvesting infrastructures" have further added to the stress in the region (Bhisht et al. 2014). The ever-growing population and a parallel increase in the demand for natural resources have left agricultural and water resources in the

region susceptible to increasing climate change risks, affecting livelihoods of local communities. Crop productivity is influenced by the changing weather conditions all throughout the year. South-west monsoon plays an important role during the sowing time in the fields; however, it has been fluctuating drastically in the past few years, causing huge losses to the farmers. These regions experience both development challenges as well as climate-change uncertainties. Thus, focusing on climate adaptation interventions becomes a high priority. In order to assess the livelihood-related vulnerabilities and derive the strategies and solutions for mitigating the impacts of climate change, a vulnerability assessment was conducted in the proposed watershed area.

The concept of vulnerability has been evolving over the years. Vulnerability is "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes" (Parry et al. 2007). Different methodologies have been proposed by scientists to dissect the vulnerabilities to climate change. However, the definition proposed by the Intergovernmental Panel on Climate Change (IPCC) that views vulnerability as a function of exposure, sensitivity and adaptive capacity is widely adopted (McCarthy et al. 2001). The vulnerability framework as proposed by the IPCC is viewed as one of the most powerful analytical tools for assessments (Turner et al. 2003).

The LVI–IPCC vulnerability approach includes the major indicators into three contributing factors to vulnerability and these are exposure, sensitivity and adaptive capacity. According to the IPCC report, exposure is "the magnitude and duration of climate related exposure, such as drought temperature variability or change in precipitation" (Parry et al. 2007). Sensitivity is defined as "the degree to which a system can be affected, negatively or positively, by a change in climate". This includes the change in mean climate and the frequency and magnitude of extremes. The effect may be direct or indirect (Parry et al. 2007). Adaptive capacity is a "system's ability to adjust to climate change (including climate variability and extremes), to moderate potential damage, to take advantage of the opportunities or cope with the consequences" (Parry et al. 2007). The more adaptive a system is, the less vulnerable it is.

The purpose of this study is to assess the vulnerability of people, livelihood and ecosystem with the purpose of identifying relevant adaptation response mechanisms, in the four selected watersheds of Bundelkhand region, that is Ur watershed (Tikamgarh district, MP), Kathan watershed (Chhatarpur–Sagar district, MP), Patrahi–Lakheri watershed (Jhansi district, UP) and Sajnam watershed (Lalitpur district, UP) shown in Fig. 3.1. These selected watersheds give a representation of the overall water scenario in these districts. The area of the watersheds selected is approximately 1000 km^2. For our study, the selected watersheds have been further divided into sub-watersheds on the basis of drainage network, topography and soil types for carrying out detailed study. The sub-watershed level vulnerability assessment was done, mostly on secondary data, to identify highly vulnerable sub-watersheds for further assessment and implementation of pilot adaptation measures.

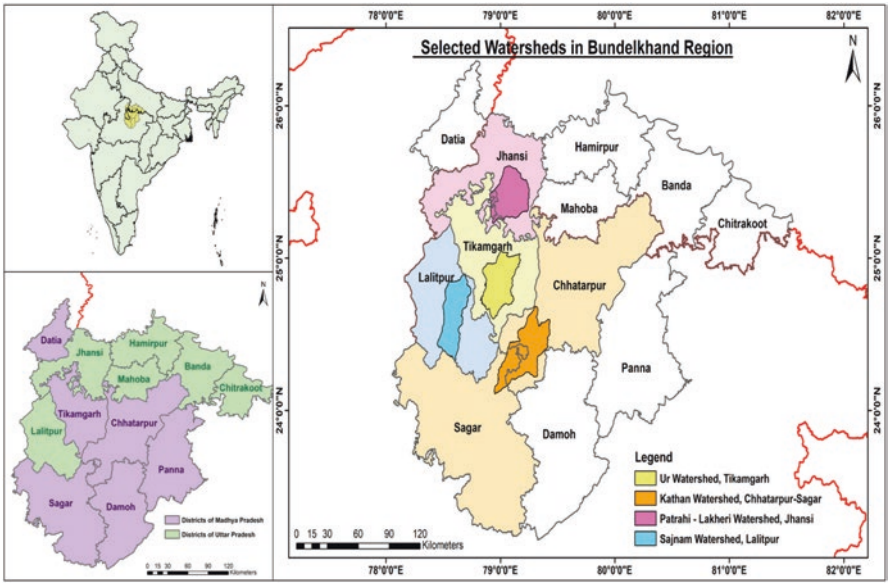

Fig. 3.1 Index map and location map of the selected watersheds

3.2 Physical and Socio-economic Description of Study Area

3.2.1 Ur Watershed, Tikamgarh District, Madhya Pradesh

Tikamgarh District is located at the centre of the historical and geographical region of Bundelkhand of which physical boundaries are formed by Betwa River and two of its tributaries, Jamni and Dhasan. The study area selected for our research is Ur watershed which is located in Tikamgarh district. It is bounded by Chhatarpur in the east and south, while the western and northern boundaries run along Lalitpur and Jhansi districts of Uttar Pradesh, respectively. The mainland watershed area extends between latitudes 24°35′0″ N and 25°05′0″ N and between 78°50′0″ E and 79°10′0″ E longitudes. The total geographical area of the Ur watershed is 991 km^2 and has an elevation of 400 m above the main sea level. The Ur watershed has a maximum length of 119 km from north to south with an average width of about 80 km. The Ur River flows in a north to north-east direction. The watershed has been divided into eight sub-watersheds which is shown in Fig. 3.2.

The Ur watershed area falls under four development blocks of Tikamgarh district, that is Jatara (32.81%), Palera (7.76%), Baldeogarh (27.53%) and Tikamgarh (31.90%). The study area comprises 190 villages with a population of 296,204, which is 20% of the total population of the district (Directorate of Census Operations, Madhya Pradesh 2011a). The population density of the watershed is 299 persons per sq. km. The Scheduled Castes and Scheduled Tribes population is reported as 24% and 6% of the total population of the area. The literacy rate in the watershed area is 51%, out of which 38% is female which is very low than the average literacy

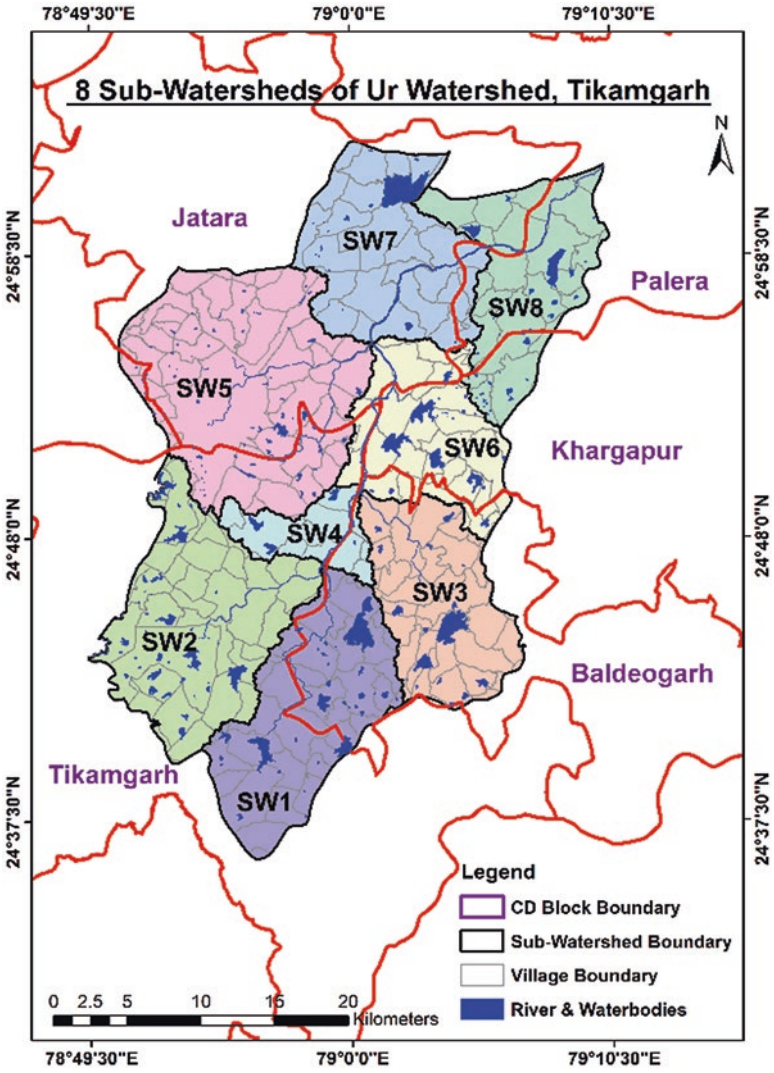

Fig. 3.2 8Sub-watersheds of Ur watershed, Tikamgarh. (Source: MPCST)

rate of Tikamgarh district (61.43%). The watershed suffers from high level of poverty, that is 35.35% of total rural families are below poverty line and also report a low percentage of working population.

Economy of this watershed is primarily based on agriculture. The per capita income generated by farmers per annum ranges from Rupees 5000 to 20,000. Apart from agriculture, people practice livestock rearing and fishery and generate livelihood out of it. The watershed reports a very high migration rate because of almost dry and less productive land. Sub-watershed-wise composition is given in Table 3.1, and the list of villages covered in each sub-watershed is given in Appendix A.

Table 3.1 Sub-watershed-wise administrative description of Ur watershed

S. no.	Sub-watershed	Total geographical area (km^2)	Number of villages	Number of households	Total population
1.	Sub-watershed 1 (SW1)	140	33	9600	45,287
2.	Sub-watershed 2 (SW2)	150	30	6457	33,530
3.	Sub-watershed 3 (SW3)	106	27	8731	38,936
4.	Sub-watershed 4 (SW4)	38	9	3118	14,984
5.	Sub-watershed 5 (SW5)	213	43	9132	54,879
6.	Sub-watershed 6 (SW6)	103	20	7495	33,590
7.	Sub-watershed 7 (SW7)	129	21	8525	43,170
8	Sub-watershed 8 (SW8)	111	18	6279	31,828
	Total watershed	**991**	**201**	**59,337**	**296,204**

Note: 11 villages are common between one or more sub-watersheds; thus, the total number of villages falling under this watershed is 190

3.2.2 Kathan Watershed, Chhatarpur–Sagar District, Madhya Pradesh

Chhatarpur district is located in the central portion of plateau of Bundelkhand region in Madhya Pradesh. It is surrounded by the districts of Mahoba (Uttar Pradesh), Panna, Tikamgarh, Sagar and Damoh. Rivers Ken and Dhasan form the physical boundaries on east and the west, respectively. The study area chosen for the research is Kathan watershed, which is located in Chhatarpur district and partially covers the Sagar district. River Kathan flows in a north to north-east direction. The mainland watershed area extends between latitudes 24°05′0″ N and 24°45′0″ N and between 78°55′0″ E and 79°30′0″ E longitudes. The total geographical area of the Kathan watershed is 1345.08 km^2. Bila dam, a major irrigation project, also exists on River Kathan and is located in Shahgarh block in Sagar district. The watershed is divided into eight sub-watersheds, which is shown in the Fig. 3.3.

The Kathan watershed area falls under four development blocks of Chhatarpur district, that is Bada Malhera (26.84%), Buxwaha (35.43%), Ghuwara (4.86%) and Bijawar (1.97%), and one development block of Sagar district, that is Shahgarh (30.90%). The distribution of the various blocks is represented graphically in Fig. 3.3. The study area comprises 231 villages and 3 towns, with a population of 246,098. The population density of the watershed is 182 persons per sq. km. The Scheduled Castes and Scheduled Tribes population are reported as 23% and 9% of the total population of the area. The literacy rate in the watershed area is 59%, out

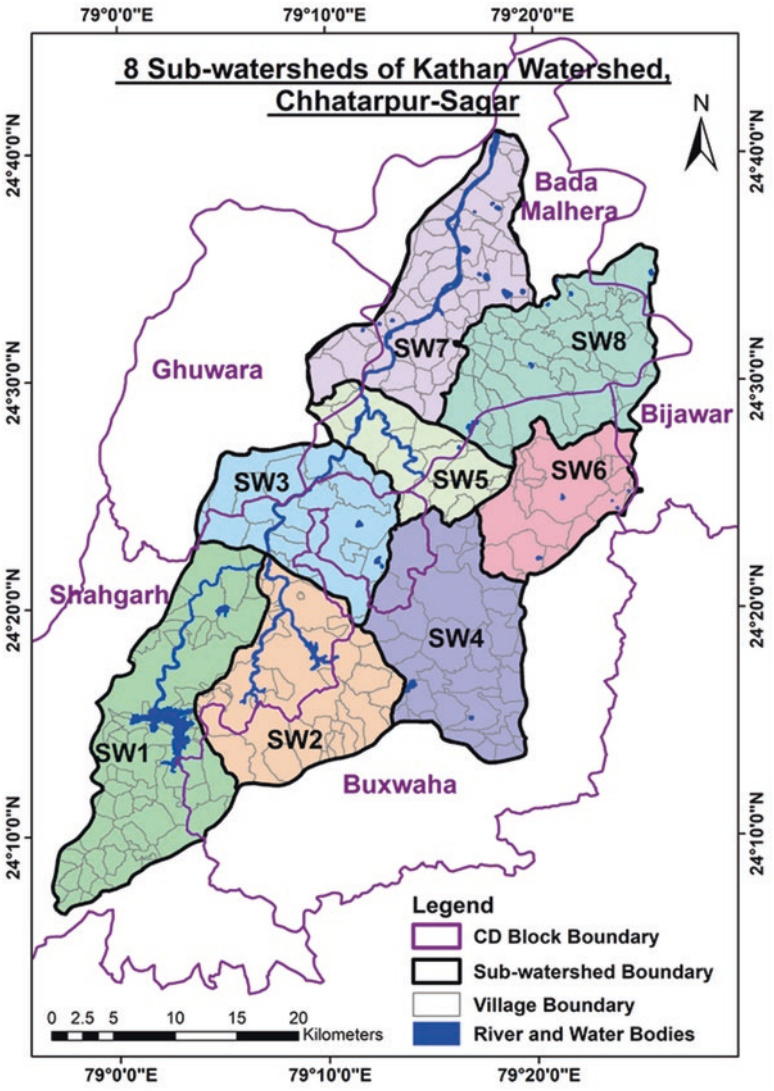

Fig. 3.3 8 Sub-watersheds of Kathan watershed, Chhatarpur–Sagar. (Source: MPCST)

of which 39% is female which is lower than the average literacy rate of Chhatarpur district (63.74%) (Directorate of Census Operations, Madhya Pradesh 2011a).

Agriculture is the prime earning activity for the people in the district, which is not very remunerative. Besides agriculture, farmers practice animal husbandry and fishery and are able to generate annual income in the range of Rupees 49,500–75,000. The landless families migrate to towns and work in bidi making, furniture making, bamboo craft, leather products and incense stick rolling. Sub-watershed-wise composition is given in Table 3.2, and the list of villages covered in each sub-watershed is given in Appendix B.

Table 3.2 Sub-watershed-wise administrative description of Kathan watershed

S. no.	Sub-watershed	Total geographical area (km^2)	Number of villages/ towns	Number of households	Total population
1.	Sub-watershed 1 (SW1)	244.09	55	14,225	63,944
2.	Sub-watershed 2 (SW2)	185.78	29	4669	19,581
3.	Sub-watershed 3 (SW3)	150.44	18	6864	30,860
4.	Sub-watershed 4 (SW4)	186.93	27	4770	22,887
5.	Sub-watershed 5 (SW5)	91.16	10	2156	10,083
6.	Sub-watershed 6 (SW6)	106.83	18	2471	11,428
7.	Sub-watershed 7 (SW7)	185.37	36	11,820	54,984
8.	Sub-watershed 8 (SW8)	194.50	41	7296	32,331
	Total watershed	**1345.08**	**234**	**54,271**	**246,098**

There are 3 towns covered within the watershed area, Shahgarh (NP) in SW1, Buxwaha (NP) in SW4 and Bada Malhera (NP) in SW7

3.2.3 Patrahi–Lakheri Watershed, Jhansi District, Uttar Pradesh

Jhansi district, located in the Bundelkhand region, is surrounded by the districts of Jalaun, Tikamgarh, Hamirpur and Mahoba. The important rivers of the district are Betwa, Pahuj, Dhasan and Lakheri. The study area chosen for the research is Patrahi–Lakheri watershed. Both Rivers Patrahi and Lakheri flow in a north-east direction. The mainland extends between latitudes 25°36′05.04″ N and 25°16′00.62″ N and between 79°03′26.86″ E and 79°07′28.72″ E longitudes. The total geographical area of the Patrahi–Lakheri watershed is 965.38 km^2, out of which 886.40 sq. km is in UP and the remaining 78.60 sq. km is in MP. There is an irrigation project and two medium-sized tanks inside the watershed. The watershed has been divided into four sub-watersheds which is shown in the Fig. 3.4.

The Patrahi–Lakheri watershed area falls under four development blocks of Jhansi district: Mauranipur (22.52%), Bangara (28.40%), Gursarai (38.85%) and Bamour (1.17%), and covers a very small portion of two development blocks of Tikamgarh district: Niwari (8.60%) and Palera (0.47%). The study area comprises 192 villages and 3 towns with a population of 357,666, which is 18% of the total population of the Jhansi district (Directorate of Census Operations, Uttar Pradesh 2011a). The population density of the watershed is 370 persons per sq. km. Scheduled Castes population is reported as 35% of the total population of the area, whereas the watershed has almost nil percentage of Scheduled Tribes population. The literacy rate in the watershed area is 70%, out of which 37% is female, which is lower than the average literacy rate of Jhansi district (75.05%).

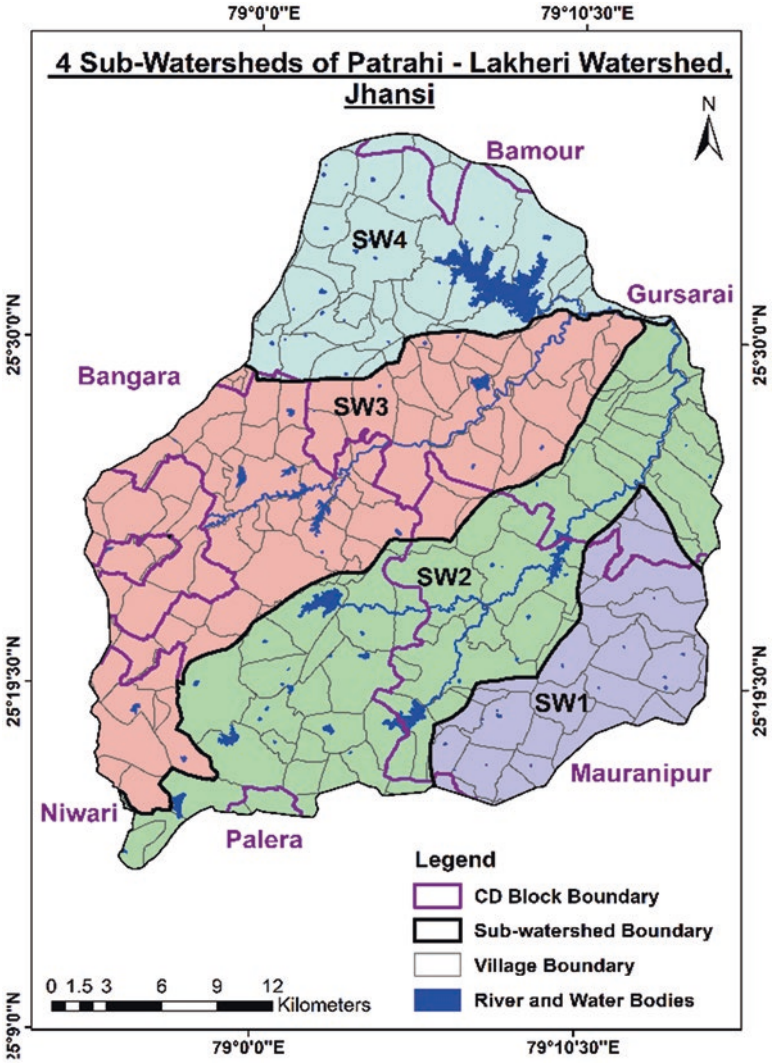

Fig. 3.4 4Sub-watersheds of Patrahi–Lakheri watershed, Jhansi. (Source: UPRSAC)

There is a high-level dependency on agriculture in the rural sector despite having many industries in the district. The farmers generally have an average landholding size of 2–5 hectares. Besides agriculture, farmers practice animal husbandry; fishery and landless families generate income for their livelihood mainly from labour and batai cultivation. The per capita income generated by farmers per annum ranges from Rupees 14,000 to 50,000. There is an increased trend of migration observed. The people usually migrate as they get a higher wage in cities, that is Rupees 250–300/day. The sub-watershed-wise composition is given in Table 3.3 and the list of villages covered in each sub-watershed is given in Appendix C.

Table 3.3 Sub-watershed-wise administrative description of Patrahi–Lakheri watershed

S. no.	Sub-watershed	Total geographical area (km^2)	Number of villages/towns	Number of households	Total population
1.	Sub-watershed 1 (SW1)	124.69	29	11,006	59,482
2.	Sub-watershed 2 (SW2)	320.97	56	23,833	1,27,205
3.	Sub-watershed 3 (SW3)	346.20	75	22,017	1,13,061
4.	Sub-watershed 4 (SW4)	173.52	35	10,891	57,918
	Total watershed	**965.38**	**195**	**67,747**	**357,666**

There are 3 towns covered within the watershed area, Kathera (NP) in SW 2 and Tarichar Kalan (NP) and Tondi Fatehpur (NP) in SW3

3.2.4 Sajnam Watershed, Lalitpur District, Uttar Pradesh

Lalitpur district is surrounded by Jhansi, Guna, Sagar and Tikamgarh districts. The district forms a portion of the hill country of Bundelkhand, sloping down from the outliers of the Vindhya Range on the south to the tributaries of the River Yamuna on the north. Most of the Lalitpur district lies in the watershed of Betwa River. The study area chosen for the research is Sajnam watershed. The Sajnam River flows in a north to north-east direction. The mainland extends between latitudes 24°23′09.87″ N and 24°23′15.66″ N and between 78°30′47.00″ E and 78°30′45.55″ E longitudes. The total geographical area of the Sajnam watershed is 964.55 km^2. Only two irrigation projects exist in the watershed with very few tanks. The watershed is further divided in into four sub-watersheds which is shown in the Fig. 3.5.

The Sajnam watershed area falls under five development blocks of Lalitpur district: Mandwara (18.31%), Birdha (38.27%), Mahroni (7.51%), Bar (35.56%) and Jakhaura (0.35%). The study area comprises 136 villages with a population of 213,161, which is 17% of the total population of the Lalitpur district (Directorate of Census Operations, Uttar Pradesh 2011a). The population density of the watershed is 220 persons per sq. km. Scheduled Castes and Scheduled Tribes population is reported as 21% and 4% of the total population of the area. The literacy rate in the watershed area is 56%, out of which 37% is female, which is relatively lower than the average literacy rate of Lalitpur district (63%).

A vast majority of the population in the watershed relies primarily on agriculture for its livelihood. Landholdings are dominated by small and marginal farmers. More than 73% of the holdings are less than one or two hectares. Besides agriculture, animal husbandry is an integral part of the rural economy. It provides milk and milk products and helps in supplementary income of the people living in villages. Despite the presence of a major power plant falling in the watershed area, people migrate to towns and bigger cities as they are not provided employment. The per capita income generated by farmers per annum ranges from rupees 12,000 to 72,000. The sub-watershed-wise composition is given in Table 3.4 and the list of villages covered in each sub-watershed is given in Appendix D.

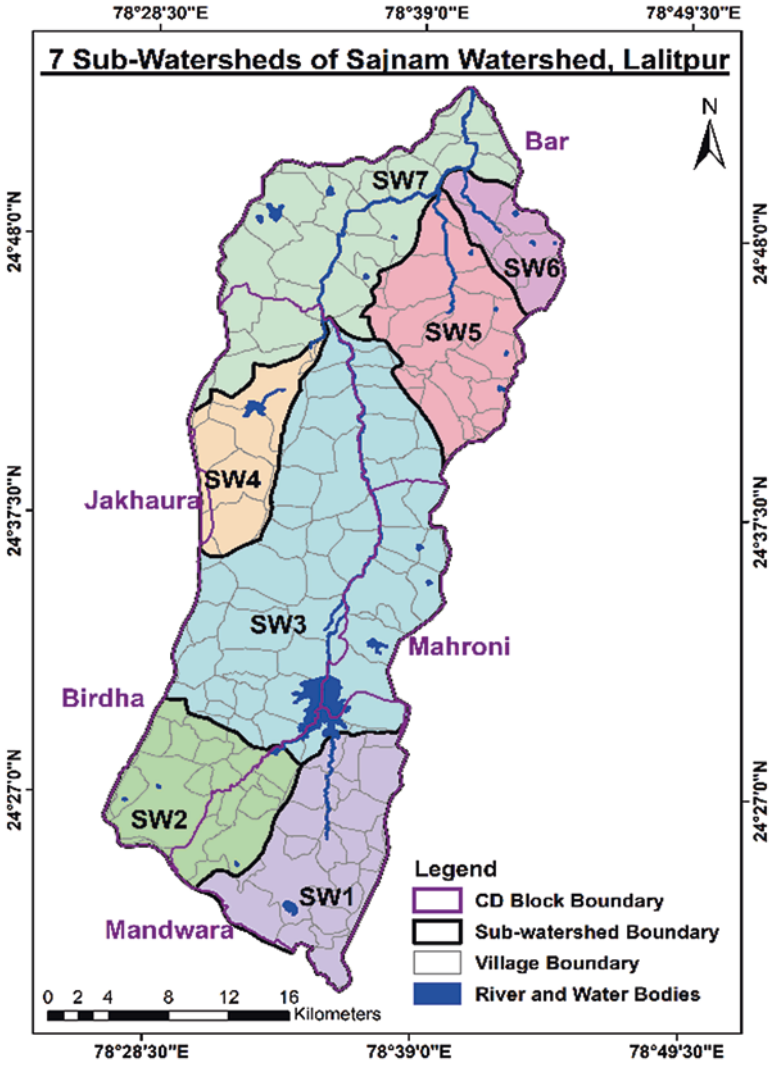

Fig. 3.5 7 Sub-watersheds of Sajnam watershed, Lalitpur. (Source: UPRSAC)

3.3 Climate Description

The climate of the district is characterized by scorching dry summers, erratic rainfall and cold winter. The district receives rainfall from the south-west monsoon during months of June to September. The rainfall pattern is erratic, irregular, scanty and uncertain which causes drought and is a common feature of the district. The details about temperature and rainfall for all the four watersheds have been provided in Table 3.5. The climate data used in this study was obtained from India Meteorological Department.

Table 3.4 Sub-watershed-wise administrative description of Sajnam watershed

S. no.	Sub-watershed	Total geographical area (km^2)	Number of villages/towns	Number of households	Total population
1.	Sub-watershed 1 (SW1)	121.64	19	4732	27,013
2.	Sub-watershed 2 (SW2)	103.64	21	3284	19,085
3.	Sub-watershed 3 (SW3)	337.55	46	13,481	77,830
4.	Sub-watershed 4 (SW4)	66.76	5	2027	12,261
5.	Sub-watershed 5 (SW5)	113.13	12	3453	19,627
6.	Sub-watershed 6 (SW5)	41.39	6	1700	9448
7.	Sub-watershed 7 (SW7)	180.44	27	8626	47,897
	Total watershed	**964.55**	**136**	**37,303**	**213,161**

Table 3.5 Temperature and rainfall details for the 4 watersheds

Watersheds	Minimum temperature (°C)	Maximum temperature (°C)	Average annual rainfall (mm)
Ur watershed, Tikamgarh	7.0	41.8	854.00
Kathan watershed, Chhatarpur-Sagar	7.1	42.3	1068.33
Patrahi–Lakheri watershed, Jhansi	24.1	42.6	837.00
Sajnam watershed, Lalitpur	21.0	42.0	1204.50

The departure analysis of annual rainfall was carried out for all the districts using climate data obtained from India Water Portal, which is given in Fig. 3.6b. The analysis reveals that recurrent droughts, moderate and severe, were experienced in 2006–2007, 2007–2008 and 2010–2011. Moderate drought conditions prevailed in most of the drought years in all the four districts. The average drought frequency varies between 1 in 4 years.

3.4 Methodology

3.4.1 Data and Analytical Tool

For the analysis, village level, block level and district level secondary information have been obtained from the district statistical handbooks and, additionally, validated through in-depth interviews, focused group discussion (FGDs) and observing

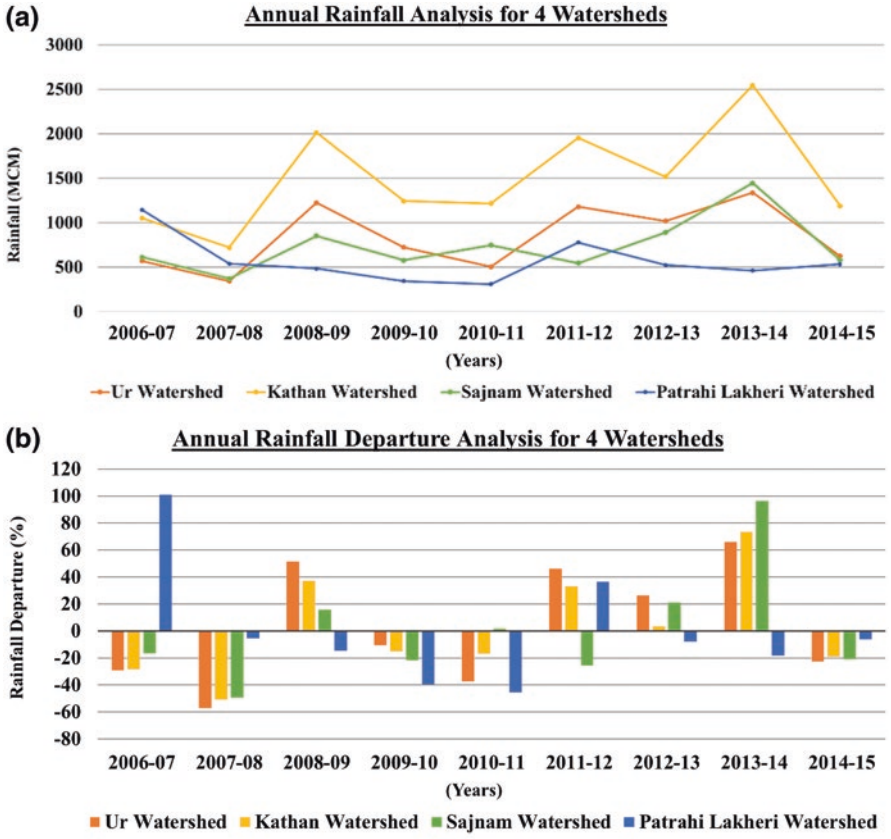

Fig. 3.6 (**a**) Annual rainfall analysis, (**b**) annual rainfall departure analysis

onsite conditions using questionnaires prepared for the purpose. Table 3.6 gives the list of villages that were selected for conducting FGDs, interviews and surveys for the study during the year 2016 and 2017. Each of the FGD composed of 25–30 participants from all age groups and gender.

3.4.2 Selection of Indicators

For the purpose of conducting vulnerability assessment, Livelihood Vulnerability Index was computed for all the four watersheds, and the sub-watersheds of each watershed and were used to derive vulnerability contributing factors, namely "exposure (E), sensitivity (S) and adaptive capacity (A)". These are represented through a number of indicators that would reflect these major components. The description along with the source of data for different indicators chosen is presented in Table 3.7. These indicators were chosen from a broader list of sub-indicators. These are based on literature review, discussions with the experts and nature of relationship with the

Table 3.6 List of villages selected for conducting FGDs/interviews/surveys

S. no.	District	Villages visited for FGDs / interviews/ surveys
1.	Tikamgarh	Bad Madai, Baisa Ugad, Baiwarkhas, Banpura Khurd, Bilgaon, Ghooratal, Gudanwara, Karmasan Hata, Karmaura, Lar Khurd, Lidhouratal, Mahendra Maheva, Mamaun, Manchi, Moramanna, Nainwari, Pali, Papawani, Patar Khera, Patha Khas, Pipra, Samarra, Shyampura, Sujanpur and Vikrampura
2.	Chhatarpur	Amarmau, Bada Malhera, Bamni, Bamnora Kalan, Bhojpura, Bhanguwan, Bilagram, Dalipur, Hirapur, Majhora and Phutwari
3.	Jhansi	Atrauli, Akseo, Barwar, Bacchera, Bamhauri, Bhadokhar, Dhamna Payak, Durgapur, Imlia, Kachaneo, Lidhora, Magawara, Pacchwara, Rajwara, Tondi Fatehpur and Uldan
4.	Lalitpur	Anaura, Bacchrawani, Bagoni, Dulawan, Gangchari, Gona, Jariya, Jharkon, Mirchwara, Narahat, Samogar, Talgaon and Tila

three major components of vulnerability. Through LVI–IPCC, sub-watershed level vulnerabilities were assessed, after which strategies were suggested to cope up with climate change problems.

3.4.3 Calculation of LVI-IPCC Framework Approach

The LVI–IPCC major components, that is exposure, sensitivity and adaptive capacity, were further categorized into 9 indicators with 39 sub-indicators under them. Table 3.8 shows the organization of the 9 indicators in the LVI–IPCC framework.

Firstly, the raw data is collected for the selected 39 sub-indicators which is then transformed into appropriate data measurement units such as percentages, ratios and indices. Secondly, the sub-indicators are standardized as an index using Eq. (3.1) since, each of the sub-indicators is measured on a different scale.

$$\text{Indicator Index}\left(Ix\right) = \left(I_b - I_{\min}\right) / \left(I_{\max} - I_{\min}\right) \tag{3.1}$$

where I_x is the standardized value for the sub-indicator, I_b is the value for the sub-indicator I for a particular sub-watershed and $I_{\min}$ and $I_{\max}$ are the minimum and maximum values, respectively, for each sub-indicator across the sub-watershed.

After standardization, the sub-indicators were averaged using Eq. (3.2) to calculate the profile value of each indicator.

$$\text{Profile Value}\left(P\right) = \sum_{n_{i=1}} \text{Indicator Index}_{I_x i} / n \tag{3.2}$$

where P is one of the 9 indicators for the sub-watershed and index $I_x i$ represents the sub-components, indexed by i, that make up each indicator, and n is the number of sub-indicators in each indicator. The profile values calculated highlight the vulnerability arising through that particular indicator. This is depicted with the help of spider diagrams where the scale ranges from 0 (least vulnerable) at the centre of the web to 1.00 (more vulnerable) at the edge, increasing in increments of 0.20.

Table 3.7 List of indicators and sub-indicators included in computation LVI

Indicators	Sub-indicators	Source of data	Rationale
Climate change and natural disasters (CCND)	Average annual rainfall (mm)	India Meteorological Department, 1991–2013	Higher rainfall is better for the crop growth and also in case of water availability
	Average number of rainy days		
	Inter-annual variation in rainfall		Higher inter-annual variation indicates high probability for occurrence of drought events
	Average number of droughts within 24 years		Increase in such events can further worsen the problems of water availability and water quality, thereby affecting the life of people
	Average number of floods within 24 years		
Demographics (D)	Density of population	Directorate of Census Operations (2011a, b, c, d)	High density is an indication of population pressure on natural resources
	Percentage of child population (0–6 age)		Children are the most dependent section of the society because of limited adaptive capacities
	Percentage of Schedule Caste population		This population is relatively poorer and less educated and depends heavily on natural resources for their livelihood
	Percentage of Schedule Tribe population		
	Sex ratio		The social and cultural structure and sector-specific employment make it harder for women to recover from any tragic event due to limited access to the facilities
	Percentage of marginal workers		These work for less than 183 days, so in order to meet the expenditure for the rest of the year, the villagers migrate to towns in order generate a livelihood
	Percentage of below poverty line (BPL) families	National Resource Cell for Decentralised District Planning (2007–2012), BPL Survey 2002	This population is already deprived of the basic facilities and has limited access to resources to sustain because of which they are less adapted to the climate change stressors

(continued)

Table 3.7 (continued)

Indicators	Sub-indicators	Source of data	Rationale
Health (H)	Infant mortality rate (IMR)	Annual Health Survey (2011–12)	Temperature and rainfall changes may change the geographic range of the vector borne diseases exposing new populations to it
	Per capita public health expenditure (Rs)	Choudary and Amarnath (2012)	Lower expenditure can limit the people to avail the health facilities, thus delayed treatment for the ailments
Agriculture (A)	Percentage of agricultural main workers	Agriculture Census (2011)	A high level of agricultural dependency will increase district's vulnerability to climate change and fluctuation in terms of agriculture trade
	Percentage of cultivators main workers		
	Percentage of marginal agricultural workers		
	Percentage of non-agricultural labour		This population doesn't have stable occupation, and they mostly migrate to towns and cities in search for better opportunities and livelihood
	Cropping intensity		This indicates pressure on the same land for farming. Extensive cropping will require extensive irrigation facilities, making it sensitive to climate change
	Density of poultry population	Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries (2014)	Adverse impacts of climate change can severely affect the livestock and poultry population. Their sensitivities can be increased due to the occurrences of newly unidentified diseases, heat strokes, scarcity of water, non-availability of fodder and low productivity
	Density of livestock population		

Ecosystem (E)	Per cent forest cover	MPCST/UPRSAC (2011)	Forests are highly sensitive to the impacts of climate change as it affects the composition and distribution of forest resources. It can disturb the balance of bio-geochemical cycle, making the forests prone to degradation. It can also affect the forest productivity. Lastly, this may result in habitat shifting of fauna in the region
	Per cent wasteland area	Directorate of Census Operations (2011a)	Wasteland in the region increases the sensitivity due to the loss in land fertility, thus decreasing the land area fit for farming or grazing in the region
	Surface water availability (m^3)	MPCST/UPRSAC (2011)	There is a high reliance on surface water for irrigation, drinking water and other purposes. Variation in rainfall may affect the recharging of ponds and talabs
	Groundwater availability (m^3)	Ministry of Water Resources (2013a, b)	There is a high reliance on groundwater for irrigation, drinking water and other purposes. Variation in rainfall may affect the recharging of groundwater resulting in over-extraction of groundwater resources
	Soil organic carbon (% weight)	Soil and land use survey of India (2007–08)	Low levels can affect the fertility of the soil further, impacting the crop yield
Human capital (HC)	Percentage of women panchayat representatives	MP/UP State Election Commission (2014–2019)	More number of women at administrative positions will understand the problems of other women and, thus, help in the uplifting their status
	Literacy rate	Directorate of Census Operations (2011b)	Increased literacy levels increasing people's capabilities and access to information and thus their ability to cope with adversities
	Number of educational centres		Education level of a population is seen as an important determinant of its quality of life Higher education trains them to cope up with adversities
	Number of health-care centres		Health-care facilities increase the adaptive capacity by providing infrastructures to respond to the health impacts of climate variability
	Number of veterinary care centres		Health-care facilities are important for the livestock as it is an alternative occupation practiced, so it is necessary to maintain the livestock healthy

(continued)

Table 3.7 (continued)

Indicators	Sub-indicators	Source of data	Rationale
Physical capital (PC)	Percentage of households with access to drinking water, within the premises	Directorate of Census Operations (2011b)	Accessibility to adequate water facilities within the village provides easy access to drinking water and carrying out household chores and, thus, reduces time lost for women travelling distances to fetch water
	Percentage of households with access to sanitation facilities		Accessibility to adequate excreta disposal facilities is fundamental to decrease the frequency of associated disease to climate change
	Percentage of households with access to electricity		Access to electricity is fundamental to daily life and for quality life because it is central to all aspects of lives—lighting, heating, pumping, agricultural productivity, refrigeration of food and medicines, etc.
	Percentage of functioning hand pumps	National Rural Drinking Water Programme (2017)	Provision of hand pumps is there in every village, but very few are in working state. For better access and availability, more number of functioning hand pumps should be installed in accordance to the number of households of a village
Social capital (SC)	Number of self-help groups (SHGs)	Directorate of Census Operations (2011b)	Provision of SHGs increased social connectivity and contributes in poverty alleviation and women empowerment
	Number of public distribution shops (PDS)		Availability and accessibility to PDS is important as it enables the supply of food to the poor at subsidized prices. It also ensures that there is equal distribution amongst the villagers and makes them equipped in situations of food shortages
Financial capital (FC)	Access to credit (number of banks/MFI/VC)	Directorate of Census Operations (2011b)	Greater number of these banks in a district implies easy credit to small and marginal framers; these play a pivotal role in the development and transformation of the rural and agrarian economy
	Number of agricultural credit societies		

Table 3.8 IPCC contributing factors to vulnerability and major indictors

S. no.	IPCC major components	Indicators
1.	Exposure	Climate change and natural disasters
2.	Sensitivity	Demographics, health, agriculture and ecosystem
3.	Adaptive capacity	Human capital, physical capital
		Social capital and financial capital

Once the values for each of the 9 indicators for each sub-watershed were calculated, the weights of each major indicator W_P are determined by the number of sub-indicators that make up each indicator and are included to ensure that all sub-indicators contribute equally to vulnerability measurement (Sullivan et al. 2002).

Following the calculation of the profile values of the indicators, they are further combined according to the categorization scheme stated in Table 3.8 into IPCC contributing factors using Eq. (3.3) for calculation of the LVI-IPCC.

$$\text{Contributing Factor}\left(\text{CF}\right) = \sum_{i=1}^{n} W_{P_i}\, x\, P_i \,/\, \sum_{i=1}^{n} W_{P_i} \tag{3.3}$$

where W_{Pi} is the weightage of the Profile I and P_i are the major indicators for the sub-watershed.

Once exposure, sensitivity and adaptive capacity were calculated, the three contributing components were combined and LVI-IPCC of a sub-watershed using the Eq. (3.4):

$$\text{LVI} - \text{IPCC} = \left(\text{Exposure} - \text{Adaptive Capacity}\right) \times \text{Sensitivity} \tag{3.4}$$

Scaling is done from −1 to +1 indicating low to high vulnerability. This is done for each area and then they are ranked in a decreasing order of vulnerability.

3.5 Results and Discussion

3.5.1 Ur Watershed, Tikamgarh District, Madhya Pradesh

The vulnerability indices of the indicators ranged from 0.07 to 0.70 and the differences in vulnerability of the 8 sub-watersheds are presented individually in the spider diagrams (Fig. 3.7).

The vulnerability spider diagram shows that all the sub-watersheds are more vulnerable due to climate change and natural disasters, agriculture and health problems. The climate data indicates that villages have witnessed increasing temperature and decreasing rainfall over the last 24 years that has directly affected the crops, fodder, land, water and forest resources. With such variations in the climatic conditions, the indicator that makes all the 8 sub-watersheds vulnerable is the occurrence of natural disasters. Tikamgarh district exists in the semi-arid regions and is one of

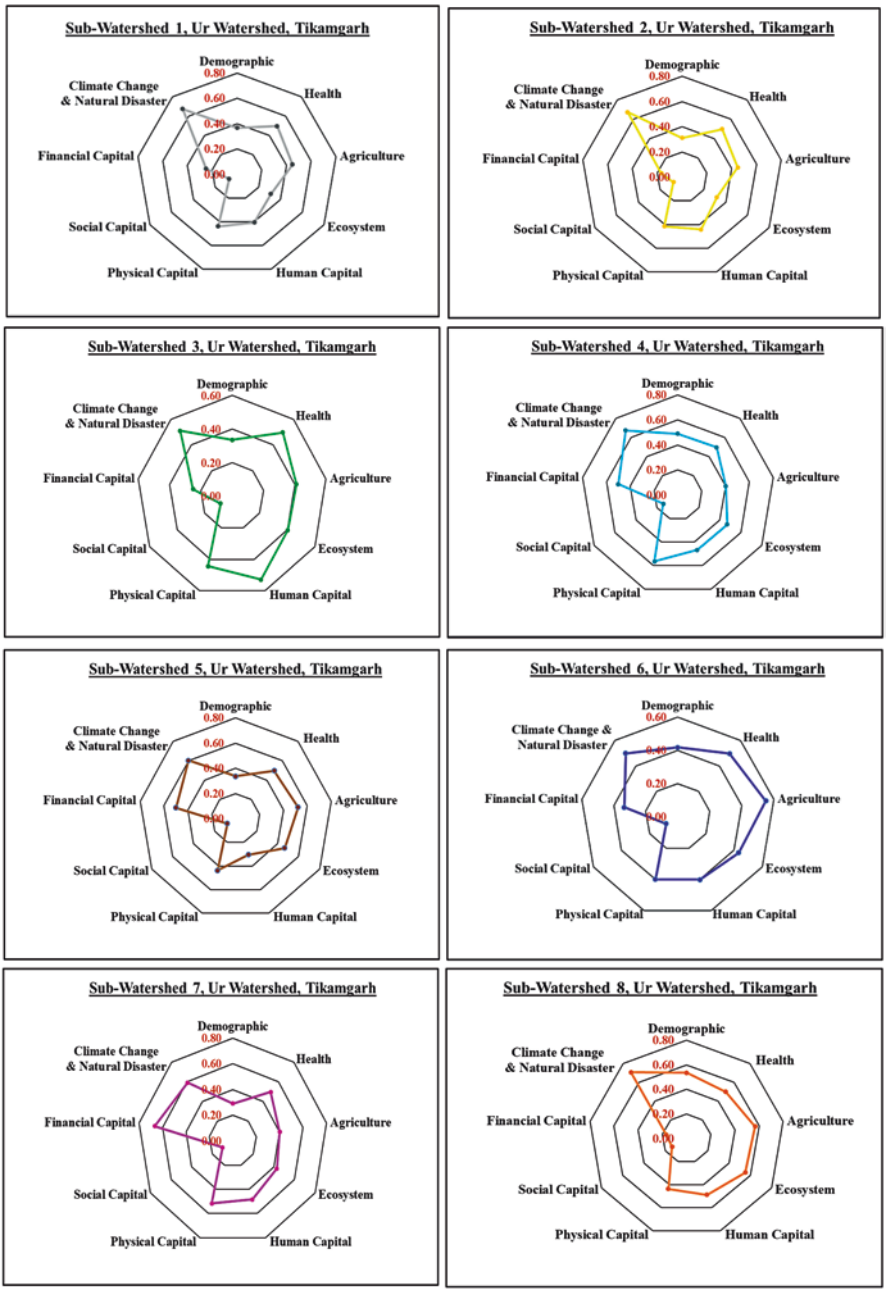

Fig. 3.7 Spider diagrams for the major indicators for 8 sub-watersheds of Ur watershed

the drought-affected districts in Madhya Pradesh. The frequency of occurrence of droughts is once in 4 years. The most drought-prone block is Jatara where the critical dry spells last for more than 17 days and least is Tikamgarh (Songhua 2014). The drought is manifested in the form of late onset and early withdrawal, drying of reservoirs, crop failure, etc. The cumulative build-up of meteorological droughts ripples into hydrological drought with a complex set of highly differentiated adverse impacts and trade-offs. Tikamgarh district is not known as a flood-prone region; however floods are most likely to occur due to excessive rains and release of water from the Matatila dam situated in Uttar Pradesh. The most flood-prone block is Palera and the least is Tikamgarh. Thus, flood becomes one of the major disasters during heavy downpour.

In regards to health services, Tikamgarh is construed as one of the backward districts of Madhya Pradesh. The value of IMR is high against the state value. The district lags behind in providing basic facilities. There are very few health centres present because of which the municipal health workers have to stay in the villages and have to perform deliveries at the patients' houses. They also attend to minor health problems as the district lacks professional doctors and paramedic staff.

With already low levels of health status in Madhya Pradesh, further economic vulnerabilities have worsened the situation, pushing the poor into the trap of poverty. The overall health expenditure is comparatively very low for Madhya Pradesh in comparison with other states, which is a matter of concern. Also it is observed that there is a very slow rise in the health spending both by the central and state government. This can be supported by the fact that there is unequal distribution of resources for health across different states. The result of this is that Madhya Pradesh is unable to generate enough resources through revenue generation and thus is also unable to allocate a greater proportion of budgetary resources for health care.

The district lacks in the access to human, social, financial and physical resources, thereby making them more vulnerable to the adversities of climate change events. Lack of infrastructure to support high school and higher secondary level education has resulted in deterioration in quality of education and hence human resource development. This has further resulted in lower literacy rates and situation far more poor in case of female literacy. The area suffers from low accessibility to drinking water and sanitation facilities. Scarcity of drinking water increases drudgery among women as they have to travel long distance to fetch water in order to carry out the daily household chores. Infrastructural constraints, particularly in the electricity sector, disallow farmers to tap groundwater resources for agricultural irrigation.

Table 3.9 represents the results for the LVI–IPCC, focusing on the three factors contributing to vulnerability: exposure, sensitivity and adaptation. Since the value is larger than 0, all the 8 sub-watersheds are found to be exposed to climate extremes than its adaptive capacity.

The vulnerability triangle diagram (Fig. 3.8) shows the contributing factors for vulnerability index based on the LVI-IPCC approach. The diagram clearly shifts towards right, indicating that the exposure factor contributes majorly to the vulnerability for the entire watershed. As we can see from Table 3.9, the exposure values are higher than adaptive capacity and sensitivity values in all the sub-watersheds,

Table 3.9 LVI-IPCC results for 8 sub-watersheds of Ur watershed

LVI-IPCC components	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8
Exposure	0.67	0.67	0.51	0.67	0.60	0.50	0.59	0.70
Sensitivity	0.39	0.38	0.39	0.46	0.45	0.47	0.38	0.55
Adaptive capacity	0.34	0.33	0.39	0.45	0.34	0.34	0.46	0.37
LVI–IPCC	0.13	0.13	0.05	0.10	0.12	0.07	0.05	0.18

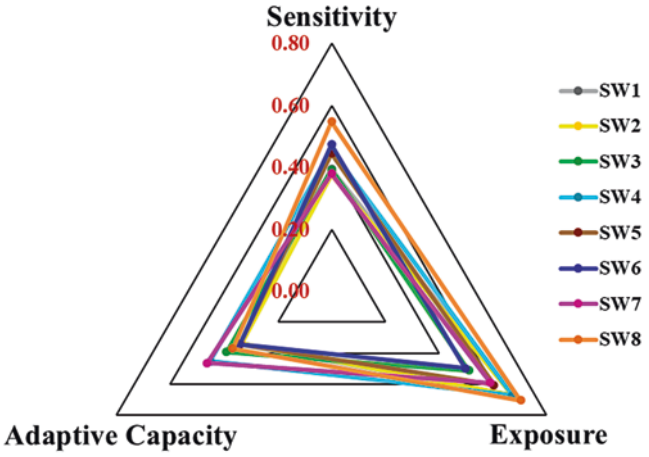

Fig. 3.8 Vulnerability triangle diagram for 8 sub-watersheds of Ur watershed

thereby, indicating that all the sub-watersheds are vulnerable to climate change events in present as well as future.

The following is the order of vulnerability of the eight sub-watersheds of Ur watershed, as shown in Fig. 3.9:

$$SW8 > SW1 > SW2 > SW5 > SW4 > SW6 > SW7 > SW3$$

As per the LVI–IPCC results, the most vulnerable sub-watershed in the Ur watershed is SW8, which falls majorly in the Palera block. The high vulnerability is because the exposure (0.70) and sensitivity (0.55) values are the highest among all the sub-watershed and also are more than the adaptive capacity values (0.37).

At the sub-indicator level, high inter-annual variation in rainfall makes SW8 most exposed to drought and extreme climate change conditions. This indicates high probability of drought years. SW8 falls in the Palera block which also experiences floods occasionally. Villages falling in this sub-watershed, such as Mahendra Maheva and Budaur, are affected by floods (Songhua 2014).

The sub-watershed reports high percentage of marginal agricultural labour, that is workers who work less than 183 days. So in order to meet the expenditure for the rest of the year, the villagers migrate to towns in order generate a livelihood.

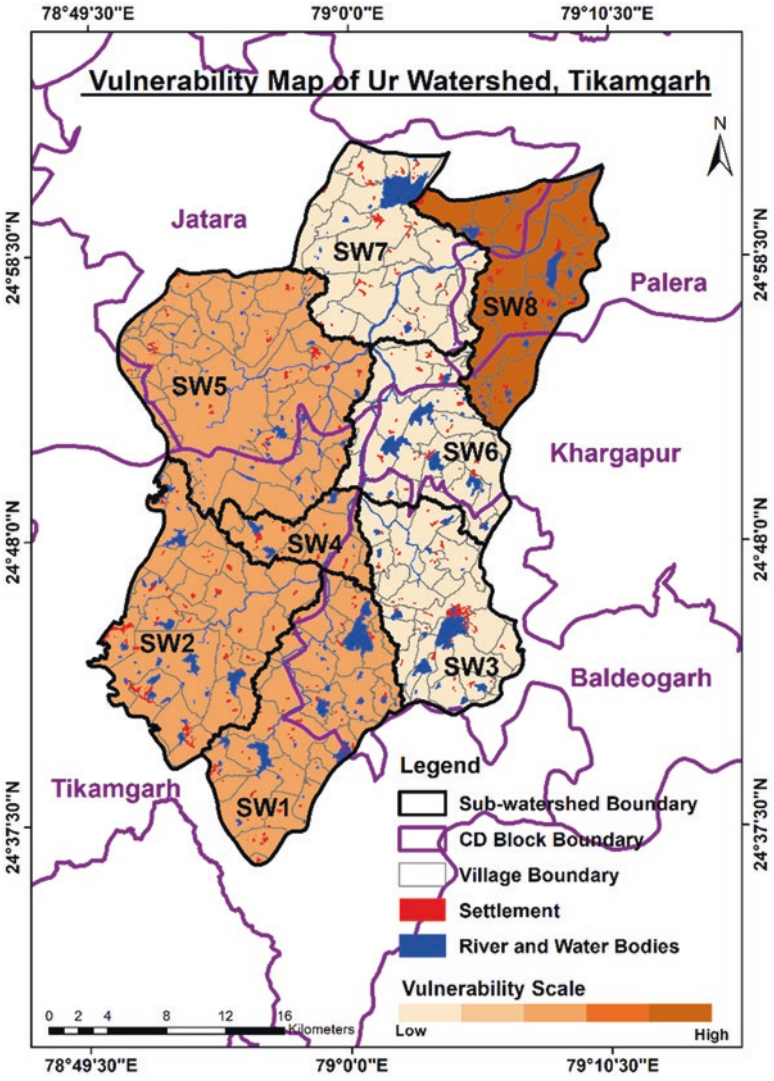

Fig. 3.9 Vulnerability map of Ur watershed

The natural resources of this sub-watershed need to be protected as it can hamper the forest productivity and soil quality to greater extent. The sub-watershed has the highest percentage of wastelands which are left unutilized.

More concentrated efforts are required to tackle the increasing health problems. Financially, more facilities and support are required to be provided to the villagers as they majorly depend on agriculture for their livelihood.

The overall LVI-IPCC scores indicate that SW7 falling in Jatara block is comparatively less vulnerable than other sub-watersheds because of better adaptive

capacity (0.44) and less sensitivity (0.42). The sub-watershed is relatively equipped with infrastructure facilities in comparison to the rest of the sub-watersheds which makes it less vulnerable. It has a higher access to human resources and physical resources that allows them to cope up with the adversities of climate change events. The villagers also have access to primary health centres and medicine centres located within the premises. However, provision of government/private hospitals was there only in the nearby town which provided ambulance van facilities in the villages in case of emergencies. The sub-watershed has a relatively better provision for drinking water facilities within the village premises as result of which women of the villages do not have to travel long distances and lesser time is consumed in fetching water. Most of the houses have electricity connections and receive light for like 12 h a day.

3.5.2 Kathan Watershed, Chhatarpur–Sagar District, Madhya Pradesh

The vulnerability indices of the major indicators ranged from 0.05 to 1.00, and the differences in vulnerability of the eight sub-watersheds are presented individually in the spider diagram (Fig. 3.10).

The diagrams show that all the sub-watersheds fall in somewhat mildly vulnerable zone which is due to better access to human, social, financial and physical resources that allows them to cope up with the adversities of climate change events. Availability of human capital resources is reported to be high in the study area. The villages have facilities for providing basic education to the children and also making them aware and capable to face the adversities due to climate change. Along with the schools, most of the blocks have the provisions for skill development centres. The centres provide trainings to youth in different domains such as information technology, management services, agriculture, telecom, etc., and help them in getting good jobs and generate a livelihood for themselves.

The villages have the provision of primary health centres and medicine centres, located within the premises. However, government/ private hospitals were there only in the nearby towns which do provide ambulance van facilities in the villages in case of emergency.

Considering the financial infrastructures, the villages have provision for cooperative banks, rural development banks and primary agricultural credit societies which deals with the agricultural farmers and help in providing loans to the farmers and rural artisans.

The physical capital resources comprising the basic infrastructure and services are more equally distributed in this region. The villagers have access to water resources for drinking and domestic purposes within the premises of their villages which reduces their time and distances travelled for fetching water. Some households also have electricity connections and receive light for like 12 h a day. Under the Swachh Bharat Mission (implemented by the Ministry of Drinking Water and Sanitation in 2014), toilets have also been constructed within the villages with the

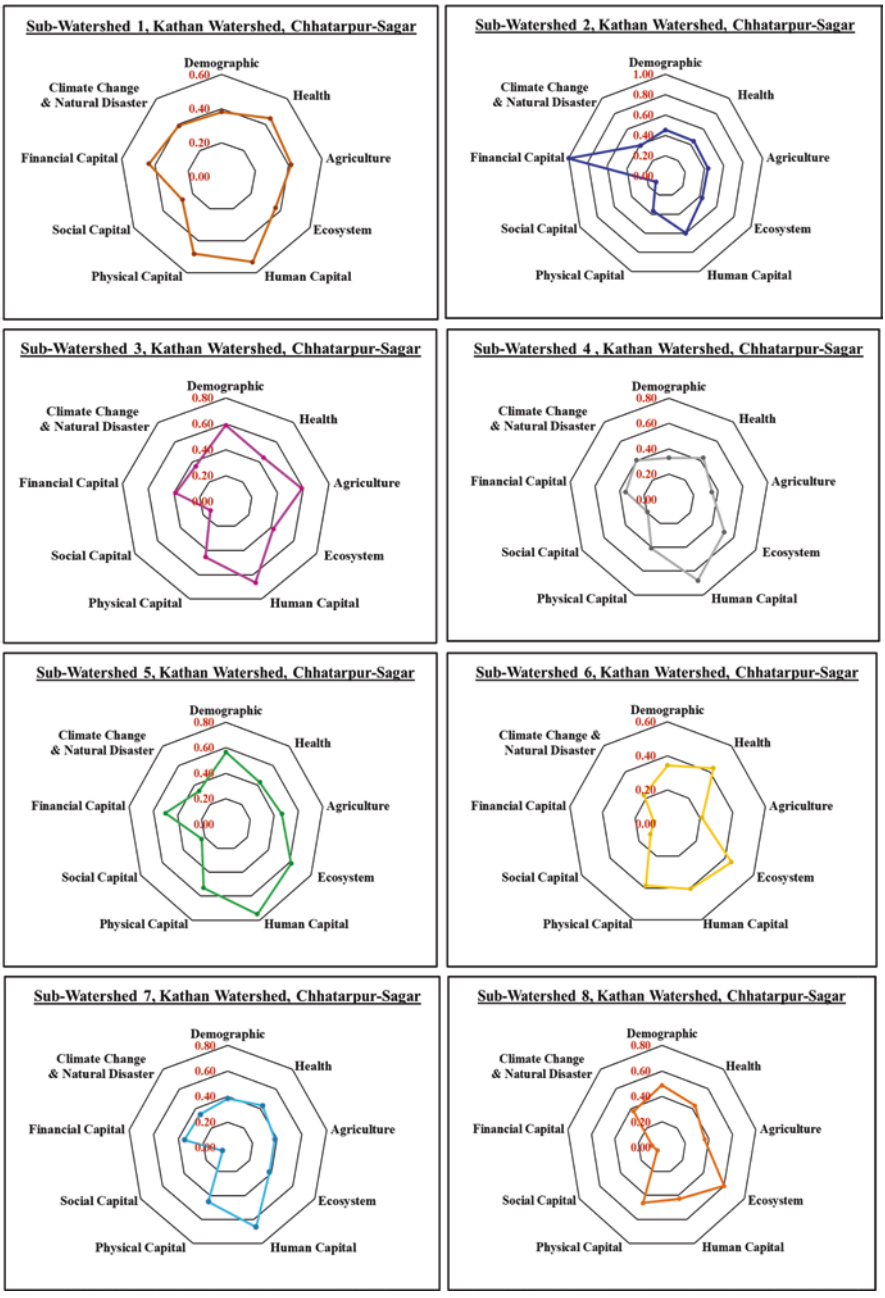

Fig. 3.10 Spider diagram of the major indicators for 8 sub-watersheds of Kathan watershed

Table 3.10 LVI–IPCC results for 8 sub-watersheds of Kathan watershed

LVI-IPCC components	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8
Exposure	0.39	0.39	0.36	0.40	0.34	0.22	0.34	0.37
Sensitivity	0.40	0.44	0.53	0.39	0.53	0.33	0.39	0.47
Adaptive capacity	0.46	0.51	0.48	0.47	0.56	0.31	0.45	0.33
LVI–IPCC	−0.03	−0.05	−0.06	−0.03	−0.12	−0.03	−0.04	0.02

aim of reducing the problems of open defecation and other unhygienic practices. The availability of basic facilities and the provision of important infrastructure facilities have thereby increased the adaptive capacity to any climatic stressor.

The vulnerability is mainly arising due to higher agriculture dependence. Agriculture is the prime earning activity for the people in the district, which is not very remunerative. Majority of the population in the district is of unskilled agriculture labour. There is a lack of proper irrigation facilities and advanced agricultural practices due to which most of the land is used for single cropping. Due to poverty and traditional agricultural inputs, output is not able to meet the needs of growing population. Forward linkages are not up to the need of farmers. Due to lack of market and credit facilities, farmers are facing various problems.

The situation of health has also been evaluated to be quite bad for the district. Due to unhygienic surroundings and open sewage, various diseases like filarial, elephantiasis and malaria are prevalent. Considering a limited availability of medical facilities, many people are not able to get the proper medical attention at the right time.

Table 3.10 presents the results for the LVI–IPCC, focusing on the three factors contributing to vulnerability: exposure, sensitivity and adaptation. The values of adaptive capacity are higher than the exposure and sensitivity values, except the SW8, which indicate that the rest of the sub-watersheds have a higher capacity to adapt or overcome the adverse situations of climate change.

The vulnerability triangle diagram (Fig. 3.11) shows the contributing factors for vulnerability index based on the LVI–IPCC approach. The diagram clearly shifts towards left, which indicates that the adaptive capacity values are higher than exposure and sensitivity to climate change in all the sub-watersheds. This further implies that all the sub-watersheds have a better access to the human, social, physical and financial resources which mobilize them to build resilience to climate change impacts.

The order of vulnerability of the eight sub-watersheds of Kathan watershed is shown in Fig. 3.12:

$$\text{SW8} > \text{SW4} > \text{SW6} > \text{SW1} > \text{SW7} > \text{SW2} > \text{SW3} > \text{SW5}$$

As per the results, the most vulnerable watershed is SW8, falling under the Bada Malhera block of the Chhatarpur district. The sub-watershed reports higher exposure (0.37) and sensitivity (0.47) values and low adaptive capacity (0.33) value indicating that the sub-watershed area is more exposed to and prone to climate changes and its impacts. The condition of drought develops mainly during March–May and

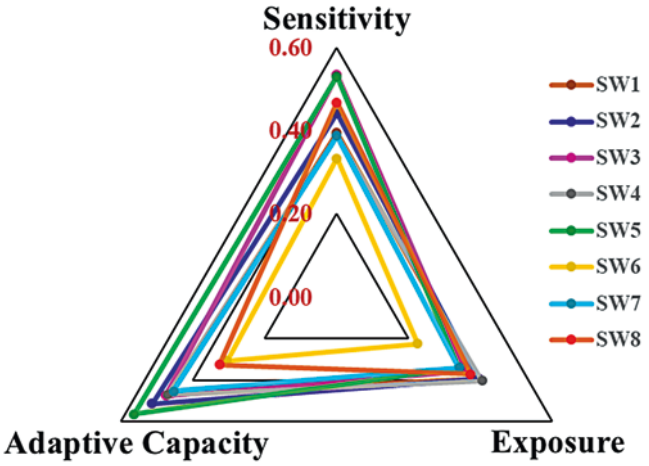

Fig. 3.11 Vulnerability triangle diagram for 8 sub-watersheds of Kathan watershed

is found to be a temporary reduction in water and moisture availability. It has also been reported that bore wells and tube wells dry up in the scorching heat during summer posing severe threats to life.

At the sub-indicator level, the sub-watershed has recorded the highest percentage of Scheduled Castes population. This section of the society, in particular, is characterized by a lack of education and its facilities, an absence of ownership of productive resources, extreme dependence for livelihood on agriculture, economic indebtedness and poor participation in the secondary and tertiary sector. Without education and access to resources, they are not able to realize their strength and opportunities to develop themselves.

The vulnerability is also arising due to high agriculture dependence. The sub-watershed reports the highest percentage of cultivators and lowest percentage of non-agricultural labour. The area suffers from successive dry spells causing heavy amount of crop failure leading to low and unstable agricultural production; as a result, the people are under financial stress.

There is an increasing pressure on the natural resources of this sub-watershed. The sub-watershed reports the lowest forest cover and surface water availability. The area has very few ponds and talabs which have also shrunk in the size over the years due to erratic rainfall and excessive siltation. The natural resources, thus, need to be rejuvenated and protected as it can hamper the forest productivity, soil quality and water availability to greater extent.

On the vulnerability scale, SW5 (which falls in Bada Malhera block and partially in Buxwaha and Ghuwara block) is the least vulnerable amongst the eight sub-watersheds because of highest adaptive capacity value (0.56). The area receives the highest average annual rainfall that helps in the recharging of surface and ground-water resources. In terms of natural resources, the sub-watershed reports the highest percentage of dense forest cover which helps in meeting the requirements of timber,

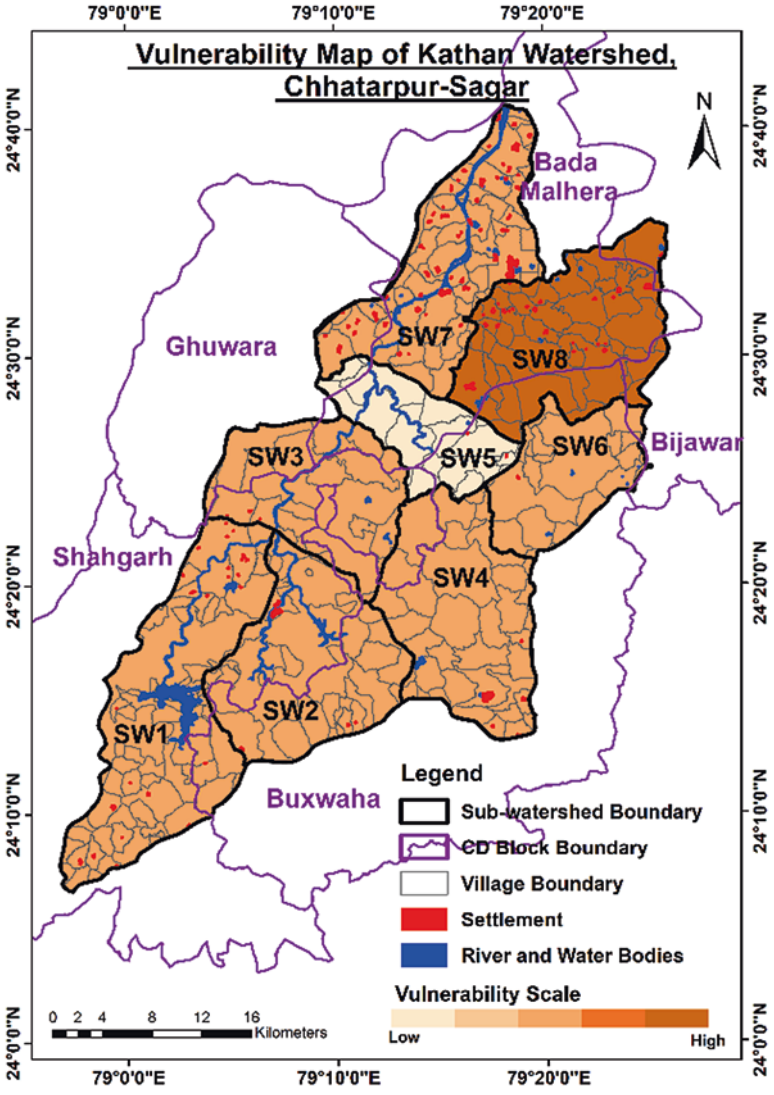

Fig. 3.12 Vulnerability map for Kathan watershed

poles, bamboo and fuel wood for the villagers. The sub-watershed is well equipped with infrastructure facilities in comparison to the rest of the sub-watersheds which makes it less vulnerable. The area is equipped with various facilities within the village premises, such as educational centres up to secondary level, primary health centres, community health centres and medicine shops, animal care centres, etc. Around 66% households have electricity connections in their homes and receive electricity for like 12 h a day. Under the Swachh Bharat Mission, private and

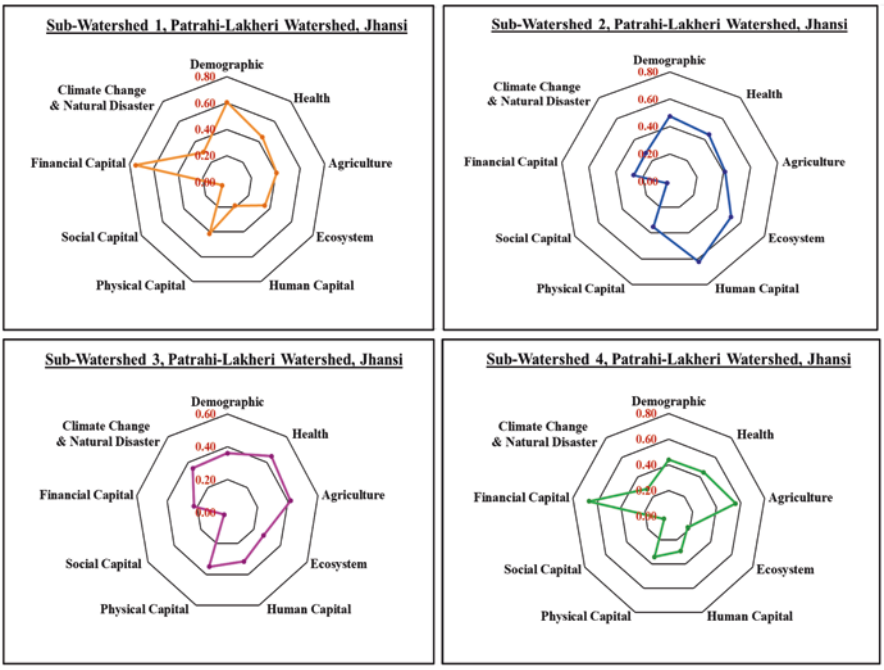

Fig. 3.13 Spider diagrams of the major indicators for 4 sub-watersheds of Patrahi–Lakheri watershed

community toilets have also been constructed in order to reduce the problems of open defecation and other unhygienic practices. The availability of basic facilities and the provision of important infrastructure facilities allow them to cope up with the adversities of climate change events.

3.5.3 Patrahi–Lakheri Watershed, Jhansi District, Uttar Pradesh

The vulnerability indices of the major indicators ranged from 0.02 to 0.75, and the differences in vulnerability of the four sub-watersheds are presented individually in the spider diagram (Fig. 3.13).

The diagram demonstrates that all the sub-watersheds fall in mildly vulnerable zone, which is due to higher access to human resources and financial resources that enable them to deal with climate change impacts. The villages have government schools up to secondary level that provide the students with the fundamental education and make them conscious about the events related to climate change and their impacts. In addition to the schools, many skill-training centres have opened up that deliver vocational training and skilling to help individuals with better employment opportunities and make them financially independent.

Considering the health sector, there are PHCs and medical shops in the villages that provide an integrated curative and preventive health care to the villagers. In case of the severe or chronic medical conditions, there are government/ private hospitals in the nearby towns that can provide proper treatment. To assist the villagers in financial matters, there is provision of agricultural credit societies that provide short term and medium term loans to the farmers and local artisans to meet their financial requirements.

The vulnerability of the sub-watersheds is mainly arising due to the negligence in the health sector. The value of IMR of Jhansi district is less than the state average, that is 70. Some of the reasons responsible for increasing number of infant deaths are malnutrition and lack of facilities on addressing ailments of infants and proving immunization injections. Since the region is mostly rural, there is high level of gender discrimination where girl child is not preferred or very neglected. Further, the existing health infrastructure facilities are the least in the Bundelkhand region. With already low levels of health status in Jhansi, further economic vulnerabilities have worsened the situation, by increasing the miseries of the poor.

The people of the watershed are highly dependent on agriculture as a main source for livelihood. The farmers are small scale with an average landholding size of 2–5 hectares which means that it is mainly them who will be impacted in case of any climate change implications. The cropping pattern is dominated by Rabi crops which occupy major gross cropped area. Cereals like paddy, wheat and pulses like black gram, masoor, gram, peas and oil seeds are the main crops, whereas sesame seeds and vegetables are grown mainly for subsistence. The area suffers from drought leading to recurrent crop failure, due to which there is low and unstable agricultural production. As a result, the people are under financial stress. Moreover, there is a decrease in crop production due to insufficient irrigation, undulated rocky terrain, erratic rainfall, excessive use of fertilizers, inadequate nursery and shortage of cold storages, soil erosion, low carbon and humus content and low seed replacement rate (SRR) for pulses. It has been experienced by the farmers that the onset of monsoons has shifted from June end to July end which has led to delayed sowing and subsequent reduction in crop yield. Apart from these issues, another issue that the farmers face is regarding fixing the price of their produce. Their decision on agriculture inputs is influenced either by large farmers or middlemen in deciding prices as there are no government shops to sell their produce.

Table 3.11 presents the results for the LVI-IPCC, focusing on the three factors contributing to vulnerability, exposure, sensitivity and adaptation, with the help of which a vulnerability map for the watershed was prepared (Fig. 3.14).

Table 3.11 LVI-IPCC results for 4 sub-watersheds of Patrahi–Lakheri watershed

LVI-IPCC components	SW1	SW2	SW3	SW4
Exposure	0.30	0.27	0.35	0.27
Sensitivity	0.46	0.46	0.37	0.42
Adaptive capacity	0.32	0.39	0.27	0.33
LVI–IPCC	−0.01	−0.06	0.03	−0.02

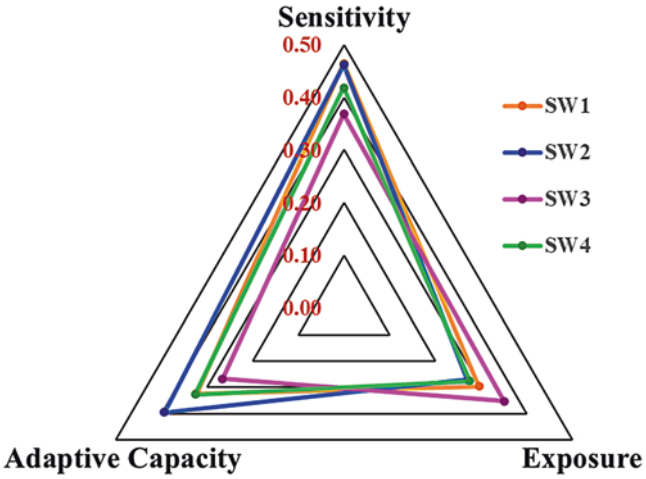

Fig. 3.14 Vulnerability triangle diagram for 4 sub-watersheds of Patrahi–Lakheri watershed

The vulnerability triangle diagram (Fig. 3.14) shows the contributing factors for vulnerability index based on the LVI–IPCC approach. The diagram clearly shifts towards top, which indicates that the all the sub-watersheds are highly sensitive to climate change. The changing environmental conditions have a significant impact on the people, natural resources and the biodiversity. Climate stresses and shocks in drought-prone areas lead to high-scale migration of people as their livelihoods heavily depend on natural resources. The diagram also shows that all the sub-watersheds show high adaptive capacity values indicating that the area is well equipped with facilities and infrastructure which help them to fight back and cope up with the adverse conditions arising due to the climate change impacts.

The following is the order of vulnerability of the four sub-watersheds of Patrahi–Lakheri watershed (Fig. 3.15):

$$\text{SW3} > \text{SW1} > \text{SW4} > \text{SW2}$$

According to the results, the most vulnerable sub-watershed is SW3, which falls in two developmental blocks of Jhansi district, that is Bangara and Gursarai, and very little portion of Tikamgarh district (i.e. Niwari). The sub-watershed experiences high exposure (0.35) values and lowest adaptive capacity values (0.27) in comparison to the rest of the sub-watersheds.

At the sub-indicator level, the sub-watershed receives the lowest average annual rainfall amongst the four sub-watersheds, thus causing impacts on the agriculture as well as on the availability of surface and groundwater. Low groundwater recharge levels have been reported over the years. The situation has further aggravated due to low availability of the functioning hand pumps in the sub-watershed area.

In demographic terms, the sub-watershed reports a high percentage of Scheduled Castes and Scheduled Tribes population. This population is relatively poorer and less educated and deprived of the basic necessities of life, for example they are not allowed

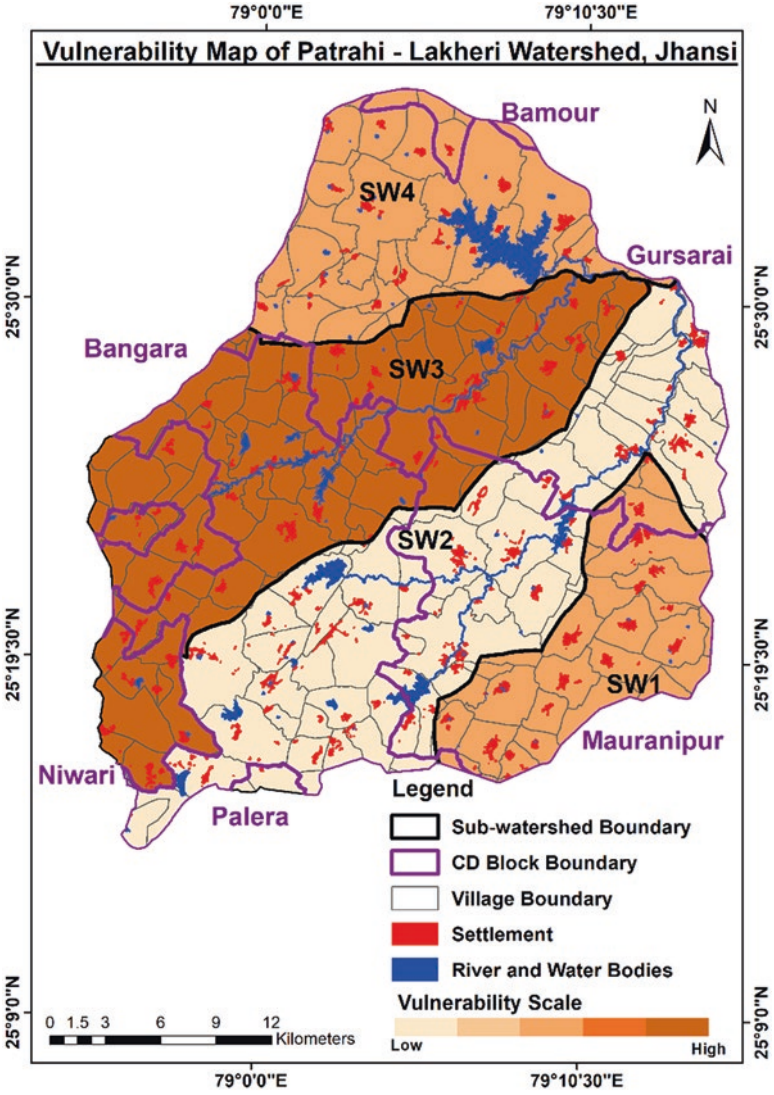

Fig. 3.15 Vulnerability map for Patrahi–Lakheri watershed

to use common village wells and tanks for fetching water and they are not much involved in village meetings and discussions as a result of which the population is left uninformed and unaware. This situation worsens their condition and makes them more sensitive to climate change. The sub-watershed observes the lowest literacy rate, which makes the people less informed and capable in comparison to others and, thus, decreases their ability to cope with adversities. There is a higher level of agricultural dependency in this sub-watershed, which increases sub-watershed's vulnerability to climate change and fluctuation in terms of agriculture trade.

On the contrary, SW2 is the least vulnerable amongst the four sub-watersheds because of better adaptive capacity (0.39) which gives them a better access to resources and facilities that allows them to cope up with the adversities of climate change events. The sub-watershed covers three developmental blocks of Jhansi district (i.e. Bangara, Mauranipur and Gursarai). It reports the lowest percentage of Scheduled Castes and Scheduled Tribes population. There is a lower percentage of cultivators and marginal agricultural labours which highlight that the population under this sub-watershed isn't solely dependent on agriculture for their livelihood. Also the percentage of marginal agricultural workers, that is workers who work less than 183 days, is also low indicating that they practice other occupations by staying in villages and do not migrate too frequently. Considering the natural resources, this sub-watershed reports the highest percentage of dense forest cover which helps in meeting requirements of timber, poles, bamboo and fuel wood for the villagers. The sub-watershed also shows high availability of human capital and social capital resources such as schools, skill development centres, health centres, public distribution shops, etc.

3.5.4 Sajnam Watershed, Lalitpur District, Uttar Pradesh

The vulnerability indices of the major indicators ranged from 0.00 to 0.82, and the differences in vulnerability of the seven sub-watersheds are presented individually in the spider diagram (Fig. 3.16). The diagram shows that all the sub-watersheds fall in mildly vulnerable zone which is due to better access to human, social, physical and financial resources that allows them to cope up with the adversities of climate change events.

The villages have primary and secondary level education centres. Along with these, most of the blocks have the provision for skill development centres that provide a chance to the youth and the rural women to hone their skills and earn a steady income. Skills imparted help in improving employability and livelihood opportunities, reduces poverty, enhances productivity and promotes environmental sustainable development. There is provision for medical facilities available within the district. A good number of sub centres and primary health centres are present in each block as well as one community health centre in each block. The area is well equipped with a number of commercial and cooperative banks, rural banks and agricultural credit societies that have helped the farmers in accessing financial assistance largely. They have also encouraged the rural artisans by providing them loans that have helped them in expanding their work.

The vulnerability of the sub-watersheds is mainly arising due to poor state of the rural health. Although the medical facilities are available in each block, most of the villages still lack the access to the health-care facilities. There is also lack of female doctors and paramedic staff due to which lot of females find difficulty in discussing their medical issues and at times prefer not to consult. Since the region is mainly rural, there have been evidences of high female child mortality, which highlights gender discrimination. This has further added to a higher value of IMR for the

Fig. 3.16 Spider diagrams of the major indicators for 7 sub-watersheds of Sajnam watershed

Table 3.12 LVI-IPCC results for 7 sub-watersheds of Sajnam watershed

LVI-IPCC components	SW1	SW2	SW3	SW4	SW5	SW6	SW7
Exposure	0.35	0.37	0.27	0.38	0.38	0.38	0.38
Sensitivity	0.47	0.50	0.39	0.52	0.41	0.41	0.44
Adaptive capacity	0.43	0.40	0.42	0.51	0.30	0.28	0.41
LVI–IPCC	−0.04	−0.01	−0.06	−0.07	0.04	0.04	−0.01

district. In analysing infant mortality, some of the other dominant factors are maternal factors in the reproduction process, environmental contaminations, nutritional deficiency, injuries to child and practices in the health care of the child.

The economy of the study area is mainly based on agriculture. Cropping pattern is dominated by Rabi crops. The region suffers from drought or flood consistently due to which there is low and unstable agricultural production, and consequently the farmers are under financial stress. Moreover, crop production experiences severe problems in district due to poor irrigation, undulated rocky terrain and erratic rainfall, thereby making the watershed vulnerable.

Table 3.12 presents the results for the LVI–IPCC, focusing on the three factors contributing to vulnerability: exposure, sensitivity and adaptation.

The vulnerability triangle diagram (Fig. 3.17) shows the contributing factors for vulnerability index based on the LVI–IPCC approach. The diagram clearly shifts towards top, which indicates that all the sub-watersheds are highly sensitive to climate change. The changing environmental conditions have a significant impact on the people, natural resources and the biodiversity. Climate stresses and shocks in drought-prone areas lead to high-scale migration of people as their livelihoods heavily depend on natural resources.

The diagram also shows that all the sub-watersheds show high adaptive capacity values indicating greater access to human, social, physical and financial facilities and infrastructures to the villagers which together enable people achieve their livelihood objectives and help in uplifting their poverty status. These services also make them aware and prepare them to face and cope up with climate change impacts.

The following is the order of vulnerability of the seven sub-watersheds of Sajnam watershed, as shown in Fig. 3.18:

$$SW6 > SW5 > SW7 > SW2 > SW1 > SW4 > SW3$$

The most vulnerable sub-watershed is SW6, which falls in Bar block of Lalitpur district because the sub-watershed reports the highest exposure value (0.38) which is more than the adaptive capacity (0.28). In fact, the adaptive capacity value for the sub-watershed is the lowest amongst all the sub-watersheds.

At the sub-indicator level, the sub-watershed reports a higher percentage of Scheduled Caste population. This population continues to be oppressed,

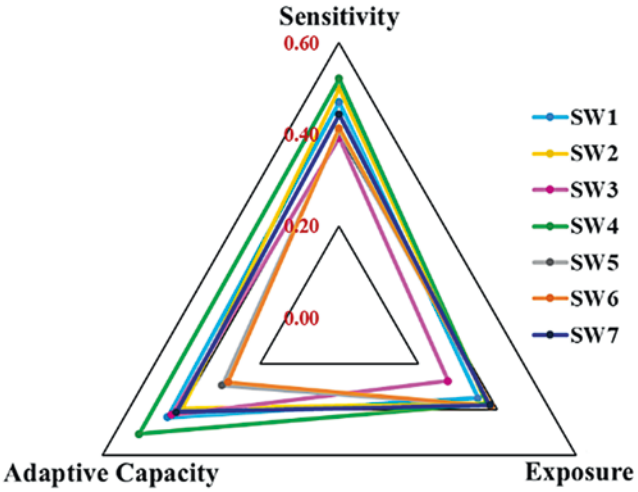

Fig. 3.17 Vulnerability triangle diagram for 7 sub-watersheds of Sajnam watershed

discriminated against in villages, in educational institutions, in job market etc. leaving them uninformed and unaware thus, making them more susceptible to climate change.

In terms of the natural resources, the sub-watershed does not support any forest cover and reports a lower soil quality. The natural resources, thus, need to be restored and sustainably managed as it can hamper the productivity of the forests and soil status to a greater extent.

Another important reason that makes the region vulnerable is due to the presence of coal-based thermal power plant, Lalitpur Power Generation Company Limited, that produces 1980 megawatts of power in 2015. For the setup of the plant, agricultural lands of close by villages were taken away in return of very less compensation and promises of employment in the plant and better infrastructural facilities in the village. But as promised, none of the things were provided to the villagers, making them more vulnerable to shocks and reducing their adaptive capacity to recover from those shocks. Also, the plant has been affecting their existing and main source of livelihood, that is, agriculture. The fly ash from the plant settles down on their crop and destroys the crop which affects crop productivity and puts a financial pressure on the people. Another problem is the alarming level of groundwater. After the setup of the plant, the people drill the ground till 700 ft. for irrigation purposes which was earlier just 200 ft.

Considering the human capital component, the sub-watershed completely lacks infrastructure supporting education which has resulted in the lowest literacy rate of the sub-watershed amongst the seven sub-watersheds. The people are less informed and less capable in comparison to others which have ultimately decreased their ability to cope with adversities. The sub-watershed does not even have facility of healthcare centres within the premises, and the villagers have to go to the neighbouring

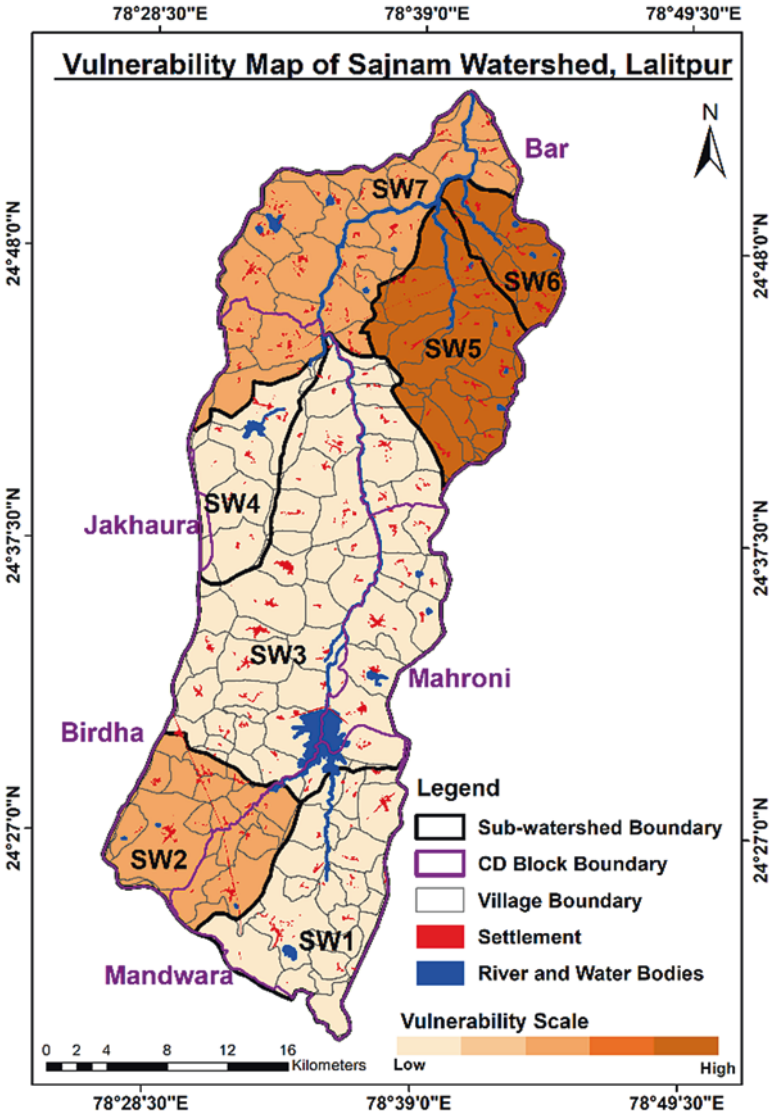

Fig. 3.18 Vulnerability map for Sajnam watershed

villages/towns for treatment. In case of emergency, there is no immediate facility available for the villagers. The provision of self-help groups in this sub-watershed is at a very nascent stage in comparison to the others. Few SHGs that have come into existence are helping in empowering the women of the villages. The financial situation seems to be a little grim in this sub-watershed. There are no banking facilities available within the watershed. So the villagers have to go to the neighbouring villages or nearby towns in case if they have to take loans or any financial assistance.

On the contrary, SW3 is the least vulnerable amongst the seven sub-watersheds because of lowest exposure (0.27) and sensitivity (0.39) values. The sub-watershed covers four developmental blocks, majorly Birdha and Mahrauni and partially Bar and Mandwara. The sub-watershed exhibits low inter-annual rainfall variation which indicates the low occurrence of droughts in the region. Considering the demographics component, the sub-watershed reports low percentage of child population and Scheduled Caste population. This section of society is highly sensitive to climate change as they are dependent and less informed and have limited adaptive capacities. The sub-watershed reports a low percentage of wasteland which shows that the land is well utilized in this sub-watershed for farming or grazing purposes. Additionally, the sub-watershed is well equipped with infrastructure facilities in comparison to the rest of the sub-watersheds, which makes it less vulnerable. It has a higher access to human resources and financial resources that allows them to cope up with the adversities of climate change events.

3.6 Results

The overall results for LVI–IPCC assessment for the four watersheds are given in Table 3.13.

Out of the four watersheds chosen for the study, Ur watershed (Tikamgarh district) shows high vulnerability in comparison to other four watersheds. Mostly, the sub-watersheds in the Ur watershed are somewhat vulnerable which is because their exposure and sensitivity levels are very high, whereas the adaptive capacity levels are low. There has been more climatic variability due to uncertain precipitation pattern and increasing temperature over the last decade. These together have resulted in very high exposure values. The pressure on the ecosystem is more in this district with more land utilization, higher groundwater extraction and larger area under irrigation, which has made them more sensitive to any form of impacts in the context of climate variability. Lower levels of development in the form of infrastructure and low levels of access to resources as well as assets have resulted in lower coping capacity of the people in these districts which makes them more vulnerable to any form of impacts occurring due to climate change.

Followed by Ur watershed on the vulnerability scale is Kathan watershed (Chhatarpur–Sagar district) due to relatively high exposure values and lower

Table 3.13 Overall LVI–IPCC results for the 4 watersheds in Bundelkhand region

LVI–IPCC components	Ur Watershed, Tikamgarh	Kathan Watershed, Chhatarpur-Sagar	Patrahi–Lakheri Watershed, Jhansi	Sajnam Watershed, Lalitpur
Exposure	0.52	0.37	0.29	0.35
Sensitivity	0.31	0.35	0.35	0.35
Adaptive capacity	0.20	0.23	0.24	0.29
LVI–IPCC	0.10	0.05	0.02	0.02

adaptive capacity values making it prone to more climate change impacts such as droughts and floods. The high vulnerability is reported from the sub-watershed located in the Bada Malhera block of the Chhatarpur district. The block reports higher exposure and sensitivity values and low adaptive capacity value indicating that the sub-watershed area is more exposed to and prone to climate changes and its impacts. The rest of the sub-watersheds are somewhat mildly vulnerable due to reported higher adaptive capacity which gives them a better access to human, social, financial and physical resources, thus making them more adaptive to cope up with the adversities of climate change events.

Next to Kathan watershed is the Sajnam watershed in Lalitpur District. The high vulnerability is reported from the sub-watershed that falls in the Bar block. This sub-watershed reports the lowest adaptive capacity value amongst all the sub-watersheds. The problems are further aggravated due to the presence of coal-based thermal power plant that has acquired agricultural lands for the setup and has reduced the groundwater levels due to excessive extraction. The rest of the sub-watersheds are relatively less vulnerable due to low exposure to climate change stressors and shocks and also have better access to the human, physical, social and financial resources.

Patrahi–Lakheri watershed in Jhansi district is comparatively less vulnerable because of lowest exposure values and relatively high adaptive capacity values. The sub-watersheds have an access to and control over the human, social, physical and financial resources which mobilize them to build resilience to climate change impacts.

3.7 Community Adaptations to Coping with Climate Change Impacts

Bundelkhand's agriculture scenario is at crossroads. It has to find a way to feed the growing population while being environmentally, socially and economically sustainable. To achieve this, the Bundelkhand region needs to focus on developing and deploying technologies that improve water, fertilizer, labour and energy use efficiency while simultaneously improving soil, ecosystem and social resilience, restoring degraded agro-ecosystems and creating alternate sources of income for farmers. In addition to these formidable goals, the issue of climate change and its potential impacts on agriculture and food security must be addressed appropriately through smart agricultural interventions.

The long-term nature of climate change and its imminent impact on agriculture warrant an agricultural development policy and practices that incorporates both short- and long-term planning perspectives. As regards climate change, there are two different types of adaptation—reactive adaptation and anticipatory adaptation. As the names suggest, reactive adaptation responds to changes or impacts after they have occurred, while anticipatory adaptation responds to these changes before they occur.

Based on the assessment and consultation, the National Institute of Hydrology, under its two projects based in Bundelkhand region, funded by Technology Information, Forecasting and Assessment Council (TIFAC) and Ministry of Water Resources (MoWR), designed an adaptation plan, based on both reactive and anticipatory approaches. The plan provides adaptation strategies in the selected study areas catering to sustainable agricultural practices, soil and water conservation, water purification technology, alternative livelihood occupations and market linkages and land resource planning for improving the productivity and income of the farmers and providing safe drinking water to the villagers. The proposed strategies have been piloted in some villages of the Ur watershed and Kathan watershed, and these are some of the best strategies and easily accepted by the farmers. Similar activities have been proposed and planned for the other two watersheds also.

3.7.1 Sustainable Agricultural Practices

- Under the project, demonstration on line sowing technique with seed drill and specific seed varieties was tested in three villages, involving seven progressive farmers in Manchi, Baisa and Samara villages, Ur watershed. Sites were selected through community participation. The seeds for major crops such as soybean, black gram (AZAD 1 and PU35) and groundnut (IG20) were provided in order to ensure livelihood, nutritional security and economic empowerment of farmer at faster pace.
- Understanding the importance of agro-horti model to sustainable agriculture practices, demonstration on the implementation of the Wadi model was provided in two progressive farmer's land, one in Baisa village, Baldeogarh, and another one in Chaturkari village, Jatara, Ur watershed (Fig. 3.19). The Wadi model presents a sustainable solution that makes farming profitable even on small plots and ensures nutritional security of the households by the provisioning of cereals, pulses, vegetables and fruits. This agri-horti-based model reduces climate risks, regenerates production potential of the land and ensures that farmers enjoy a regular flow of income due to diversification of production.

3.7.2 Soil and Water Conservation

Promotion of check dams, Gabion structure and farm pond was started as an appropriate intervention to enhance water storage capacity and recharge groundwater in the drought-prone Bundelkhand region in central India. This is proving to be a most cost-effective, smart and sustainable solutions as the farmers in this rain-fed agricultural area are able to take three crops annually. These structures help reduce erosion and increase soil water infiltration; the retained water can be used for irrigation. They also reduce the required channel maintenance and thus increase groundwater levels and recharge rate. To identify the areas where recharge structures are highly essential and to know their suitable locations, the thematic layers such as

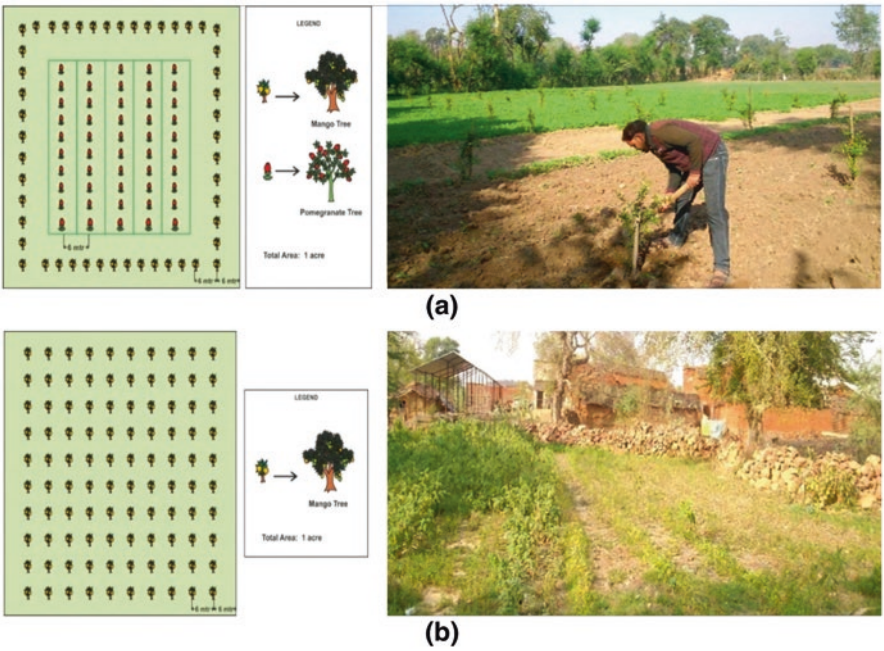

Fig. 3.19 (**a**) Demo plot (1 acre) of a farmer from Baldeogarh for mango and pomegranate tree. (**b**) Demo plot (1 acre) of a farmer from Jatara for mango tree

hydro-geomorphology, land use, soils, etc., were generated by MPCOST and UPRSAC and were integrated to locate suitable areas and structures for artificial recharge.

3.7.3 Water Purification Technology

TIFAC supported the technology demonstration programme for the access to safe water where one school was selected in Baisa village, Baldeogarh block, Ur watershed, based on the student strength and status of water contamination (faecal coliform—highly positive; TDS—148; absence of chemical contamination) and availability of electricity. Jal TARA filter has been installed within the primary school premises. The filter is designed to treat drinking water contaminated with pathogenic bacteria and turbidity using slow sand filtration technique. Training was given to the administration on how to use the filter and conduct the water quality testing (Fig. 3.20).

Fig. 3.20 (**a**) Jal TARA filter installed in middle school, Samarra village. (**b**) Training on water quality testing

Fig. 3.21 Trainings provided to villagers on market-friendly products

3.7.4 Alternative Livelihood Occupations and Market Linkages

Small-scale and landless farmers are quite prevalent in villages of the selected study areas. These farmers do not have any fixed source of income and often migrate when weather conditions disrupt economic activities in the region. So in order to generate additional income for the villagers and stop their migration to nearby cities in search of livelihood, trainings were provided for market-friendly products. Some of the activities for which trainings were provided are listed below and shown in Fig. 3.21.

- Vermicomposting and biofertilizer/biopesticide production training
- Low-cost edible mushroom production training
- Jute items making with natural colours training
- Bamboo craft training

- Bee keeping training
- Pisciculture

3.7.4.1 Success Story: Jute and Bamboo Craft Training in Tikamgarh and Market Linkage

There is always a huge demand for products made from jute, and it also provides an alternative source of income and also helps in restoring the traditional art. Samarra village, Ur watershed, was chosen where hands-on training on making jute and bamboo products was given to a group of 30 villagers, which included men, women and young girls. After the completion of jute and bamboo craft trainings, a marketing exposure visit of artisans at Vigyan Mela Bhopal and Antyoday Mela Tikamgarh was organized (Fig. 3.22). The artisans displayed their finished craft items at stalls and sold the item. During this marketing exposure period, both male and female artisans got an opportunity to learn and understand about the customers' choice, negotiations and the demand for items along with the exposure to other craftsmen and their products/designs.

3.7.5 Land Resource Planning

Land resources plan is similar to land use plan. The land use plan is a scheme of rational land use worked out on the basis of economic and social development objectives. The purpose of this land use planning is to use land resources rationally to coordinate and rationally allocate land use amongst different sections of the national economy. In the light of the extent of the planning and the aim of the plan, the land use plan can be divided into three kinds, that is overall land use planning, detailed land use planning and special land use planning. The suggested land resources management actions for the study areas are:

1. Action for double cropping
2. Action suggested for ley farming and fuel wood plantation
3. Action suggested for gap plantation
4. Action suggested for agroforestry

Adoption of appropriate adaptation strategies in all the four watersheds would result in the empowerment of rural communities and sustainable livelihoods. Some of the measures based on vulnerability assessment are detailed in Table 3.14 sector-wise.

Fig. 3.22 Market exposure to jute and bamboo craft artisans

Table 3.14 Sector-wise short-term and long-term measures based on the assessment

Sectors	Key risks	Short term	Long term
Demographics	Imbalanced male-female ratio	Awareness on SHGs	Encourage girl child birth
	Increased migration	Engage in non-farm occupations (pisciculture, fishing, handicrafts)	Strengthening of technology dissemination centres
	Increased poverty	Livestock and poultry rearing	E-governance in agriculture, finance, health
		Increase in microfinance facilities	
Health	Food and water shortage causing malnourishment	Strengthen primary health care	Public health surveillance
	Heat strokes and loss of life	Increased public health expenditure	Implement heat warning systems
Agriculture	Reduced crop productivity	Use of improved seeds	Agro-forestry and agro-horticulture models, Wadi
		Mulching	
		Organic farming	Multi-cropping
		In situ moisture conservation	Crop intensification
	Livestock migration in search of water	Dry sowing and line sowing	Drip irrigation
		Ridge and furrow irrigation methods	Drought-tolerant and short-duration crops
		Strategic weaning of calves	Extension of crop insurance
		Supplementary fodder during dry season	Relocating the herds
Ecosystem	Stress on water resources	Rejuvenation of village tanks and water bodies	Construction of farm ponds and storage tanks
	Reduction in soil moisture	Soil carbon sequestration	Construction of Nala bunds, check dams, percolation ponds and stop dams
	Increase of forest fires	Increase in forest cover	
	Desertification of land	Conversion of wasteland to pastureland, gap plantation, etc.	Early warning capability of forest fire danger
Human capital	Withdrawal of children from schools to have more earning hands	Raising community awareness on climate change issues	Encouraging vocational training courses
	Not sufficient amount of health-care facilities	Training on health and knowledge skills	Building health and education infrastructure
	Reduced quality of life		

(continued)

Table 3.14 (continued)

Sectors	Key risks	Short term	Long term
Physical capital	Scarcity of water and conflicts over sharing of water	Rooftop rainwater harvesting	Efficient water distribution system to avoid water loss and wastage
		Water supply tanker services	
	Sanitation and hygiene problems	Repairing of existing and introduction of new hand pumps to utilize groundwater	Infrastructure to sustain greater number of electricity connections
	Daily household chores come to standstill due to no electricity		
Social capital	Increased prices of food and other products	Subsidized prices of goods	Increased storage facilities of agriculture produce
		Availability of substitutes	Transparency in distribution system from farm to consumer
		Organizing recreational activities	
	Community networks are broken and social interaction decreases	Capacity building programmes for government schemes and facilities	
		Establishment of farmers adaptation clubs/clusters	Weekly mandatory meetings for updated interventions
Financial capital	Reduced income	Access of loans at lower interest rates	Subsidies on agricultural inputs
	Economic losses	Awareness on available government schemes like Sampoorna Gramin Rojgar Yojna	Awareness on SHGs
	Increased credit risk for financial institutions		Provision of finance for setting up agro-processing industries
	Loss of tax revenue generation	Facilitate microfinancing support	
	Rural indebtedness		

Along with this, there is a need to follow a systematic approach to completely eliminate the problem, which may consist of:

- Conducting research in the field of agriculture so as to identify better strategies to adapt to climate change, for example determining crop mix that can resist the impacts of climate change in different parts/block of the state.
- Establishing better meteorological stations that will help in dissemination of local weather information and provide forecast and disaster warnings to the farmers.
- Long-term capacity building on climate change adaptation will play an important role in coping up and adapting to climate variability.

- Review of state procurement policies to incorporate measures for purchase of alternate crops that are grown in the drought-prone regions.

3.8 Conclusion

The main objective of this study was to identify climate change vulnerable watersheds and sub-watersheds along with the villages falling under the selected study area. This was done in order to attain knowledge and understanding on the contributing factors of vulnerability and to prioritize the area which needs immediate action for the agro-based households of the region.

The findings of the study are based on the LVI–IPCC approach, which reveals that Ur watershed is the most vulnerable out of the four watersheds. The difference in the vulnerability arises because of differences in the watershed's sensitivity, adaptive capacity and exposure to disaster and climate change. The agro-based households of the region are majorly exposed to extreme climate change, rising temperature and decreasing rainfall leading to occurrence of successive droughts. Some of the other reasons leading to high vulnerability of the regions are dependence on rain-fed agriculture which is highly sensitive to climate change, increasing pressure on natural resources, acute water shortage, over-extraction of groundwater, lack of infrastructure facilities, extreme poverty and high-scale migration from villages to towns. Based on the vulnerability assessment, the findings and the suggested adaptive strategies would enable the villagers of Bundelkhand to better adapt to the impacts of the climate change and enable government and local bodies to develop programmes and take initiatives to strengthen the most vulnerable villages.

Acknowledgement This work was carried out at the National Institute of Hydrology (NIH), under the projects supported by Technology Information, Forecasting and Assessment Council (TIFAC), Department of Science and Technology and Ministry of Water Resources, RD & GR, Government of India. The authors would like to acknowledge the team of Madhya Pradesh Council of Science and Technology (MPCST) and Remote Sensing Applications Centre, Uttar Pradesh (UPRSAC), for generating all GIS database required for the study.

Appendices

Appendix A: Villages Falling Under each Sub-watershed in Ur Watershed, Tikamgarh District, Madhya Pradesh

Sub-watershed 1		
S. no.	Village	Block
1.	Ahar	Baldeogarh
2.	Duda Khera	Baldeogarh
3.	Ganeshpura	Baldeogarh
4.	Kachhya Khera Khas	Baldeogarh
5.	Karmasan Hata	Baldeogarh
6.	Khushipura	Baldeogarh
7.	Ladwani Khas	Baldeogarh
8.	Luharra	Baldeogarh
9.	Madan Sagar	Baldeogarh
10.	Narayanpur	Baldeogarh
11.	Pratappura	Baldeogarh
12.	Sukora	Baldeogarh
13.	Ajnaur Khas	Tikamgarh
14.	Bad Madai Khas	Tikamgarh
15.	Bakpura	Tikamgarh
16.	Banjarya	Tikamgarh
17.	Basgoi	Tikamgarh
18.	Budki Khera	Tikamgarh
19.	Gudanwara	Tikamgarh
20.	Jamuniya Khera	Tikamgarh
21.	Kachhya Khera	Tikamgarh
22.	Lar Khas	Tikamgarh
23.	Lar Ugad	Tikamgarh
24.	Nainwari	Tikamgarh
25.	Parsuwa	Tikamgarh
26.	Patar Khera	Tikamgarh
27.	Prempura	Tikamgarh
28.	Radhapur	Tikamgarh
29.	Samarra	Tikamgarh
30.	Sapaun Khas	Tikamgarh
31.	Shyag	Tikamgarh
32.	Shyampura	Tikamgarh
33.	Sundarpur	Tikamgarh

Sub-watershed 2		
S. no.	Village	Block
1.	Anantpura	Tikamgarh
2.	Bad Madai	Tikamgarh
3.	Bahadurpur	Tikamgarh
4.	Dhajrai	Tikamgarh
5.	Durgapur	Tikamgarh
6.	Gopalpura Bhata	Tikamgarh
7.	Gopalpura Khas	Tikamgarh
8.	Hajuri Nagar	Tikamgarh
9.	Jatauwa Khas	Tikamgarh
10.	Lakhora	Tikamgarh
11.	Laxmanpura	Tikamgarh
12.	Mabai Bhata	Tikamgarh
13.	Madhumar Gross Form	Tikamgarh
14.	Madhumar Khas	Tikamgarh
15.	Madhuwan	Tikamgarh
16.	Madumar Bhata	Tikamgarh
17.	Mamaun	Tikamgarh
18.	Manik Chowk	Tikamgarh
19.	Matauli	Tikamgarh
20.	Mohanpura	Tikamgarh
21.	Narguda Bhata	Tikamgarh
22.	Narguda Khas	Tikamgarh
23.	Papawani	Tikamgarh
24.	Patha Bhata	Tikamgarh
25.	Patha Khas	Tikamgarh
26.	Ranipura	Tikamgarh
27.	Rigaura	Tikamgarh
28.	Shri Nagar Khas	Tikamgarh
29.	Sundarpur	Tikamgarh
30.	Uttampura	Tikamgarh

Sub-watershed 3		
S. no.	Village	Block
1.	Badaghat	Baldeogarh
2.	Baisa Khas	Baldeogarh
3.	Baisa Ugad	Baldeogarh
4.	Banera	Baldeogarh
5.	Banpura Khurd	Baldeogarh
6.	Bhaira Novar	Baldeogarh
7.	Bhelsi	Baldeogarh
8.	Brishbanpura	Baldeogarh
9.	Chandooli	Baldeogarh
10.	Devi Nagar	Baldeogarh
11.	Dumbar	Baldeogarh

(continued)

Sub-watershed 3		
S. no.	Village	Block
12.	Durga Nagar	Baldeogarh
13.	Gukrai Khas	Baldeogarh
14.	Jhinguwan	Baldeogarh
15.	Jinagarh Jangal	Baldeogarh
16.	Jinagarh Khas	Baldeogarh
17.	Kailpura	Baldeogarh
18.	Karmasan Hata	Baldeogarh
19.	Lakheri	Baldeogarh
20.	Pratappura	Baldeogarh
21.	Raj Nagar	Baldeogarh
22.	Rajpura	Baldeogarh
23.	Sebar Khas	Baldeogarh
24.	Sebar Ugad	Baldeogarh
25.	Sujanpura	Baldeogarh
26.	Talmau	Baldeogarh
27.	Tamora	Baldeogarh

Sub-watershed 4		
S. no.	Village	Block
1.	Karmasan Ghat	Baldeogarh
2.	Karmasan Hata	Baldeogarh
3.	Daryaw Nagar	Tikamgarh
4.	Jaswant Nagar	Tikamgarh
5.	Kater Khera	Tikamgarh
6.	Mabai Bhata	Tikamgarh
7.	Majana Khas	Tikamgarh
8.	Mavai	Tikamgarh
9.	Papawani	Tikamgarh

Sub-watershed 5		
S. no.	Village	Block
1.	Bachhoda Bhata	Jatara
2.	Bachhoda Khas	Jatara
3.	Barmadang Bhata	Jatara
4.	Barmadang Khas	Jatara
5.	Barmamanjh	Jatara
6.	Bilgay Bhata	Jatara
7.	Bilgay Khas	Jatara
8.	Chandaua Khera	Jatara
9.	Chandrapura	Jatara
10.	Chatukari	Jatara
11.	Deokha	Jatara

(continued)

Sub-watershed 5		
S. no.	Village	Block
12.	Deopur	Jatara
13.	Dhamna Bhata	Jatara
14.	Dhamna Khas	Jatara
15.	Harpura	Jatara
16.	Hirdenager	Jatara
17.	Janakpur Bhata	Jatara
18.	Janakpur Khas	Jatara
19.	Kamal Nagar	Jatara
20.	Kurrai	Jatara
21.	Kuwarpura	Jatara
22.	Larkhurd	Jatara
23.	Luharguwa Khas	Jatara
24.	Luharguwa Bhata	Jatara
25.	Mahuabag	Jatara
26.	Mathupura	Jatara
27.	Man Bujurg Bhata	Jatara
28.	Mau Bujurg Khas	Jatara
29.	Panyara Khera	Jatara
30.	Pathara	Jatara
31.	Ramgarh	Jatara
32.	Serai	Jatara
33.	Vaidpur	Jatara
34.	Vikrampura	Jatara
35.	Bamhori Nakiban	Tikamgarh
36.	Bhadra	Tikamgarh
37.	Majana Bhata	Tikamgarh
38.	Mavai	Tikamgarh
39.	Pagara Jangal	Tikamgarh
40.	Raipur	Tikamgarh
41.	Rorai	Tikamgarh
42.	Sunoni	Tikamgarh
43.	Kari (NP)	Tikamgarh

Sub-watershed 6		
S. no.	Village	Block
1.	Balwantpura Khas	Baldeogarh
2.	Balwantpura Ugad	Baldeogarh
3.	Banpura Sapaun	Baldeogarh
4.	Banyani	Baldeogarh
5.	Bhiloni	Baldeogarh
6.	Bhitarwar	Baldeogarh
7.	Chaubara	Baldeogarh
8.	Hirapur Kha	Baldeogarh
9.	Jatera	Baldeogarh

(continued)

Sub-watershed 6		
S. no.	Village	Block
10.	Madori	Baldeogarh
11.	Majguwan	Baldeogarh
12.	Pipra	Baldeogarh
13.	Sarkanpur Khas	Baldeogarh
14.	Sarkanpur Ugad	Baldeogarh
15.	Shyampura	Baldeogarh
16.	Sijaura	Baldeogarh
17.	Jauwa	Jatara
18.	Karmaura	Jatara
19.	Raghunathpura	Jatara
20.	Majana Khas	Tikamgarh

Sub-watershed 7		
S. no.	Village	Block
1.	Garroli	Baldeogarh
2.	Bagoura	Jatara
3.	Baiwarjangal	Jatara
4.	Baiwarkhas	Jatara
5.	Bajetpura	Jatara
6.	Baldeopura	Jatara
7.	Bandarguda	Jatara
8.	Deoraha	Jatara
9.	Gor	Jatara
10.	Hirdenager	Jatara
11.	Kandwa	Jatara
12.	Kitakhera	Jatara
13.	Lidhouratal	Jatara
14.	Machora	Jatara
15.	Manch	Jatara
16.	Muhara Khas	Jatara
17.	Pathara	Jatara
18.	Piprat	Jatara
19.	Shah	Jatara
20.	Simariya	Jatara
21.	Jatara (NP)	Jatara

Sub-watershed 8		
S. no.	Village	Block
1.	Gora	Baldeogarh
2.	Guna	Baldeogarh
3.	Baharo Tal	Jatara
4.	Bamhori Abda	Jatara

(continued)

Sub-watershed 8		
S. no.	Village	Block
5.	Deoraha	Jatara
6.	Hunarganj	Jatara
7.	Tanga	Jatara
8.	Jatara (NP)	Jatara
9.	Bhatgora	Palera
10.	Budaur	Palera
11.	Guda Najdik Pali	Palera
12.	Magrai	Palera
13.	Mahendra Maheva	Palera
14.	Morramanna	Palera
15.	Pali	Palera
16.	Phoolpur	Palera
17.	Ratanguwan	Palera
18.	Toury	Palera

Appendix B: Villages Falling Under Each Sub-watershed in Kathan Watershed, Chhatarpur-Sagar District, Madhya Pradesh

Sub-watershed 1		
S. no.	Village	Block
1.	Bicchaun	Buxwaha
2.	Lahar	Buxwaha
3.	Semra Sekh	Buxwaha
4.	Bagaich	Shahgarh
5.	Baghrohi	Shahgarh
6.	Barkhera Shahgarh	Shahgarh
7.	Basona	Shahgarh
8.	Batwaha	Shahgarh
9.	Bei	Shahgarh
10.	Bilagram	Shahgarh
11.	Bilguwan	Shahgarh
12.	Birthipur	Shahgarh
13.	Chakk Dalpatpur	Shahgarh
14.	Chakk Kaneri	Shahgarh
15.	Chakkmohari	Shahgarh
16.	Chhayan	Shahgarh
17.	Dalpatpur	Shahgarh
18.	Dhurmar	Shahgarh
19.	Dulchipur	Shahgarh
20.	Gadgara	Shahgarh
21.	Ghutrai	Shahgarh

(continued)

Sub-watershed 1		
S. no.	Village	Block
22.	Gomatupur	Shahgarh
23.	Harrai	Shahgarh
24.	Kajrawan	Shahgarh
25.	Kaneri	Shahgarh
26.	Kanikhedi	Shahgarh
27.	Kanikhedi Khurd	Shahgarh
28.	Khatora Kalan	Shahgarh
29.	Khatora Khurd	Shahgarh
30.	Lamnau	Shahgarh
31.	Luharra	Shahgarh
32.	Malkhuwan	Shahgarh
33.	Mohari	Shahgarh
34.	Mudari Bujurg	Shahgarh
35.	Muhli	Shahgarh
36.	Nanakpur	Shahgarh
37.	Narwan	Shahgarh
38.	Niwahi	Shahgarh
39.	Nouraj	Shahgarh
40.	Padrai	Shahgarh
41.	Papet	Shahgarh
42.	Papeti	Shahgarh
43.	Pratppura	Shahgarh
44.	Pura Shahgarh	Shahgarh
45.	Rabara	Shahgarh
46.	Rajoula	Shahgarh
47.	Ranipur	Shahgarh
48.	Rurawan	Shahgarh
49.	Shahgarh (NP)	Shahgarh
50.	Simariya Kalan	Shahgarh
51.	Simariya Khurd	Shahgarh
52.	Simriya Uwari	Shahgarh
53.	Singhpur	Shahgarh
54.	Tatarwara	Shahgarh
55.	Tinsuwa	Shahgarh

Sub-watershed 2		
S. no.	Village	Block
1.	Bebasa	Buxwaha
2.	Beergarh	Buxwaha
3.	Bhadator	Buxwaha
4.	Bijawali	Buxwaha
5.	Chaurai	Buxwaha
6.	Gewlai	Buxwaha
7.	Ghaughara	Buxwaha

(continued)

Sub-watershed 2		
S. no.	Village	Block
8.	Ghaughari	Buxwaha
9.	Govindpura	Buxwaha
10.	Gugwara	Buxwaha
11.	Iashwarmau	Buxwaha
12.	Luharpura	Buxwaha
13.	Madiya Buzurg	Buxwaha
14.	Majhaguwan Batton	Buxwaha
15.	Mandpur	Buxwaha
16.	Nibar	Buxwaha
17.	Sanauda	Buxwaha
18.	Amarmaoh	Shahgarh
19.	Chandola	Shahgarh
20.	Fulwari	Shahgarh
21.	Garera	Shahgarh
22.	Jamuniya	Shahgarh
23.	Karrai	Shahgarh
24.	Khargorani	Shahgarh
25.	Madantala	Shahgarh
26.	Mohanpura	Shahgarh
27.	Neguwan	Shahgarh
28.	Ratanpur Shahgarh	Shahgarh
29.	Sasan	Shahgarh

Sub-watershed 3		
S. no.	Village	Block
1.	Lidhoura	Bada Malhera
2.	Luhani	Buxwaha
3.	Maddeora	Buxwaha
4.	Bamnora Kalan	Ghuwara
5.	Dalipur	Ghuwara
6.	Halawani	Ghuwara
7.	Mawai	Ghuwara
8.	Agara	Shahgarh
9.	Bodanganj	Shahgarh
10.	Garroli	Shahgarh
11.	Hansrai	Shahgarh
12.	Indora	Shahgarh
13.	Kalra	Shahgarh
14.	Khairwaha	Shahgarh
15.	Ludayara	Shahgarh
16.	Rampur	Shahgarh
17.	Sadpur	Shahgarh
18.	Tigoda	Shahgarh

Sub-watershed 4		
S. no.	Village	Block
1.	Amakhuwa	Buxwaha
2.	Birampura	Buxwaha
3.	Buxwaha (NP)	Buxwaha
4.	Dangrai	Buxwaha
5.	Dardoniya	Buxwaha
6.	Dugasara	Buxwaha
7.	Gadhoi	Buxwaha
8.	Harduwa	Buxwaha
9.	Hinota	Buxwaha
10.	Hirdepur	Buxwaha
11.	Jakha	Buxwaha
12.	Jara	Buxwaha
13.	Jujharpura	Buxwaha
14.	Kasera	Buxwaha
15.	Kero	Buxwaha
16.	Kuhi	Buxwaha
17.	Madia Khurd	Buxwaha
18.	Mangarai	Buxwaha
19.	Mara	Buxwaha
20.	Palda	Buxwaha
21.	Pondi	Buxwaha
22.	Sagouriya	Buxwaha
23.	Sahpura	Buxwaha
24.	Teiyamar	Buxwaha
25.	Tilai	Buxwaha
26.	Chouki	Shahgarh
27.	Hirapur	Shahgarh

Sub-watershed 5		
S. no.	Village	Block
1.	Bineda	Bada Malhera
2.	Dhanguan	Bada Malhera
3.	Manakpura	Bada Malhera
4.	Pandajhir	Bada Malhera
5.	Pipariya Kalan	Bada Malhera
6.	Sirbon	Bada Malhera
7.	Surajpura Road	Bada Malhera
8.	Darguwa	Buxwaha
9.	Hatna	Buxwaha
10.	Raipura Kalan	Ghuwara

Sub-watershed 6		
S. no.	Village	Block
1.	Bajna	Buxwaha
2.	Banpura	Buxwaha
3.	Baranand No. 1	Buxwaha
4.	Baranand No. 2	Buxwaha
5.	Basantpura	Buxwaha
6.	Chhayan	Buxwaha
7.	Dhimarwa	Buxwaha
8.	Jagara	Buxwaha
9.	Kachari	Buxwaha
10.	Kanjra	Buxwaha
11.	Kherakhurd	Buxwaha
12.	Kuwapalo	Buxwaha
13.	Majhora	Buxwaha
14.	Malar	Buxwaha
15.	Mudar	Buxwaha
16.	Nimani	Buxwaha
17.	Shobha	Buxwaha
18.	Siddhai	Buxwaha

Sub-watershed 7		
S. no.	Village	Block
1.	Gorakhpura	Ghuwara
2.	Jhigari	Ghuwara
3.	Kheri	Ghuwara
4.	Panwari	Ghuwara
5.	Richhara	Ghuwara
6.	Bada Malhera (NP)	Bada Malhera
7.	Bandha	Bada Malhera
8.	Bankpura	Bada Malhera
9.	Baraj	Bada Malhera
10.	Barma	Bada Malhera
11.	Bhojpura	Bada Malhera
12.	Dharampura	Bada Malhera
13.	Erora	Bada Malhera
14.	Futwari	Bada Malhera
15.	Garkhuwan	Bada Malhera
16.	Ghinochi	Bada Malhera
17.	Hardotha	Bada Malhera
18.	Kanera	Bada Malhera
19.	Kayan	Bada Malhera
20.	Khirkuwa	Bada Malhera
21.	Kuwarpura Kalan	Bada Malhera
22.	Kuwarpura Khurd	Bada Malhera
23.	Lakhanwa	Bada Malhera

(continued)

Sub-watershed 7		
S. no.	Village	Block
24.	Malpura	Bada Malhera
25.	Monpura	Bada Malhera
26.	Morra	Bada Malhera
27.	Nadiya	Bada Malhera
28.	Pathiya	Bada Malhera
29.	Pipra Kalan	Bada Malhera
30.	Rajpura	Bada Malhera
31.	Salaiya	Bada Malhera
32.	Satpara	Bada Malhera
33.	Sedhpa	Bada Malhera
34.	Sijwaha	Bada Malhera
35.	Silaro	Bada Malhera
36.	Sujanpura	Bada Malhera
37.	Tigari	Bada Malhera

Sub-watershed 8		
S. no.	Village	Block
1.	Chopra	Buxwaha
2.	Andhiyara	Bada Malhera
3.	Arol	Bada Malhera
4.	Baman Kola	Bada Malhera
5.	Bamni	Bada Malhera
6.	Barsat	Bada Malhera
7.	Bhanguwan	Bada Malhera
8.	Bharwani	Bada Malhera
9.	Bilwar	Bada Malhera
10.	Chhaikuwan	Bada Malhera
11.	Gopalpura	Bada Malhera
12.	Jasguwan Kalan	Bada Malhera
13.	Kalothar	Bada Malhera
14.	Karri	Bada Malhera
15.	Kewlai	Bada Malhera
16.	Khatola	Bada Malhera
17.	Kheron	Bada Malhera
18.	Maharajganj	Bada Malhera
19.	Maharajpura	Bada Malhera
20.	Mailwar	Bada Malhera
21.	Mawai	Bada Malhera
22.	Moli	Bada Malhera
23.	Murli Kheda	Bada Malhera
24.	Para	Bada Malhera
25.	Pargaspura	Bada Malhera
26.	Partappura	Bada Malhera
27.	Patan	Bada Malhera

(continued)

Sub-watershed 8		
S. no.	Village	Block
28.	Rajapur	Bada Malhera
29.	Ranikheda	Bada Malhera
30.	Ranipura	Bada Malhera
31.	Ranital	Bada Malhera
32.	Sadwa	Bada Malhera
33.	Sigrampura	Bada Malhera
34.	Sironj	Bada Malhera
35.	Suka	Bada Malhera
36.	Surajpura Kalan	Bada Malhera
37.	Surajpura Khurd	Bada Malhera
38.	Tahanga	Bada Malhera
39.	Toriya	Bada Malhera
40.	Udaipura Khurd	Bada Malhera

Appendix C: Villages Falling Under Each Sub-watershed in Patrahi- Lakheri Watershed, Jhansi District, Uttar Pradesh

Sub-watershed 1		
S. no.	Village	Block
1.	Bhakauro	Bangara
2.	Lidhora	Gursarai
3.	Akseo	Mau Ranipur
4.	Bamhauri	Mau Ranipur
5.	Barauri	Mau Ranipur
6.	Chakara	Mau Ranipur
7.	Churari	Mau Ranipur
8.	Dhamna Payak	Mau Ranipur
9.	Dhawakar	Mau Ranipur
10.	Ghatlahchura	Mau Ranipur
11.	Itaial	Mau Ranipur
12.	Jabalpura	Mau Ranipur
13.	Jhankari	Mau Ranipur
14.	Khandarka	Mau Ranipur
15.	Khanuwan	Mau Ranipur
16.	Kharka Sani	Mau Ranipur
17.	Kotra	Mau Ranipur
18.	Lakhesur	Mau Ranipur
19.	Larauni	Mau Ranipur
20.	Madwan	Mau Ranipur
21.	Mailoni	Mau Ranipur
22.	Mau Rural	Mau Ranipur

(continued)

Sub-watershed 1		
S. no.	Village	Block
23.	Merki	Mau Ranipur
24.	Piprokhar	Mau Ranipur
25.	Rora	Mau Ranipur
26.	Rupa Dhaman	Mau Ranipur
27.	Sijari Khurd	Mau Ranipur
28.	Suhagpur	Mau Ranipur
29.	Tilera	Mau Ranipur

Sub-watershed 2		
S. no.	Village	Block
1.	Bagarauni	Bangara
2.	Bangara Dhawa	Bangara
3.	Banhauri Suhaga	Bangara
4.	Bar Urf Rampur	Bangara
5.	Chaukri	Bangara
6.	Chirkana	Bangara
7.	Gairaha	Bangara
8.	Ghurat	Bangara
9.	Gudha	Bangara
10.	Kachaneo	Bangara
11.	Kathera (NP)	Bangara
12.	Kathera Rural	Bangara
13.	Luhar Gaon Ranipu	Bangara
14.	Magarwara	Bangara
15.	Nimoni	Bangara
16.	Pachauro	Bangara
17.	Pachwara	Bangara
18.	Palara	Bangara
19.	Patha Kharka	Bangara
20.	Rajpura	Bangara
21.	Ratosa	Bangara
22.	Sanaura	Bangara
23.	Sewara	Bangara
24.	Sewkara Dhawa	Bangara
25.	Tikari	Bangara
26.	Bagrauni	Gursarai
27.	Bikram Pura Sani	Gursarai
28.	Deora Khurd	Gursarai
29.	Eoni	Gursarai
30.	Ghat Kuwan	Gursarai
31.	Gorpura	Gursarai
32.	Kedar Tai	Gursarai
33.	Khali Pura	Gursarai
34.	Kotra	Gursarai

(continued)

Sub-watershed 2		
S. no.	Village	Block
35.	Kutaura	Gursarai
36.	Maheba	Gursarai
37.	Maru Kachhiyau	Gursarai
38.	Pasaura	Gursarai
39.	Pucchi	Gursarai
40.	Turka Lahchura	Gursarai
41.	Bachera	Mau Ranipur
42.	Berwai	Mau Ranipur
43.	Bihata	Mau Ranipur
44.	Budhai	Mau Ranipur
45.	Chimadwara	Mau Ranipur
46.	Durgapur	Mau Ranipur
47.	Garhwan	Mau Ranipur
48.	Kakwara	Mau Ranipur
49.	Khan Pura	Mau Ranipur
50.	Kishor Pura	Mau Ranipur
51.	Rewan	Mau Ranipur
52.	Saptwara	Mau Ranipur
53.	Siaori	Mau Ranipur
54.	Siyawnikhurd	Mau Ranipur
55.	Jewar	Palera
56.	Mardanpura	Palera

Sub-watershed 3		
S. no.	Village	Block
1.	Amanpura	Bangara
2.	Bagroni Jagir	Bangara
3.	Baman Naiguwan	Bangara
4.	Bansar	Bangara
5.	Bhagaro	Bangara
6.	Bhitaura	Bangara
7.	Bijaigarh	Bangara
8.	Bijna	Bangara
9.	Budhawali	Bangara
10.	Charhrau Dhawari	Bangara
11.	Dadpura	Bangara
12.	Darbatyau	Bangara
13.	Dhonda	Bangara
14.	Ghatrajwara	Bangara
15.	Hanauta	Bangara
16.	Hati	Bangara
17.	Imilia	Bangara
18.	Khajraha	Bangara
19.	Lathesra	Bangara

(continued)

Sub-watershed 3		
S. no.	Village	Block
20.	Luhar Gaon Bhat	Bangara
21.	Luhari	Bangara
22.	Nimghana	Bangara
23.	Nota	Bangara
24.	Pahai Khurd	Bangara
25.	Pura Bujurg	Bangara
26.	Rajgir	Bangara
27.	Satpura	Bangara
28.	Sijara	Bangara
29.	Sijaura	Bangara
30.	Siguwan	Bangara
31.	Uldan	Bangara
32.	Ataniya Dehat	Gursarai
33.	Baswaha	Gursarai
34.	Bela	Gursarai
35.	Birsingh Pura	Gursarai
36.	Chhiraura buzurg	Gursarai
37.	Dabar	Gursarai
38.	Dhan Bilgaon	Gursarai
39.	Dhurwai	Gursarai
40.	Dugara	Gursarai
41.	Garaha	Gursarai
42.	Itawa	Gursarai
43.	Joniya	Gursarai
44.	Karri	Gursarai
45.	Lathawara	Gursarai
46.	Majhara Tai	Gursarai
47.	Mawai	Gursarai
48.	Pandwaha	Gursarai
49.	Rajapur	Gursarai
50.	Rajwara	Gursarai
51.	Semari Kachhiyan	Gursarai
52.	Silori	Gursarai
53.	Sujawan	Gursarai
54.	Tondi Fatehpur (NP)	Gursarai
55.	Tori Fatehpur Deh	Gursarai
56.	Bandh	Mau Ranipur
57.	Madarwas	Mau Ranipur
58.	Bamhori	Niwari
59.	Baraipura	Niwari
60.	Bhamora Khas	Niwari
61.	Chachawali	Niwari
62.	Dhamna	Niwari
63.	Dhimarpur (najumri)	Niwari
64.	Ghugsi Khas	Niwari

(continued)

Sub-watershed 3		
S. no.	Village	Block
65.	Gwavali	Niwari
66.	Jikhangaon	Niwari
67.	Kalothara	Niwari
68.	Majra Chachawali	Niwari
69.	Majra Patharam	Niwari
70.	Patharam	Niwari
71.	Tehar ka Khas	Niwari
72.	Taricharkalan (NP)	Niwari
73.	Uboura	Niwari
74.	Umri	Niwari
75.	Urdora	Niwari

Sub-watershed 4		
S. no.	Village	Block
1.	Atarsuwan	Bamour
2.	Bachheh	Bamour
3.	Baraura	Bamour
4.	Pureniya	Bamour
5.	Sarsenda	Bamour
6.	Atrauli	Gursarai
7.	Baghaira	Gursarai
8.	Bamanwan	Gursarai
9.	Banka Pahari	Gursarai
10.	Barwar	Gursarai
11.	Basari	Gursarai
12.	Bhadokhar	Gursarai
13.	Bhasneh	Gursarai
14.	Bitthaura	Gursarai
15.	Dhawari	Gursarai
16.	Garhi Kargaon	Gursarai
17.	Gata	Gursarai
18.	Ghuraiya	Gursarai
19.	Gundaha	Gursarai
20.	Itaura	Gursarai
21.	Jhala	Gursarai
22.	Khiriya	Gursarai
23.	Lohar Gaon	Gursarai
24.	Londi	Gursarai
25.	Madha Dilwali	Gursarai
26.	Madhura Pura	Gursarai
27.	Maigaon	Gursarai
28.	Pasrai	Gursarai
29.	Puratani	Gursarai
30.	Rana pura	Gursarai

(continued)

Sub-watershed 4		
S. no.	Village	Block
31.	Raniyara	Gursarai
32.	Tahrauli Kalan	Gursarai
33.	Tahrauli Khas	Gursarai
34.	Tai	Gursarai
35.	Tenduwa	Gursarai

Appendix D: Villages Falling Under Each Sub-watershed in Sajnam Watershed, Lalitpur District, Uttar Pradesh

Sub-watershed 1		
S. no.	Village	Block
1.	Arjun Khiriya	Mandwara
2.	Bacchra	Mandwara
3.	Badgana	Mandwara
4.	Banyana	Mandwara
5.	Bareja	Mandwara
6.	Daulatpur	Mandwara
7.	Digwar	Mandwara
8.	Dongra Kalan	Mandwara
9.	Jharaota	Mandwara
10.	Kakaruwa	Mandwara
11.	Khairai	Mandwara
12.	Lalitapur	Mandwara
13.	Machharka	Mandwara
14.	Madawara Range	Mandwara
15.	Maharaj Pura	Mandwara
16.	Mahrauni Range	Mandwara
17.	Makripur	Mandwara
18.	Narahat	Mandwara
19.	Padariya	Mandwara
20.	Parsai	Mandwara
21.	Patna Mahdawara	Mandwara
22.	Piyara	Mandwara
23.	Taraoli	Mandwara

Sub-watershed 2		
S. no.	Village	Block
1.	Bangariya	Birdha
2.	Barkhera	Birdha
3.	Barodiya Raen	Birdha

(continued)

Sub-watershed 2		
S. no.	Village	Block
4.	Betna	Birdha
5.	Dorna	Birdha
6.	Kewlari	Birdha
7.	Kirroda	Birdha
8.	Laltipur Range	Birdha
9.	Maholi	Birdha
10.	Mamda	Birdha
11.	Patauwa	Birdha
12.	Pipariya Donga	Birdha
13.	Riccha	Birdha
14.	Saja	Birdha
15.	Salaiya	Birdha
16.	Sukhpura	Birdha
17.	Umariya Dongra	Birdha
18.	Bamhori Sindwaha	Mandwara
19.	Gona	Mandwara
20.	Imilia Kalan	Mandwara
21.	Jamora	Mandwara
22.	Jilauni	Mandwara
23.	Naya Gaon	Mandwara
24.	Patna Sindwaha	Mandwara
25.	Sarkhadi	Mandwara

Sub-watershed 3		
S. no.	Village	Block
1.	Banoni	Birdha
2.	Bharoni	Birdha
3.	Dailwara	Birdha
4.	Daroni	Birdha
5.	Gangchari	Birdha
6.	Semaria	Birdha
7.	Andela	Birdha
8.	Bajarra	Birdha
9.	Bhadrau	Birdha
10.	Bhagwaha	Birdha
11.	Bhonrda	Birdha
12.	Birdha	Birdha
13.	Charhrau	Birdha
14.	Chhilla	Birdha
15.	Kalothara	Birdha
16.	Kalro	Birdha
17.	Karisa	Birdha
18.	Khajuriya	Birdha
19.	Khiriya Chhatara	Birdha

(continued)

Sub-watershed 3		
S. no.	Village	Block
20.	Khitwans	Birdha
21.	Kokata	Birdha
22.	Kuluwa	Birdha
23.	Menwar	Birdha
24.	Neem Khera	Birdha
25.	Pipriya Pali	Birdha
26.	Rameshra	Birdha
27.	Richh Pura	Birdha
28.	Satarwans	Birdha
29.	Sataura	Birdha
30.	Singepur	Birdha
31.	Tenga	Birdha
32.	Tikra Tiwari	Birdha
33.	Tila	Birdha
34.	Tor	Birdha
35.	Amora	Mahrauni
36.	Baryo	Mahrauni
37.	Chirola	Mahrauni
38.	Jariya	Mahrauni
39.	Kuraura	Mahrauni
40.	Naiguwan	Mahrauni
41.	Samogar	Mahrauni
42.	Silawan	Mahrauni
43.	Silawangrant	Mahrauni
44.	Sindwaha	Mahrauni
45.	Sukadi	Mahrauni
46.	Bagoni	Mandwara
47.	Bairwara	Mandwara
48.	Pathabiaipura	Mandwara

Sub-watershed 4		
S. no.	Village	Block
1.	Anor	Birdha
2.	Hansara Kalan	Birdha
3.	Jharkon	Birdha
5.	Kalyanpura	Birdha
7.	Patsemra	Birdha
9.	Talgaon	Birdha
4.	Jijyawan	Jakhaura
6.	Mirchwara	Jakhaura
8.	Raghunath Pura	Jakhaura

Sub-watershed 5		
S. no.	Village	Block
1.	Ajnora	Bar
2.	Badokhara	Bar
3.	Banpur	Bar
4.	Bar Range	Bar
5.	Billa	Bar
6.	Booti	Bar
7.	Chhilla	Bar
8.	Kuwagaon	Bar
9.	Mirchwara	Bar
10.	Pah	Bar
11.	Sunwahagran	Bar
12.	Suri Khurd	Bar
13.	Surikalan	Bar
14.	Talbehat Range	Bar
15.	Udaipura	Bar
16.	Udya	Bar
17.	Umari	Bar

Sub-watershed 6		
S. no.	Village	Block
1.	Bangra	Bar
2.	Bilata	Bar
3.	Dangrana	Bar
4.	Jaraoli	Bar
5.	Kailoni	Bar
6.	Kakdari	Bar
7.	Mogan	Bar
8.	Pura Dhadkuwa	Bar

Sub-watershed 7		
S. no.	Village	Block
1.	Bachhrawni	Bar
2.	Bahrawani	Bar
3.	Bar	Bar
4.	Basatrawan	Bar
5.	Bhawani	Bar
6.	Bhelonilodh	Bar
7.	Burogaon	Bar
8.	Chandawali	Bar
9.	Dashrara	Bar
10.	Dulawan	Bar
11.	Fadari	Bar

(continued)

Sub-watershed 7		
S. no.	Village	Block
12.	Gadyana	Bar
13.	Gahrao	Bar
14.	Gugarwara	Bar
15.	Karmai	Bar
16.	Kathwar	Bar
17.	Khaira	Bar
18.	Marroli	Bar
19.	Nagara	Bar
20.	Pata Pachaura	Bar
21.	Purapachuani	Bar
22.	Semara Bujurg	Bar
23.	Semrabhag Nagar	Bar
24.	Talbehat Range	Bar
25.	Teela	Bar
26.	Thatkhera	Bar
27.	Todi	Bar
28.	Toria	Bar
29.	Turka	Bar
30.	Birari	Birdha
31.	Kachnoda Kalan	Birdha
32.	Khokhra	Birdha
33.	Mailwara Kalan	Birdha
34.	Mailwara Khurd	Birdha
35.	Tera	Birdha

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