Chapter 15
Path Towards Sustainable Water Management: A Case Study of Shimla, India

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Abstract About four billion people around the world experience severe water scarcity during at least one month of the year. These issues have also begun to surface in Shimla city, located in hilly terrains of India. While the city draws its water from its peripheral rural areas, the declining freshwater availability has recently caused severe unrest among the local natives. To address this issue, land use and land cover of Shimla district were analysed for the year 2005–2006 to 2015–2016. It has been found that rapid urbanisation and change in cropping pattern has largely impacted the water resources of Shimla city. Based on the study results, this chapter emphasises the nature-based solutions for integrated and comprehensive management of water resources in Shimla city.

Keywords Water stress · Urbanisation · Land use land cover change · Cropping pattern · Nature-based solution

15.1 Introduction

A popular phrase by Samuel Coleridge, "Water, water everywhere, nor any drop to drink", gives an insight into earth's freshwater availability (UNDP 2006). Freshwater accounts for 3% of the earth's total water resource, out of which only 0.5% is available

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M. Mukherjee and R. Shaw (eds.), *Ecosystem-Based Disaster and Climate Resilience*, Disaster and Risk Research: GADRI Book Series,
https://doi.org/10.1007/978-981-16-4815-1_15

due to heterogeneity in space and time (U.S. Department of the Interior 2020; Oki and Quiocho 2020). As explained by Earthwatch Institute (2020), “From a human perspective it means that water is often in the wrong place, in the wrong form or available at the wrong time”. This uneven distribution of freshwater along with the constantly growing population has now raised the concern of freshwater availability and accessibility (Earthwatch Institute 2020).

As per UNESCO’s ‘Water for Sustainable World’ report, growing population, urbanisation, migration, industrialization along with changing production and consumption pattern have intensified the freshwater demands (UNESCO 2015). Together with climate change, the water stress situation has been further aggravated in the water-stressed regions of the world (WWDR 2020). Water stress refers to a situation wherein the demand for freshwater exceeds the currently available resources or when the poor quality of water restricts its use (Veolia 2016). Cassella et al. (2019) based on World Resource Institute report highlights that, 17 countries are experiencing extremely high baseline water stress as more than 80% of supplied water are withdrawn annually for agricultural, industrial and municipal use. Of these 12 out of 17 extremely water-stressed countries are mainly located in parts of Middle East, North African and South Asian region. Herein, India ranks 13th which caters to more than three times the population of other remaining water-stressed countries (Hofste et al. 2019).

Water is a major concern in India, as it is home to 17% of world’s population with only four percent of global water resources (Veolia 2016). As per Shiao et al. (2015), about 54% of the country experiences high to extremely high levels of water stress. Both the quantity and quality of water have progressively been deteriorating in the country. As per World Resource Institute report, of the 4,000 groundwater wells, around 54% of wells have deteriorated while 16% are declining by more than 1 m per year. Similarly, among 632 districts, only 59 districts have groundwater quality above the limits of Bureau of Indian Standards (BIS). Majority of the districts have high levels of fluoride, chlorine, iron and nitrate contents in the groundwater, which are unsafe for drinking (Shiao et al. 2015).

To rectify these emerging challenges of water stress, United Nations World Water Development Report (2018) highlighted the role of “Nature-based Solution” (NbS), to improve the supply and quality of water along with minimising the impact of natural disasters. The report advocates the traditional and indigenous knowledge that embraces a greener approach to manage the water resource (WWAP 2018). The concept of NbS is relatively new, which is primarily based on the relationship between biological diversity and human wellbeing (Cohen-Shacham et al. 2019). Although this relationship was well acknowledged from earlier times, its framing as ‘Ecosystem Services’ was initiated from the 1970s. Major scientific and political acceptance to Ecosystem Services came with the publication of Millennium ecosystem assessment in 2005, which highlighted the interdependence of people and nature (Vihervaara et al. 2010; Cohen-Shacham et al. 2019). To fully comprehend the potential of NbS, it is necessary to implant the concept of NbS in the national and state planning system, not only for water resources but also for other sectors.

15.2 Understanding Nature-Based Solution (NbS) and Water

In the late 2000s, a significant evolution was observed in the concept of NbS, where people moved from being passive beneficiaries to proactively protecting, managing or restoring the ecosystems to address societal challenges (Cohen-Shacham et al. 2019). Over the years, extensive work has been done by various international organisations to, develop the knowledge base and practically implement the concept of NbS *to rectify the problem of water security, food security, human health, disaster risk reduction and climate change*. For example, the European Commission (EC) and International Union for Conservation of Nature and Natural Resources (IUCN) attempted to define NbS in different ways but with similar goal of "safeguarding human wellbeing and enhance the resilience of ecosystems and their capacity for renewal". EC has defined NbS as "*living solutions inspired by, continuously supported by and using nature* designed to address various societal challenges in a resource-efficient and adaptable manner and to provide simultaneously economic, social and environmental benefits *(European* Commission 2017*)*. While, IUCN has defined NbS as "an action to protect, manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively simultaneously providing human wellbeing and biodiversity benefits" (Cohen-Shacham et al. 2016).

In respect to water security, NbS for water resource management involves a collaboration of ecosystem services with conventional water infrastructure to improve the quantity & quality of water as well as to increase resilience against climate change (UN Environment-DHI, UN Environment and IUCN 2018). Herein, it emphasises managing the built and natural infrastructure to achieve the water management goals as shown in Fig. 15.1.

As per UN Environment-DHI, UN Environment and IUCN (2018), NbS for water management can be applied in three ways, i.e. 'Protection', 'Restoration', 'Extension'. Herein, 'Protection' means identifying, quantifying, utilising and protecting the existing ecosystem services; 'Restoration' signifies rehabilitation and restoration of degraded ecosystem services and 'Extension' implies reproducing ecosystem services for sustainable water resource management. There are ample instances around the world, where these three ways of NbS were applied to manage the water resource. For example, in South Africa, Department of Water Affairs established the intersectoral programme to increases the upstream water flow by destroying the intrusive foreign plants that consume more water. Likewise, Kongoni River farm constructed a wetland for purification of its wastewater to address the problem of eutrophication caused due to mixing of untreated wastewater released through commercial agriculture (UN Environment-DHI, UN Environment and IUCN 2018). Similar to these, there are many evidences which show NbS provides tools for attaining sustainable use of water resource.

Similarly need of managing the water resource of famous tourist destinations, i.e. Shimla city, located in northern state of Himachal Pradesh (India) has been realised.

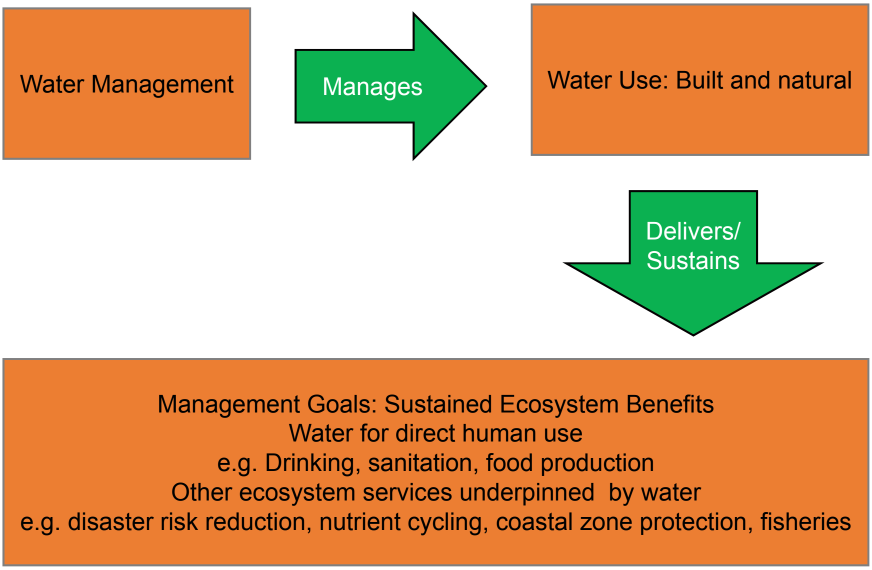


Fig. 15.1 Water ecosystem nexus. *Source* WWAP (2018)

Following sections explains the growing water concern of Shimla city and factors contributing to the water stress in the city.

15.3 Introduction of Study Area

The state of Himachal Pradesh is located at an elevation ranging from 350 m in lower Shivalik to 7000 m in Greater Himalayas (NABCONS 2015). It enjoys diverse climatic and physiographic conditions due to its locational and altitudinal variation (Chand 2013). The state is largely drained by tributaries of Satluj, Beas, Ravi and Yamuna which provides potentiality for agriculture/ horticulture. As shown in Fig. 15.2, the state is divided into 12 districts with Shimla being its administrative capital.

For administrative and development convenience, Shimla district is sub-divided into 13 tehsils and 7 sub tehsils and 10 Development Blocks (as shown in Fig. 15.2). It further comprises 363 Panchayat, 3231 villages and 11 local urban bodies (NABCONS 2015). Amongst which, Shimla Municipal Corporation is the largest urban agglomeration that serves as a major administrative, educational, heritage and tourist centre for both the state and district.

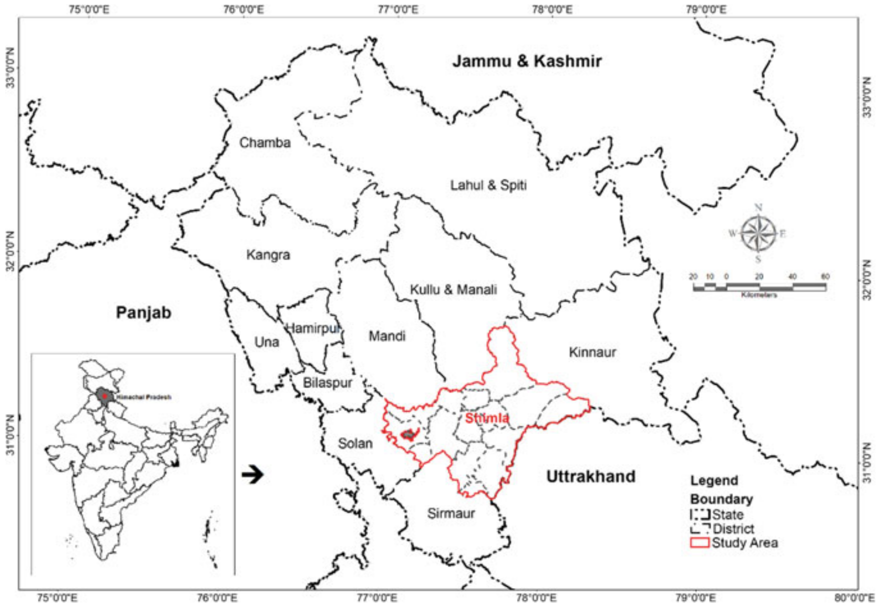


Fig. 15.2 Administrative division of Himachal Pradesh India. *Source* Census of India (2011a)

15.4 Growing Concern of Water Stress in Shimla City

As mentioned earlier, 54% of India faces high to extremely high water stress, this phenomenon is particularly noticeable in north-west part of the country (Shiao et al. 2015). One of the major tourist destinations of Himachal Pradesh, i.e. Shimla city, has been experiencing acute water stress in recent past. Generally, the state is blessed with water resources as it forms the catchment of major river systems (Indus and Ganga) of India and serves as a main source of water to its neighbouring states (TERI 2015). But, ironically in 2018, the state's own capital struggled to keep up with the unprecedented water shortage for continuously eight days (Thakur 2018).

Water supply system of Shimla city was laid down in the late 19th and early twentieth century during British time (Snyder 2014). With increasing demand, extensions were made in the water supply system and water was augmented from multiple sources namely Dhalli, Churat, Chair, Gumma, Ashwini and Giri which are located in peripheral rural areas. However, the reliability and sustainability of these sources are very low. The overall water installed capacity of the city is 61 Million Litres Per Day (MLD) out of which only 37–38 MLD water is produced (Thakur 2018). Of the many other valid reasons, water leakage due to ageing infrastructure is one of the major reasons for water shortage in the city (Bajpai, 2018).

In 1986, a study was conducted by the National Environmental Engineering Research Institute (NEERI) which has highlighted that more than 45% of water loss are due to leakages (Municipal Corporation Shimla 2009). Still, the state government failed to anticipate and take precursory measures to prevent such a situation. Later in 2015, Shimla city had also reported an outbreak of jaundice epidemic which affected many lives in and around the city. This outbreak was largely caused due to contamination of Ashwini water intake, which is located downstream of Malyana sewerage treatment plant (Chatterji 2018). The reduced efficiency of the sewage treatment plant and poor connectivity of sewerage network with habitation contributed to direct discharge of greywater in the natural streams.

Understanding the severity of these problems, ample studies have been conducted by the state government and researchers to find a new avenue for water supply in Shimla city, for instance, National Institute of Hydrology Roorkee in collaboration with Irrigation & Public Health department Shimla conducted the study on the impact of sewage effluent on drinking water sources of Shimla city and suggested ameliorative measure (NIH and I&PH 2013). Similarly, Government of Himachal Pradesh and World Bank in consultation with Deloitte and DRA consultancy came up with the situation analysis report on the drinking water & sewerage system of Shimla city (Deloitte Touche Tohmatsu India LLP/DRA Consultants Ltd 2018). Further, Sharma et al. (2015) conducted a resource assessment for suggesting short term corrective measures to improve the water supply for the city. These wide-ranging studies highlighted that water stress in Shimla city is the amalgamation of multiple factors such as weak regulation, high tourists' influx, poor operation and maintenance of water infrastructure and climate change etc.

Until now, majority of the studies related to water were confined within the Shimla Planning Area (SPA) limits with very little attention towards its catchment or watershed area which forms the major source of water to Shimla city. It has been noticed from the past few years that catchment or watershed area has been experiencing the tremendous change in land use and land cover because of urbanisation, change in cropping patterns and tourism (Vasudeva 2018). The aim of the study is to examine the change in land use and land cover of Shimla district using Natural Resource Census- land use land cover database for 2005–2006 and 2015–2016. Further, study the change in cropping pattern and rate of urbanisation in Shimla district and city.

15.5 Land Use Land Cover of Shimla District

Land is becoming a very significant resource in the wake of growing population and urbanisation. Numerous studies have accepted the fact that land use and land cover change has been one of the most prominently visible change taking place around us (Roy and Roy 2010). As per Praksham et al. (2018), Land use and land cover are two different terms that are often used together. Herein land cover means physical feature of the earth surface whereas land use implies human alteration of earth's surface for social and economic uses. Together these term, land use land cover change refers to human modification of the earth's terrestrial surface (Ellis 2007). According to Roy and Roy (2010), apart from altering the physical feature, land use land cover change also impacts the secondary processes which support the whole system of earth. For example, depletion of forest cover may lead to change in water cycle, loss of biodiversity which may directly impact the quality of air, precipitation of an area and further this loop continue impacting other relatable macro or micro phenomenon. Considering the present rate and intensity of urbanisation, it is necessary to analyse the land use land cover change to maintain the equilibrium between different uses (Kumar et al. 2018). Broadly, land use and land cover of Shimla district can be categorised into different levels as shown in Table 15.1.

Generally, Shimla district is spread over ridges, spurs and valleys, which is largely covered with shrubs or dense forests. The topographical constraints provide limited opportunity for various activities (Planning Department 2005). With time, major changes have been observed in the land use land cover pattern of Shimla district. Praksham et al. (2018) attempted to perform the change detection to understand the change in land use land cover Shimla tehsil. Wherein significant changes have been observed in the Shimla tehsil over a period of time. Figure 15.3 explains the change in the areas of different land use and land cover from 2005–2006 to 2015–2016.

Shimla district covers an area of 5131 square kilometres (km^2) which forms 9.22% of the total area of the state. As mentioned earlier, majority of the district is composed of evergreen dense and scrub forest. In 2005–2006, the evergreen forests occupied 2,267 km^2 of area which forms considerable part of Shimla district and it further experienced an increase of 1.19% in 2015–2016. While scrub forests which occupied 134 km^2. in 2005–2006 have seen a significant decline of 89.3% in 2015–2016. As agriculture is the mainstay of economy, it involves cultivation of various types of cereals, fruits and off-season vegetables (Prakasam et al. 2018). Significant changes have been observed in the agriculture of the district. In 2005–2006, agriculture cropland covered an area of 656 km^2 which has seen a significant fall of 29.8% in 2015–2016. Whereas agriculture plantation which occupied 672 km^2 of area has experienced an increase of 36.4%. As the area under agriculture, fallow land has drastically decreased to 98.4%, this depicts extensive utilisation of agricultural land. In 2005–2006, a considerable area of 732 km^2 falls under grazing land, but a notable dip of 37.19% has been observed in the grazing land. Along with agriculture and livestock rearing, tourism also contributes to the economy of the state.

Shimla is one of the major tourist and recreational centres. Corresponding to that, the urban built-up lands which include settlements, industries, government buildings and other recreational areas have experienced an increase of 34.7% from 2005–2006 to 2015–2016. However, rural built-up area has seen a decline of 9.8%. The district has witnessed a substantial increase in unproductive barren rocky, scrub and sandy land. In 2005–2006 barren scrubland accounts for 406 km^2 while barren rocky land covers only 23 km^2. But by 2015–2016 it has decreased by 39.8% and increased by 858.4% respectively. This depicts that extensive degradation of land has occurred due to human or natural activity. While glaciers and snow cover has seen drastic decrease of 38.8%, it will have a major impact on the availability of water in the longer run. Figure 15.4 spatially represent the temporal variations in the land use and land cover of the Shimla district from 2005–2006 to 2015–2016.

Table 15.1 Land use and land cover classification of Shimla district

S. No.	Level 1	Level 2	Level 3
1	Built-up	Urban	Residential, mixed, communications, public utilities, transportation, vegetated area, industrial/mine dump
		Rural	Rural
		Mining	Mine/quarry, abandoned mine pit, landfill area
2	Agriculture	Cropland	Kharif, rabi, zaid, two cropped, more than two
		Plantation	Plantation agriculture, horticulture, agro horticulture
		Fallow	Current and fallow
		Current shifting cultivation	Current shifting cultivation
3	Forest	Evergreen/semi-evergreen	Dense, closed and open
		Deciduous	Dense, closed and open
		Forest plantation	Forest plantation
		Scrub forest	Scrub forest, forest blank, current and abandoned shifting cultivation
		Swamp/mangroves	Dense, closed and open mangrove
4	Grazing	Grass/grazing	Alphine, sub-alphine, temperate/sub tropical, tropical/desertic
5	Barren land	Salt affected land	Slight, moderate and strong salt-affected land
		Gully /ravinous land	Gullied, shallow ravine and deep ravine area
		Scrub land	Dense, closed and open
		Sandy area	Desertic, coastal and riverine sandy area
		Barren rocky	Barren rocky
		Rann	Rann
6	Water bodies	Inland wetland	Inland natural land and manmade wetland
		Coastal wetland	Coastal natural and coastal manmade
		Rivers/ stream/canals	Perennial and dry river/stream and line and unlined canal/drain
		Water bodies	Perennial, dry, kharif, rabi and zaid extent of lake/pond and reservoir and tanks

(continued)

Table 15.1 (continued)

S. No.	Level 1	Level 2	Level 3
7	Snow and Glaciers		Seasonal and permanent snow

Source Prakasam et al. (2018)

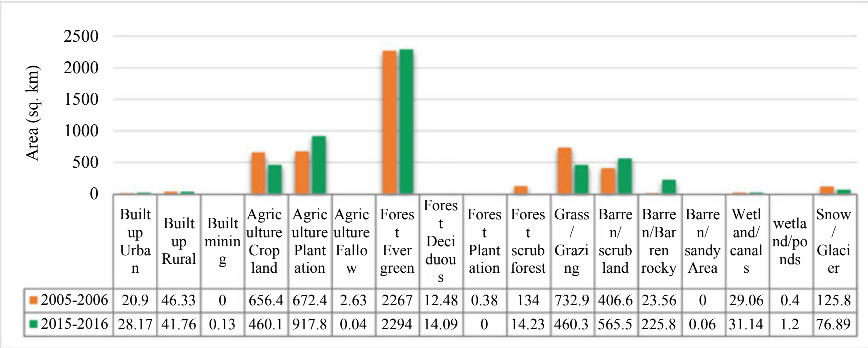


Fig. 15.3 Change in the land use land cover of Shimla district from 2005–2006 to 2015–2016, *Source* NRSC (2006); NRSC (2019)

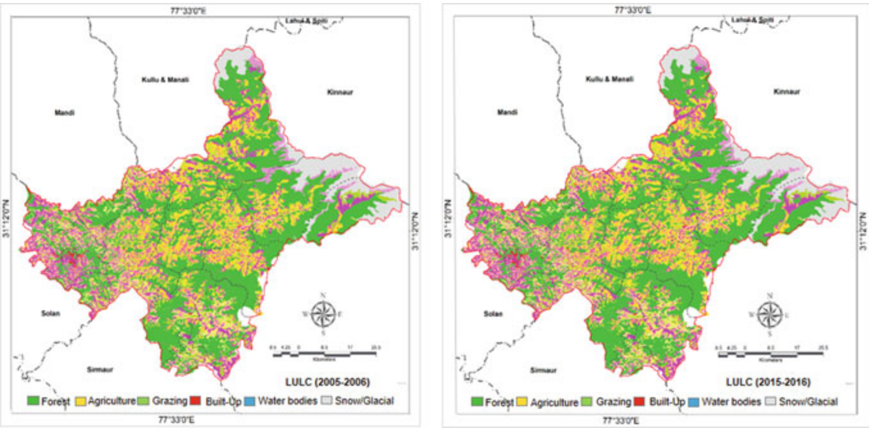


Fig. 15.4 Land use land cover of Shimla district in 2005–2006 and 2015–2016. *Source* NRSC (2019); NRSC (2006)

Further to validate the finding of land use land cover change, temporal analysis of urbanisation and change in cropping pattern of the Shimla district has been studied to build deeper understanding of the change in land use land cover.

15.6 Reasons for Increasing the Water Stress in Shimla City

This section is intended to provide support to the previous findings by discussing the factors responsible for the change in land use land cover, which directly or indirectly leads to increase in the demand for water in Shimla. This section is divided into two sub-sections. The first sub-section attempts to explain the trends of urbanisation in Shimla district and city since independence. While second sub-section provides a detailed overview of the change in the cropping pattern of Shimla district from 2005 to 2015.

15.6.1 Trend of Urbanisation in Shimla District

Urbanisation broadly refers to rural to urban transition involving population, land use, economic activity and culture (McGranahan and Satterthwaite 2014). Demographically the level of urbanisation can be measured by the percentage of the population living in urban areas (Bhagat 2011). As per Wu and Tan (2012) rapid urbanisation increases the urban water demand for different purposes and aggravates the water stress condition. Decadal population analysis of Shimla district shows a persistent and gradual rise in the level of urbanisation. At the time of attainment of Statehood, the district has only six urban centres namely Shimla Municipal Corporation, Municipal council of Rampur, Theog, Rohru and Jutogh Cantonment board. Gradually urban population grew and expanded to other parts of the district. Figure 15.5 shows, gradual rise in the urban growth rate to 15.7% in 1981 and 20.4% in 1991. Here, five settlements of Narkanda, Seoni, Chaupal, Kotkhai and Jubbal were notified as Nagar Panchayat in 1991 (Sharma 2003). The increase in urban population was largely due to natural increase, rural to urban migration and partly due to the emergence of newly notified towns by the State government. By 2011, growth rate

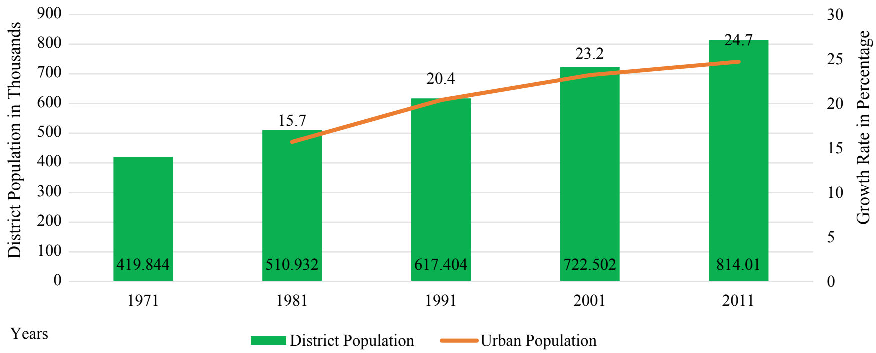


Fig. 15.5 Total population and urban growth rate of Shimla district in 1971–2011. *Source* Census of India (2011b)

reached 24.7% and Jhakhri was notified as a census town (Census of India 2011a). However, among all the urban centres, Shimla Municipal Corporation has experienced the maximum influence of urbanisation as it is the only class I city of the State which accommodates around one-fourth of the State's total urban population. This is mainly due to its early establishment, administrative capital, tourist destination and health resort (Sharma 2003). Urbanisation is largely attributed to administrative and economic primacy of Shimla city.

The historical evolution and development of Shimla city can be categorised into four stages, as explained by (Kumar and Pushplata 2015). The first stage includes the pre-independence colonial time when Shimla was originally conjointly belonged to Maharaja of Patiala and Rana of Keonthal. In 1830, the British acquired the land and established a summer resort to escape from the scorching heat of plains and to recover from homesickness. Realising the vast potentialities of Shimla, it soon became a reputed hill station and sanatorium (Jayaswal 1979). Consequently, this raised the population size of a small hamlet from less than 500 people in 1804 to 7,077 in 1860 (Jayaram 2017). The second stage of development is marked by the independence of the country, where the town continued to experience high population growth rate, largely due to partition and shifting of the East Panjab government to Shimla. However, with the relocation of the capital of East Panjab to Chandigarh, Shimla faced the worst neglect and positioned as a distant headquarter. The growth rate of population reflected the major events of the city's evolution. Figure 15.6 shows from 1941 to 1951 the population grew exceptionally high at 151.5% but suddenly dipped to −7.7% in the consecutive decade. In 1966 reorganisation of Panjab resulted in the merger of Shimla with Himachal Pradesh and it became the permanent capital, with the attainment of statehood in 1971 growth rate surged up to 71.1% which marked the third stage of development where Shimla again rejuvenated. Growth was reflected with the substantial increase in the size of the population however municipal limits increased marginally. Table 15.2 shows the population and the spatial trend of Shimla city.

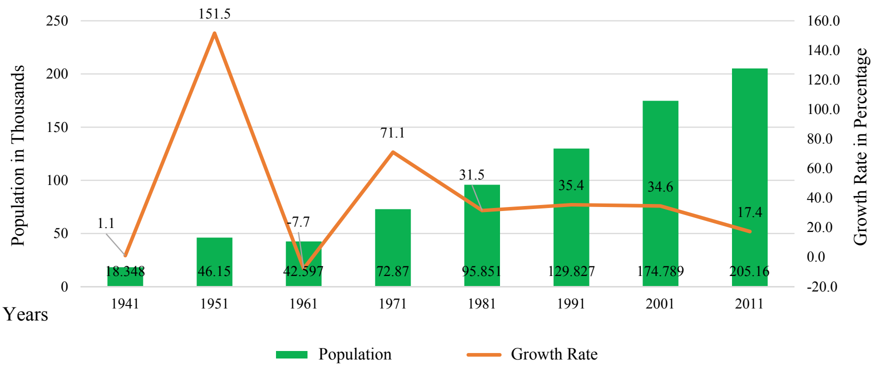


Fig. 15.6 Population and growth rate of Shimla city from 1941 to 2011. *Source* Kaistha and Sharma (1998); Deloitte Touche Tohmatsu India LLP/DRA Consultants Ltd. (2018)

Table 15.2 Total population and spatial extent of Shimla city (1961–1991)

Year	Class of Town	Population	Area in km^2	Area of agglomeration
1961	III	42,597	18.13	
1971	II	55,368	19.55	
1981	II	70,604 (73,004)	19.55 (21.66)	21.66
1991	I	82,054 (110,360)	31.60 (35.34)	35.34

Source Kaistha and Sharma (1998)

Considering the disproportionate spatial and population growth, the state government constituted Shimla Planning Area (SPA) in 1977. It was followed by the constitution of the Interim Development Plan and Shimla Development Authority to ensure planned development. SPA constituted of Shimla Municipal Corporation along with agglomeration of Dhalli, Tutu, New Shimla and Special Area of Kufri, Shoghi, Ghanahatti, which are potential growth centres for urbanisation which are experiencing rapid growth (Shekhar 2011). Major developmental changes took after independence but the issue of congestion housing, water scarcity persisted and further aggravated. This marks the last and the present stage of development, Shimla is still struggling with. Here, population continued to rise at a constant average rate of 33.8% till 2001 but suddenly dipped to 17.4% in 2011.

However, the city's available water resource is not at par with the growing urbanisation. Presently Shimla city gets its water supply from major springs/ Khads namely Dhalli, Churat, Chair, Nauti, Ashwini and Giri (Disaster Management Cell 2012). Although these sources have a total installed capacity of 62–65 MLD, the supply is limited to 33- 38 MLD. This is largely due to poor maintenance of pipelines, water reservoirs, leakage, theft and depleting resources. Considering the growing urban population and existing installed capacity the water demand of Shimla city may cater up to 2025 (GIZ ASEM 2011). The City Development Plan (2006) projected the future water demand of Shimla city as shown in Table 15.3.

In order to cater to the present and future water demand, it is important to rejuvenate the existing and augment the new water source.

Table 15.3 Water demand projection of Shimla city

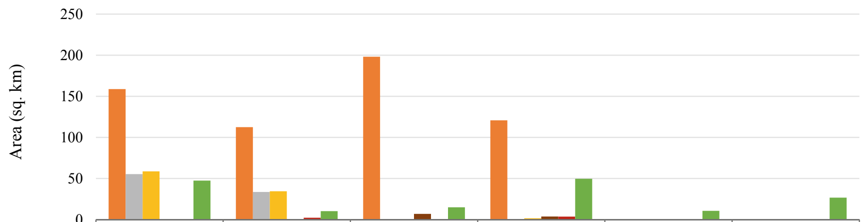
	2010	2011	2021	2031	2041
Resident population	1,98,717	2,07,063	2,56,883	3,49,361	4,18,296
Floating population	70,000	76,000	1,00,000	1,25,000	1,50,000
Water demand (MLD)	36.28	38.21	48.18	64.04	76.72

Source GIZASEM (2011)

15.6.2 Cropping Pattern of Shimla District

Cropping patterns refers to the percentage of area under different crops in a particular period of time (Kumar et al. 2018). Analysing the change in cropping patterns helps us to understand the agricultural development of a region. As per NABCONS (2015), Shimla has 855.23 km^2 of arable land which accounts for 8% of the total district area. A wide variety of food and non-food crops are grown based on the geo-climatic conditions of a region. Here, Kharif crops of maize, rice (cereals); bajra, chulai (coarse crops); rajmah, urad (pulses) are grown in 49% of arable land and Rabi crops of Wheat, barley (Cereals), Gram and lentil (Pulses), Onion and tomatoes (Vegetables) are cultivated in 45% of land while remaining 7% includes summer crops of peas and cabbage (vegetable). Shimla also has majority of its area under production of fruits (apple, pear and cherry). Over the years there has been a prominent shift observed from agricultural cropland to agriculture plantation. Figure 15.7 also shows the prominent changes that occurred in the cropping pattern of Shimla district from 2005 to 2015. In Kharif season a substantial decrease in the area under cereal (29.1%), coarse cereals (39.4%), pulses (41.3%), and vegetable (78.6%) has been noticed except under spices. Similar decrease has been noticed in cereals (39.1%) and oilseeds (46.2%) in Rabi season, while the area under pulses, spices and vegetables has seen a substantial increase. In the same fashion area under vegetable and spices has increased prominently in the summer season. However, as land is a limited resource, the production and productivity of the crops can be increased by irrigation, use of high yielding varieties and bio fertilisers etc. So, it is important to meticulously take into consideration the available water resource and its demand for various purposes.

In Shimla, majority of arable lands (855.23 km^2) are rain fed. Here, irrigation accounts to only 6% of area, largely through Khul, community/ individual ponds and bore well and open well. Although agriculture and horticulture are largely rain fed and only 19% of arable land is irrigated, but it is imperative to consider the



	Kharif 2005	Kharif 2015	Rabi 2005	Rabi 2015	Summer 2005	Summer 2015
Cereals	158.77	112.5	198.09	120.67	0	0
coarse cereals	55.29	33.53	0	0	0	0
Pulses	58.65	34.45	0.29	1.6	0	0
Oilseeds	0	0	6.88	3.7	0	0
Spices	0	2.25	0	3.61	0	0.21
Vegetables	47.4	10.16	14.85	49.56	10.6	26.64

Fig. 15.7 Change in cropping pattern of Shimla district from 2005 to 2015. *Source* NABCONS (2015); Planning Department (2005)

Table 15.4 Water requirement of the major crops in Shimla district

Crops	Number of watering	Total water requirement (in millimetre)
Paddy	12	600
Wheat	5	150
Maize	2	60
Vegetables	6	180
Horticulture crops	–	60

Source NABCONS (2015)

water requirement of different crops, to assess the present and future water demand. According to NABCONS (2015), as per the discussion with agronomists of Agriculture University, the water requirement of the major crops has been calculated as shown in Table 15.4, shows paddy, vegetables and wheat require more frequency and amount of water for cultivation.

Considering the (2015–2020) District Irrigation Plan of Shimla district, Table 15.5 shows the total crop water requirement of different blocks in Shimla district.

Herein, it is evident that the existing water potential of the district is 7.24 MCM against the requirement of 84.06 MCM, which means a total gap of 76.82 MCM is needed to be created to fill in the present requirement. Considering the depleting

Table 15.5 Block wise crop water demand of Shimla district

Block/Tehsils	Area sown (km^2)	Irrigated area (km^2)	Crop water demand (MCM)	Water potential required (MCM)	Existing water potential (MCM)	Water potential to be created (MCM)
Basantpur	68.61	4.21	7.3029	7.3029	0.8445	6.4584
Chauhara	102.8	6.03	12.8379	12.8379	2.3214	10.5165
Chopal	134.28	4.54	15.3276	15.3276	1.668	13.6596
Jubbal Kothkai	88.99	0.49	5.7999	5.7999	0.1722	5.6277
Mashobra	85.9	7.92	8.2785	8.2785	1.1415	7.137
Nankhari	29.77	0	2.1141	2.1141	0	2.1141
Narkanda	84.17	1.4	7.0074	7.0074	0.534	6.4734
Rampur	87.55	0.79	8.9445	8.9445	0.1986	8.7459
Rohru	73.41	0.62	5.8446	5.8446	0.1908	5.6538
Theog	99.75	0.97	10.6041	10.6041	0.1632	10.4409
Total	855.23	26.97	84.0615	84.0615	7.2342	76.8273

Source NABCONS (2015)

water resources, it is imperative to replace the water-guzzling crops with less water-intensive crops to maintain the ecological balance. It is important to revive the traditional crops with new technological intervention to maintain the food and livelihood security, natural resources and prevent the impact of climate change.

15.7 Suggestion

Change in the land use and land cover of Shimla district has become quite prevalent with increasing urbanisation and changing cropping patterns (as discussed in Sect. 6). Further, these changes have a direct impact on the water resource of the Shimla district. As Shimla is already undergoing through major water stress situation, it is necessary to undertake important measures to preserve water for present and future generations. Considering the topography and hydrogeology, it is important to apply nature-based solutions for effective management of water resources in Shimla.

1. Spring shed Development
   Most of the irrigation and domestic water supply are channelized through spring, *khads, khul, bowaries*. Proper development of springs and revival of traditional water storage (*bowaries*) can help in managing the groundwater resource of Shimla district. In recent times, a number of bore wells and hand pumps were constructed to extract the groundwater. However, considering the fragile ecosystem, drilling activities should be minimised or avoided. So, revival of traditional water storage (*bowaries*) could be a more appropriate and feasible solution to tap the groundwater resource of the district. Other than its primary use, these *bowaries* also serves as a point of cultural and social interactions.
2. Water harvesting
   As Shimla city is frequently witnessing the water shortage during lean period or summer seasons, there is an immediate need to conserve the water or augment new water resources. Based upon the climatic and topographic condition of Shimla district, rainwater harvesting and artificial groundwater recharge can be an appropriate solution to overcome the problem of water shortage during lean period. Rooftop rainwater harvesting in urban or rural areas and water harvesting structure in rural areas need to be promoted to supplement the water resource during lean period.
3. Agroforestry
   It is evident from land use land cover change, area under scrub forest has experienced a major decline over a period of time. Conversely, the area under plantation agriculture has seen a major increase. Studies have shown that forests play a very significant role in water conservation. So, to maintain the forest cover along with the agriculture, it is important to perform agroforestry in hilly areas. Agroforestry performs various other ecosystem services such as carbon sequestration, soil enrichment, biodiversity conservation and air & water quality improvement. Moreover, it also gives economic benefits to the farmers.

4. Biological and Mechanical measure for water conservation
   As the district has hilly terrain with rolling topography and sloppy lands. Heavy rainfall may cause splash erosion and low infiltration of surface water. To improve soil and water conservation, it is important to promote biological (vegetative Barriers, strip cropping, mulching) and physical (contour trenches, bunding, terracing) measures in rural and urban areas to conserve water and soil.
5. Watershed management
   Shimla district forms the watershed of major rivers system (Ashwini, Nauti, Giri, Satluj and Pabbar) of district. Change in land use and land cover has accelerated the problem of deforestation, land degradation in the watershed. This change along with other factors has collectively contributed to drying up the natural water source which has directly impacted the socio-economic life of the people in watershed. By promoting integrated watershed management programme, harmonious development can be achieved between natural and socio-economic environment of watershed.
6. Reviving Traditional Crop
   A major shift in the agriculture pattern of the Shimla district has been evident from land use land cover change. Area under agriculture cropland has seen drastic decline while area under agriculture plantation has seen tremendous increase. This is largely due to higher economic benefits from the plantation crops. It is essential to maintain the traditional food crops along with the commercial crops, as traditional crops are favourable to local climatic and physiographic condition and requires comparatively less input for production (Fig. 15.8).

15.8 Conclusion

In view of rapidly changing land use land cover of Shimla, it is important to manage the available water resource in Shimla district. By understanding the trend of urbanisation and change in the cropping pattern of Shimla district, the study attempted to understand the growing reliability on limited water resources and determine the pathway to sustainably manage the water. Based on literature review, the study highlighted the growing concern of water stress in India and Shimla and increasing recognition of nature-based solutions to tackle the problem of water insecurity.

Further, the study emphasised understanding the change in land use land cover of Shimla district from 2005–2006 to 205–2016. For analysing the change, databases on land use land cover of Shimla district from the specified years were retrieved from Natural Resource Census- land use land cover. It has been found that major changes have been observed in scrub forest cover, urban built-up area and cropland /plantation agriculture. To examine the observed change, temporal analysis of urbanisation and change in cropping pattern of the Shimla district has been studied. It has been found that Shimla has witnessed significant increase in urban population and their demand a b c d

Fig. 15.8 **a** Picture show reconstruction of water *bowaries*. **b** Picture show the use of pipe to capture the water. **c** Skyline view of forest cover in Narkanda. **d** Water collection tank in Narkanda. *Source* Author

for water. Prominent change has also been found in the cropping pattern and it has been realised that existing water potential of the district is less than the requirement of crops.

The study generated substantial evidence of growing water concern due to changes in land use land cover. Further study suggests a suitable direction of natured based solution to address the growing water issue in Shimla.

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