NEW ANGLE

Nepal Journal of Social Science and Public Policy

Volume 6 Number 1 2020

Water Scarcity and Sustainability in the Himalayas

Mapping Institutional Landscape for Integrated Urban Water Management in Haldwani City, Uttarakhand

Anvita Pandey, Manya Singh, Riyan Habeeb and Vishal Singh

CHIEF EDITOR

Dil Khatri, *Southasia Institute of Advanced Studies (SIAS)*

SPECIAL ISSUE EDITORS

Chandra Lal Pandey, *School of Arts, Kathmandu University*

Dil Khatri

Hemant Ojha, *University of Canberra*

INTERNATIONAL ADVISORY BOARD

Hemant Ojha

Andrea Nightingale, *University of Oslo*

Fraser Sugden, *University of Birmingham*

Siri Eriksen, *Norwegian University of Life Sciences*

Jon Ensor, *University of York*

MANAGING EDITOR

Gyanu Maskey, *SIAS and Kathmandu University*

Design and Layout

Pradip Dhakal

Sanjeeb Bir Bajracharya

©Southasia Institute of Advanced Studies

E-mail: sias-info@sias-southasia.org

Website: www.sias-southasia.org

NEW ANGLE Nepal Journal of Social Science and Public Policy
2020, Vol. 6 (1), pp.52-65

Published by **NPRN**
Hosted by **SIAS**
Available at www.nepalpolicynet.com

MAPPING INSTITUTIONAL LANDSCAPE FOR INTEGRATED URBAN WATER MANAGEMENT IN HALDWANI CITY, UTTARAKHAND

Anvita Pandey[1] , Manya Singh[1], Riyan Habeeb[1], and Vishal Singh[1]

Abstract

According to the latest government reports, India is facing evident shortfall of water in various parts of the country, and Himalayan states are likely to suffer the impacts of climate change related to water more than non-Himalayan states. Water resources are expected to affect Gross Domestic Product (GDP) of the country, and future projections are far more upsetting. In this light, sustainable and adaptive strategies such as integrated water resources management, nature-based solutions have been promoted globally for sustainable and integrated urban water management. The paper inquires into functions of respective institutions and their possibilities to adopt possible nature-based solutions such as rain water harvesting in response to water insecurity and adaptation in times of climate change. Taking case of Haldwani city, the paper assesses water demand and supply gaps, the existing water institutions, their scope of work and water management mechanism. Further, the scope of adoption of possible nature-based solution is explored by the purview of their work in water management. This was derived through an in-depth literature review, stakeholder consultations as key informant interviews, and participatory mapping. Haldwani has experienced severe water scarcity due to depletion of groundwater, decline in the discharge rate of river Gaula, and drying of springs in and around the city. Various agencies manage the existing water resources in isolation and mismanagement of water is one of the prominent problems in the city. The paper delves into the nuances of

[1] Centre for Ecology Development and Research, Dehradun, India.
Corresponding email: anvitapandey90@gmail.com

© *Pandey et al., 2020*

various strategic interventions, and the respective institutional capability to undertake the same. While most of the strategies prevalent at international level are yet to be adopted in context of Himalayan cities, a key finding is that rain water harvesting system can be easily taken up as a nature based solution by each of the institutions since it also falls in their scope of work as well as to meet the city's present and future water challenges.

Keywords: Water use, developing countries, efficient water demand and supply, strategies of water resource management, rainwater harvesting

INTRODUCTION

Global water use has increased by a factor of six over the past hundred years and continues to grow steadily at the rate of 1% per year (WWAP, 2018). The United Nations in 2018 has reported the world population is expected to grow to 10.2 billion by 2050 with two-third of the people living in cities. This puts high pressure on existing water resources in the city. Along with the issues of water quantity, people are also facing quality issues with water as it has been degrading manifolds with growing agriculture and other economic activities. While many developed nations continue to manage the resources judiciously or can arrange alternatives, the developing countries with underdeveloped infrastructure and unscientific planning grapple with uncertain water insecurity. In this paper, we assess institutional dynamics surrounding water supply management taking case of a city in Indian Himalaya. The case study city is 'Haldwani', which faces evident spells of water scarcity. The case study is used to theoretically establish the relation of different components of water management approaches and how it can be made suitable for an Indian Himalayan City. The case study of Haldwani has semblance with institutional arrangements and ecological resources to many other mid-sized cities in India. For the study, we have tried to map the existing institutions and their related functions to explore the best possible adaptive strategy for urban water security.

National context of water scarcity in India

During the past century, the global population has tripled, but our use of water has increased six-fold (WWAP, 2018). The global population is growing at an unprecedented rate for which global water demand will continue to grow significantly over the next two decades. It has been argued that much of this urban growth is taking place in developing countries and the pattern of growth is uncoordinated and fragmented (Du et al., 2004; Carruthers and Ulfarsson, 2002). It has put extreme pressure on natural resources. Increasing concerns for social wellbeing and environmental degradation has been the locus of various scientific and social scientific studies for the past decade. Cities are thriving for a sustainable living standard while struggling to maintain the ecosystem and natural resources. Developing countries have been quite unfortunate in the planning and governance of its natural resources. In these times, the most debated segment is 'water resource sector'.

Water security is emerging as an increasingly important issue of sustainable development for the Asia-Pacific region particularly for India. As per the UN World Water Report 2018, most of India has shown appalling results. The change in water scarcity from 2010 to 2050 projection shows that India has gone from 'water scarcity to 'severe water scarcity' column. India is at the top of the list in terms of groundwater abstraction, mainly for agriculture purposes. In addition, the problem has proliferated more because of the unplanned and rapid urbanisation. Domestic uses of an urban dweller are more water-intensive than a rural dweller because of the advanced technologies and lifestyle choices. According to Census of India 2011, urbanisation has escalated faster than expected at the rate of 2.76%. This has enormous implications for providing infrastructure and other civic amenities in urban areas (Bhagat, 2011). India is facing its worst water crisis in history and can lose 6% GDP due to water scarcity (Niti Aayog, 2018).

India has 16% of the global population and only 4% of the world's water resources (Government of India (MoWR, 2002). Country's water availability per capita is 1,170 m3 per person per year which is just marginally above the water-stressed criteria given by the World Resource Institute, i.e., 1000 m^3 per person. 90% of the urban population has access to drinking water, and more than 60% has access to basic sanitation, but the country is lagging in terms of access to reliable, sustainable and affordable water supply and sanitation (Bapna, 2011). The household supplies have limited hours per day for the water supply, and less than 50% urban population have access to piped water. The estimated amount of Non-Revenue Water lies between 40-70% of the total distributed water and, operation and maintenance cost recovery through water user charges is hardly 30-40% (Bapna, 2011). The practical and efficient water demand and supply management are 'limited by inadequate institutional reforms' (Saleth, 2011), poor managerial and financial autonomy, limited accountability, weak cost recovery and limited capacity (Bapna, 2011) and poor implementation of existing provisions.

While many challenges can be expected from the water stress scenario, equity in distribution and integrated water management remain a significant one in the city. In cities, there are demographically sensitive groups regarding population, workforce, literacy and water supply system (Habeeb et al., 2019). Prevalent managers are strained to meet demands of drinking water, sanitation, wastewater treatment, and other water-related services which has resulted in acute water shortages and lousy quality water service in many areas. Shortfall of water resources create competition and conflict over water. Economic development sectors have large water demand and are getting the water supply, but there are economically fragile groups and communities which are facing threats inflicted by water scarcity (Bahri, 2012). Equity issues are not adequately addressed by administrative institutions. Such issues could be a result of socio-spatial representation (Larson and Lach, 2010)

of wards regarding their geographical position and the socio-economic profile of scarce water wards.

MATERIAL & METHODS

Study Area

Haldwani comes under Haldwani-Kathgodam Municipal Corporation (Nagar Nigam). It is also known as 'Gateway to Kumaon.' It is one of the most populous towns in Uttarakhand with a total population of 156078 (Census of India, 2011). It has historically been a trading post and a hub between the hilly regions of Kumaon and the Indo-Gangetic Plain. The climate is mild, warm and temperate. The annual rainfall is recorded approximately 1,505 mm and high rainfall is recorded more in winter than summer. It is the last outpost of plains, and from here, temperature and wind change at every meter.

Haldwani is divided into 25 wards, falling under administrative boundary of Nagar Nigam. Water supply is operated and maintained by Uttarakhand Jal Sansthan (UJS) while Jal Nigam is responsible for building and executing water related projects such as overhead water-storage tanks, laying of water supply and sewerage works across the city.

The research has adopted mixed method including in-depth review and analysis of secondary sources such as peer-reviewed academic articles, secondary data, and grey literature (reports from national and international agencies). It was then substantiated by qualitative data collected from stakeholder analysis. Stakeholder analysis was conducted by mapping of important stakeholders - Urban Water Management Authority (Jal Sansthan), Forest Department, Irrigation Department, Ground Water Board (Bhujal Nigam), Haldwani-Kathgodam Municipal Corporation (HNN), related to water resource. Data was collected with the help of a water forum meeting (as focus groups discussions) and key informant interviews (KII). Sustainable strategies for urban water management were identified through literature survey and mapped with purview of respective institution to derive the most suitable approaches of water management.

Haldwani-Kathgodam Water Supply

At present, there are three primary sources of water for Haldwani-Kathgodam Township including the surface water from Gaula River, groundwater from Sheetlahat Gadhera and sub-surface water from tube wells. River Gaula is adopted as a source of drinking water for Haldwani town, and about 15.83 MLD water from the river is diverted towards Sheeshmahal Water Treatment Plant passing through Gaula Barrage. Water at this treatment plant gets filtered in four filtration units with capacities of 6.75 5.25, 15, and 7.5 MLD respectively. Similarly, about 2 MLD water from Sheetlahat Gadhera is diverted towards Sheetlahat Water Treatment Plant. The designed capacity of both the

treatment plants, i.e. Sheeshmahal Water Treatment Plant (constructed in the year 1975) and Sheetlahat Water Treatment Plant (built in the year 1962) is 34.5 and 3.5 MLD respectively. In addition to the other 2 sources mentioned above, 17.28 MLD water is drawn through a total number of 20 tube wells located in different wards of the city. After considering 10% intake losses at both the treatment plants and 20% distribution losses, net availability of water in the town is 26.67 MLD. Treated water from both the treatment plants together with water from tube wells through piped water supply caters to the water demand of Haldwani-Kathgodam Township as well as the surrounding peri-urban areas. All the water supply to the town is lifted and stored in reservoirs with the storage capacity of 18.61 MLD (SLIP-water, AMRUT, 2016-17).

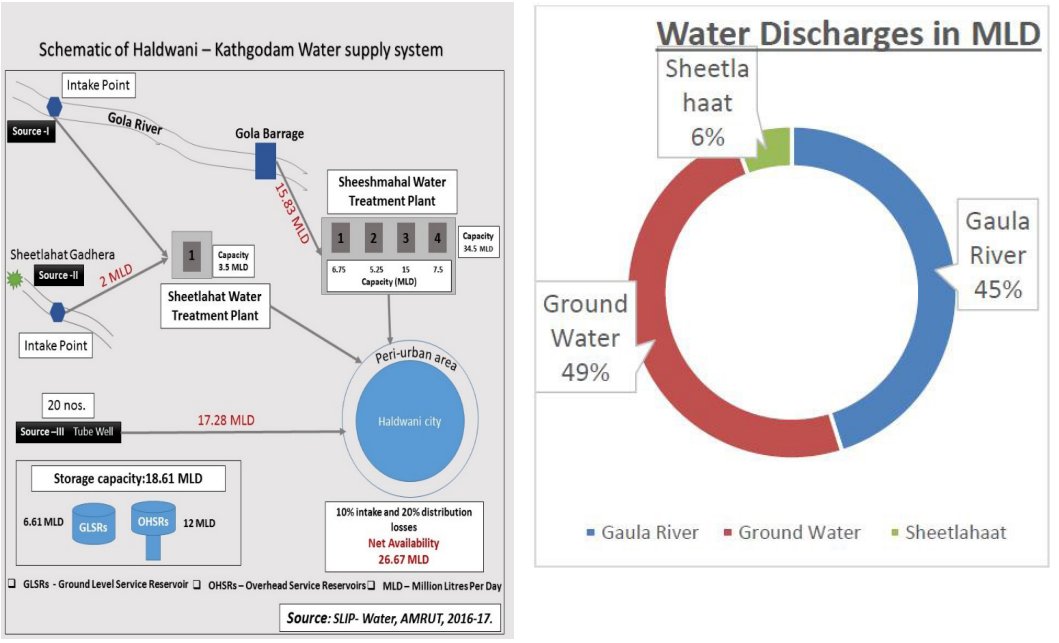


Figure 1. Halwani water systems

FINDINGS AND DISCUSSION

Institutions for Water Management

Water cycle of urban catchments is complicated, and involves water supply, wastewater disposal, and storm water drainage. For urban water supply, high quality water is harvested from different catchments, treated and then supplied. The supply mechanism involves various institutional elements that are included in the total upkeep and distribution of water resource. In Haldwani, the institutions pertaining to water management and development issues are Water Management Authority, Irrigation Department, Forest Department, Bhujal Nigam, Haldwani-Kathgodam Municipal Corporation (refer table-1).

Table 1. Functions of different institutions for water management (as per the stakeholder analysis and focus group discussions)

INSTITUTIONS	SCOPE OF WORK
Water Management Authority	Uttarakhand Jal Sansthan and Jal Nigam, are the two institutions responsible for water management in the city. While Jal Nigam is mostly responsible for planning and execution of projects, Jal Sansthan is responsible for the operation and maintenance. JS SLIP document claims to have 80% of tapped water supply to all the households at 133 LPCD. In addition, with respect to other water supply services, there is 40% non-revenue water, with 70% quality water supply, 0% metering, and 55% cost recovery in water supply services and 70% in the collection of water supply related charges. Thus, to meet these challenges, augmentation, up-gradation, and addition through new projects are required for universal coverage.
Irrigation Department	Uttarakhand Irrigation Department is also responsible for Water Management of Gaula River and oversees Gaula Barrage which channels the river water. It governs and regulates water from the river and its distribution for urban, rural and agricultural purposes. It provides 28 MLD of water withdrawal for urban drinking.
Forest Department	Forest Department is responsible for the maintenance and conservation of various categories of forest in and around the city. Their roles and responsibilities involve checking the catchments and watershed in the forest areas as well as plantation drive to restore groundwater.
Haldwani-Kathgodam Municipal Corporation	Haldwani-Kathgodam is governed by Haldwani Nagar Nigam (HNN), the Urban Local Body. The city is divided into 25 administrative wards. HNN is responsible for implementation of various government missions such as Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and Housing for All (HFA), upkeep and management of the city; it is also responsible for regulation of buildings and construction activities as well as local bye-laws in accordance with state level policies.

From the functional point of view with respect to water resources, Forest Department is responsible for conservation and preservation of natural water bodies and majority of water from Gaula river is allocated by the irrigation department for urban and rural purposes. The urban water is then stored, purified and managed by Jal Sansthan across the city to meet potable urban water demand. This is facilitated by Municipal Corporation with number of households. Earlier before 2015, Jal Sansthan was the major decision maker in water supply, treatment and discharge but with launch of AMRUT mission municipal corporations have been the nodal agency to manage urban water with technical support from Jal Sansthan. This paradigm shift has vested more powers to ULBs in allocation of water with respect to household demands. Due to the deficit in water supply, private tankers also play a key role to meet the demands during water scarce months, however, they may not be viewed as formally recognised institutions but a private entity.

Water Stress Scenario in Haldwani, Uttarakhand

The Himalayas are known as water tower of the world, and most of the rivers in North India originates from these mountain ranges and glaciers. The water resources regime is changing differently in the Himalayan states, such as changes in the discharge rates, volumes, and availability due to overutilisation and changing climate (Erikson et. al., 2009). The Himalayas contribute to water interests

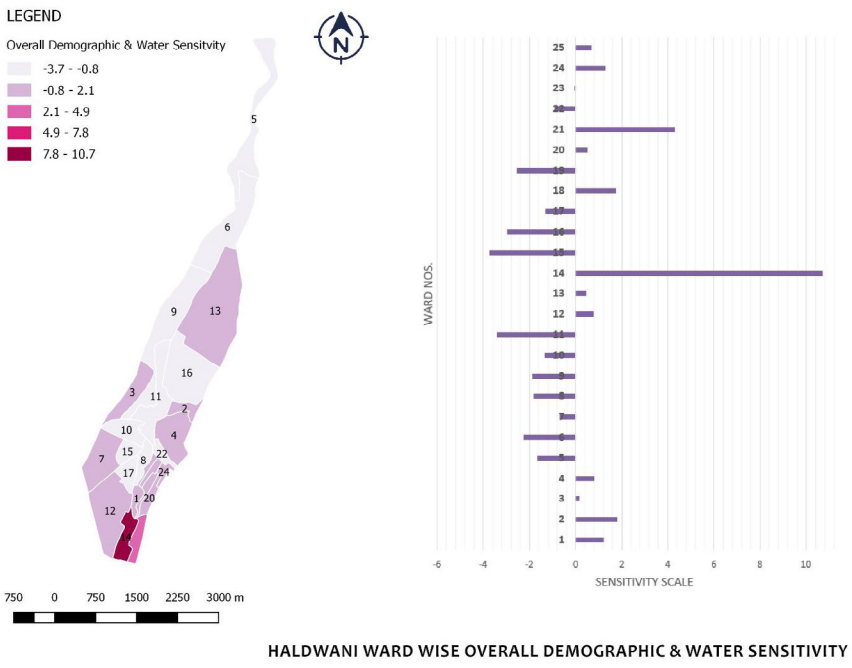


Figure 2. Population trends in Haldwani, source: Habeeb et al., 2019

of lowland and urban regions (Tiwari, 2010). Uttarakhand, an Indian state in the western Himalayas is facing evident spells of water scarcity. In a recent Composite Water Management Index report by the National Institute for Transforming India (NITI) Ayog, Uttarakhand has been listed at the bottom of the performance index. The state has been lagging in innovative and effective water management practices. It has a dismal performance under various indicators such as surface and groundwater restoration; it has restored less than 10% of water bodies and not created or mapped any infrastructure for the same. The network of its water distribution coverage has been at a low of 60% both for urban and rural access.

Haldwani has a complicated physio-geographical set up as well as a unique water system. It is a city in the plain part of Kumaon region of Uttarakhand. Haldwani is known for its in-migration flux and urban sprawl that has taken place in recent decades. There has been an increase in Built-up sparse from 4.4 sq. km to 6.3 sq. km (Bora et al., 2018). This has escalated stress on natural resources, mainly water. Water insecurity is assessed in a recent paper for Haldwani taking demographic sensitivity and water scarcity data sets. The figure below shows the most vulnerable wards regarding water insecurity in the city (Habeeb et al., 2019).

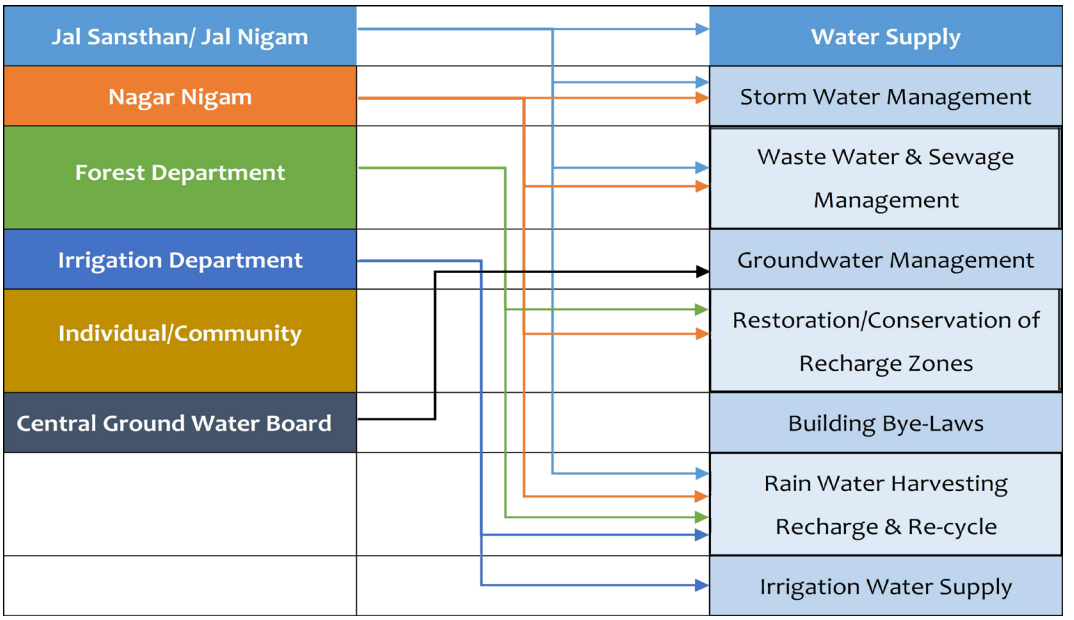
This sets the premises for the need of institutional reform and a better model to govern the water resources as well as to augment the existing resources via different approaches. Besides being a plain city, which caters all the essential amenities, facilities, job and education opportunities, the research on the planning and governance of the town has remained sparse.

Institutional Mapping with Implementation Strategies

Institutions and devolved functions

Under the legal provision, each institution is vested with responsibilities for water management. To introduce a strategic intervention, one shall understand what actors do and roles they play in the urban water system. Various institutional bodies take care of different utilities of water, from conservation of water bodies to water supply, storm water, and waste water management. Figure-3 shows the mapping of different institutions to their functions. Jal Sansthan and Jal Nigam collectively look after water supply, waste water and storm water management, and are also expected to evolve measures for rainwater harvesting, recharge and recycle. Similarly, as per the new shift in Government of India's programs (AMRUT) ULBs have been made administratively accountable to all the functions as Jal Sansthan except technical appraisal of the projects. This puts HNN in same accordance with Jal Sansthan in addition to compliance with building-bylaws to prevent unregulated construction of critical urban water zones. Water resources conservation and restoration of recharge zones lie with Forest department if they fall in protected forest zones. Irrigation department taps the water from Gaula river and is responsible for allocation of water for urban and rural areas, mainly agriculture. In addition to this, they are also responsible for harvesting

rain water and recharge and recycling of the same. Central/ State Ground Water Board is mainly the monitoring agency for underground water with no executive power. Lastly, under fundamental duties of the Constitution of India, every citizen is supposed to conserve and protect natural resources, encouraging citizens towards recharging ground water and reuse of water. While these institutions have different scope of work, most of them as per government directives are required to promote and incorporate provisions of water harvesting, recharge and recycling.



Plausible Strategies for Water Management

Various literature proposes different strategies to achieve sustainable urban water resource management, such as Integrated Water Resource Management, Water Sensitive Urban Design, Integrated Urban Water Management, and Nature-Based Solutions. At a global level in 2002 Johannesburg World Summit on Sustainable Development Implementation Plan, Integrated Water Resource Management (IWRM) was proposed. In IWRM, principles like fresh water as finite and vulnerable resource has an economic value. Its development and management require a participatory approach in which women play a central role for provisioning, management, and safeguarding. It requires robust coordination among all the actors such as individuals, companies, organisations, and governments; in all sectors such as irrigation, domestic water supply, and industry (Moriarty, 2005; Butterworth et al., 2010). A related approach known as Integrated Urban Water Management (IUWM) entails alignment of urban development and basin management for sustainable use of water resource. It has encapsulated the urban water parameters such as water supply,

sanitation, storm water, and wastewater management and integrated land use planning and economic development (GWP, 2012). Both the strategies necessitate cross-sector relationships and negotiation between different socio-economic groups or informal sectors to achieve a fair and equitable distribution of water resources. For urban water planning and design, Water Sensitive Urban Design occupies an important space because of the mismanagement of urban water cycle and catchments. The neglect for the stormwater and wastewater discharge has been distinguished. It is explained as "a philosophical approach to urban planning and design that aims to minimise the hydrological impacts of urban development on the surrounding environment. Stormwater management is a subset of WSUD directed at providing flood control, flow management, water quality improvements, and opportunities to harvest stormwater to supplement mains water for non-potable uses (that is, toilet flushing, garden irrigation, etc.)" (Lloyd et al., 2001; 2002). In 2018, the recent World Water Development report stressed upon more "Nature-Based Solutions" for improved management of water. It relies on outcomes such as ecosystem services through conserving and rehabilitating natural ecosystems or restoring natural processes in modified systems (WWAP, 2018). These approaches have evolved throughout two decades for managing single resource in different aspects. Refer figure-4 for detailed aspects of each strategy and its components.

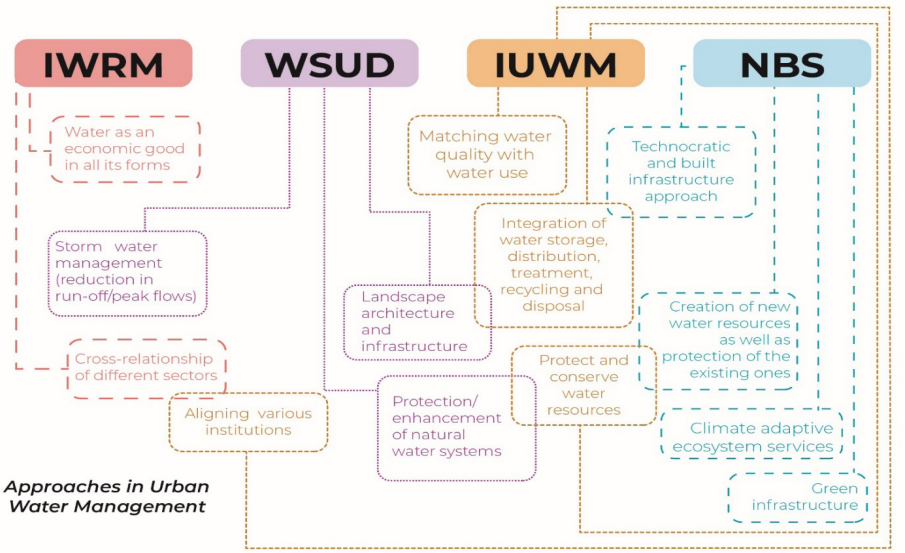


Figure 4. Systems and approaches in urban water management

Recent advent and advocacy on Nature based solutions (NBS) encompasses most of the above discussed strategic interventions and their functions in conservation, recharge and reuse of water among different institutions and respective stakeholders. In Indian context of water management, a comprehensive

water management framework is yet to evolve (McKenzie & Ray, 2009; Bharti et al., 2019), hence application of contemporary practices such as IUWM, IWRM, WSUD or NBS is still a far-fetched goal. If one examines these strategic interventions and NBS through the lens of RWH, it presents a more adoptable feature.

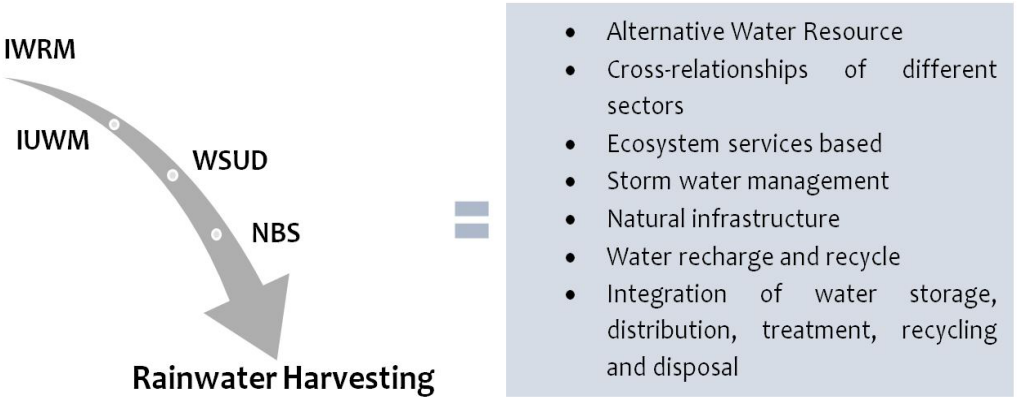


Figure 5. Rainwater harvesting as a viable intervention

With devolved functions to almost every institution for recharge and recycling as discussed in previous section, it is a more viable strategy that can be easily taken up by each of these institutions and executed at various scales. RWH also becomes an alternative water resource for various strategic framework encompassing cross-relationships of different sectors, ecosystem-based services, storm water management, natural infrastructure, water recharge and recycle, integration of water storage, distribution, treatment, recycling and disposal. Hence, to address the water demand and supply challenges, RWH can be placed in systems to recycle and reuse water as a direct substitute in stressed areas and for storage and as a conservation measure to augment the ground water resources to improved ecosystem services. Following are the suggestive interventions at different level of Institution that can be adopted:

- Promotion and adoption of RWH as NBS in stormwater management and water scarce zones for recharge and recycle by Jal Sansthan/ Jal Nigam in accordance with State/Central Ground Water Board.
- Installation of large RWH systems at identification of Critical Urban Water Zones by Jal Sansthan/ Jal Nigam in accordance with State/Central Ground Water Board.
- Haldwani Nagar Nigam as the chief administrative and governing body can intervene at regulating buildings and incorporating RWH provisions in public space such as parks and communities as well as public toilets.
- Promotion of small scale RWH systems at the level of household and neighborhood by creating incentives for the same. Before exhorting RWH structures to citizens, the institutions can set up a working example with

proper administrative framework and can then seek participation from individuals and community. Individual institutions and households can adopt RWH, with technical and financial assistance from various sources. Emphasis can also be laid upon community RWH provisions through registered societies and public bodies involved in the water sector such as SULABH (toilet scheme in India).

CONCLUSION

The findings of the paper result in the mapping of various roles and responsibilities, by different institutions and implementing agency managing a shared resource, i.e., Water. Since different agencies are provided with varying tasks for governing the water resource, the hydrologic unit is inter-related. Different management techniques discussed internationally for efficient and sustainable water governance have also been charted to equate a case-specific strategy for water scarcity. While multiple stakeholders remain to govern and manage different aspects of water in the city, it is a requisite to call for dialogue and sharing of water resources and management. In this regard, various strategic interventions can be planned at the city level with distribution of responsibilities. The paper strongly recommends nature-based solutions with easily adaptable methods to manage the resource extracted from the above discussed techniques and analysis. It further emphasises the creation of alternative water resources supported by a cross-sectoral relationship. It indicates the conception of natural infrastructure to deal with stormwater, recharge techniques and recycle — the paper stresses upon Rainwater Harvesting (RWH) technique that involves natural water collection through precipitation.

"Conflict of Interest- None"

REFERENCES

Aayog, NITI., 2018. *Composite water management index: a tool for water management*. Government of India.

AMRUT, 2016-2017. *Service Level Improvement Plans (SLIPs*). Government of India.

Bahri, A., 2012. *Integrated urban water management*, Global Water Partnership.

Bapna, M., 2011. *Decision making in a changing climate in World Resources Report*. United Nations Development Programme, United Nations Environment Programme, World Bank and World Resources Institute.

Bhagat, R.B., 2011. Emerging pattern of urbanisation in India. *Economic and Political Weekly*, pp.10-12.

Bharti, N., Khandekar, N., Sengupta, P., Bhadwal, S. and Kochhar, I., 2019. Dynamics of urban water supply management of two Himalayan towns in India. *Water Policy*.

Bora, K., Pande, R.K., Gangwar, B. and Rautela, N., 2018. *An investigation into land use and land cover change through object based classification* (A case study of South Haldwani, Uttarakhand, India).

Butterworth, J., Warner, J.F., Moriarty, P., Smits, S. and Batchelor, C., 2010. Finding practical approaches to integrated water resources management. *Water alternatives*, *3*(1), pp.68-81.

Carruthers, J.I. and Ulfarsson, G.F., 2002. Fragmentation and sprawl: evidence from interregional analysis. *Growth and change*, *33*(3), pp.312-340.

Census of India (CoI), 2011. *Population of Cities.* Government of India.

Du, M., Kawashima, S., Yonemura, S., Zhang, X. and Chen, S., 2004. Mutual influence between human activities and climate change in the Tibetan Plateau during recent years. *Global and Planetary Change*, *41*(3-4), pp.241-249.

Eriksson, M., Xu, J., Shrestha, A.B., Vaidya, R.A., Santosh, N. and Sandström, K., 2009. *The changing Himalayas: impact of climate change on water resources and livelihoods in the greater Himalayas*. International Centre for Integrated Mountain Development (ICIMOD).

Global Water Partnership (GWP), 2012. *Annual Report 2012.* https://issuu.com/gwp-publ/docs/gwp_in_action_2012_annual_report_fi

Habeeb, R., Gupta, Y., Chinwan, H. and Barker, E., 2019. Assessing demographic and water sensitivities arising due to urban water insecurity in Haldwani, Uttarakhand (India): a GIS-based spatial analysis. *Journal of Geovisualization and Spatial Analysis*, *3*(2), p.8.

Khosla, R., Mathur, S., Chakraborty, S., Dhamija, A.S. and Rahim, A., 2006. Water for All? *WaterAid India*.

Larson, K.L. and Lach, D., 2010. Equity in urban water governance through participatory, place-based approaches. *Natural Resources Journal*, pp.407-430.

Lloyd, S.D., Wong, T.H. and Chesterfield, C.J., 2001, June. Opportunities and impediments to water sensitive urban design in Australia. In *2nd South Pacific Stormwater Conference*, pp.302-309.

Lloyd, S.D., Wong, T.H. and Chesterfield, C.J., 2002. *Water sensitive urban design: a stormwater management perspective.* Cooperative Research Centre for Catchment Hydrology.

Ministry of Water Resources (MoWR), 2002. *National Water Policy*. Government of India.

McKenzie, D. and Ray, I., 2009. Urban water supply in India: status, reform options and possible lessons. *Water Policy*, *11*(4), pp.442-460.

Moriarty, P., Fonseca, C., Smits, S. and Schouten, T., 2005, June. Learning alliances for scaling up innovative approaches in the water and sanitation sector. In *Proceedings Symposium on Learning Alliances for scaling up innovative approaches in the water and sanitation sector. Delft, the Netherlands*.

Saleth, R.M., 2011. Water scarcity and climatic change in India: the need for water demand and supply management. *Hydrological Sciences Journal*, *56*(4), pp.671-686.

Tiwari, P.C., 2010. Land use changes and conservation of water resources in Himalayan Headwaters. *In: Proceedings of the 2nd German-Indian conference on research for sustainability: energy & land use, Science and Technology-Drivers for a Common Future.* Bonn, United Nations University, 27-28 April, 2009, Bonn, Federal Ministry of Education and Research (BMBF).

WWAP, U., 2015. *The United Nations world water development report 2015: water for a sustainable world*. United Nations World Water Assessment Programme.

WWAP (United Nations World Water Assessment Programme)/UN-Water, 2018. *The United Nations world water development report 2018: Nature-Based Solutions for Water*. Paris*, UNESCO.*