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Review of Climate Change Adaptation Towards Drinking Water and Sanitation in Nagarjun Municipality, Kathmandu District Nepal

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Abstract
Climate change is difference in earth's climate over time; it is largely caused by human activities which causes a serious threat to nature and people now and in the future too. Global temperature increased rapidly by four degrees Celsius. Climate change effects the water cycle and precipitation. Due to higher average temperatures and warmer air that can hold too much water, which can cause heavy precipitation and possible flooding.
Nagarjun is the municipality which lies in the Kathmandu District (Bagmati Pradesh) of Nepal. It consists of Village development committees, Bhimdhunga, Ichangu Narayan, Ramkot, Syuchartar and Sitapaila. Nagarjun Municipality has in total 67420 populations along with 16746 households. The Major sources of drinking water are public water supply, well, springs and stream water. It depends on the sewer system more than half population able to access it but it has lack of treatment facilities for waste water and faecal sludge. These things are directly discharge through Manmati and Bhadramati Rivers.

Keywords : Nagarjun, water cycle, climate change, river, discharge.

Introduction

Water is very essential thing for the survival of life. It plays an important role in our daily life. We live in watery place in which 2.5% of fresh water where as 97.5% of saline water. The naturally occurring water is called fresh water for example ground water, Glaciers, Lakes, Rivers, Surface fresh water, ponds etc. where a seawater and brackish water is called saline water for example oceans[1]. National action plan on adaptation (NAPA) has been formulated in Nepal to mitigate and adapt to the impacts of climate change [2].In 2017, major greenhouse gases such as carbon dioxide, methane and nitrous oxide breaks the record of the past. This precipitation extreme is sometimes also called "drought and deluge" [3].

Problem Statement

Nagarjun is the municipality which lies in the Kathmandu District (Bagmati Pradesh) of Nepal. It consists of Village development committees, Bhimdhunga, Ichangu Narayan, Ramkot, Syuchartar and Sitapaila. It has 10 wards with population of about 67420 according

to 2011 Nepal censuses and area of 29.8 km^2 [4]. There is deficiency of remedy facilities for waste water and faecal sludge. At last, the waste water discharges through Manmati and BhadramatiRivers [5].The water quality of Bagmati River found to be more organic pollutants and the drinking water status of Kathmandu is found to be poor quality as it contains E-Coil with less Mg but the PH value is maintained [6].

Literature Review

Now a days the populations of the world increasing day by day. Due to which the urbanization, water pollution and deforestation also increase rapidly which induced to the decrease the world's fresh water resources. The present study is meant to review the present state of our water resources and therefore the global climate change problem and to detail the challenges in addressing the impacts on water resources [7]**.**From The impact of temperature change on global river flows and water temperatures which identify regions for critical of freshwater ecosystems and water uses [8]. The lack of information in micro pollutants occurrence and its impact in climate change and treatment efficiency. Water borne diseases highly induced by the climate change which is rarely studied at temperate countries [9].

Concept of fresh drinking water resource utilization and sanitation

Water is essential for every form of life on earth. The population of the world increasing day by day but the water resources remains constant [10]. Most of the countries can save water by importing most of their food and electricity from the other countries. This virtual water tends helps them to save the water in no time which then used for higher social and economic return for the future [11]. It is needed to develop innovative technologies, to implement successful water reclamation and reuse projects [12].

Review of model of fresh water, climate change and sanitation

Now days, the interest in ecosystem services has growing rapidly among government agencies, NGO's and business community. It entailing freshwater including flood control, hydropower and water supply as well as carbon storage and sequestration which have received the much focus towards scientific and on the ground application. [13]. Due to the impacts climate change, the population, infrastructure and ecology of cities also at risk zone. We need higher resolution weather data for testing of future performance of building, urban drainage and water supply system at city area [14].

The climate change due to the human is unavoidable. Due to the higher water resistance in lower flows of rivers and lakes also enhance the potential for toxic algal blooms and reduce dissolved oxygen levels. The storms also cause the climate change by flushing nutrients from urban and rural areas that terminates drought periods [15].The empirical economic and political economic research on the water management institutions are the important theme in adaptation or mal adaptation to climatechange [16].

There is a general consensus that temperature change is an ongoing phenomenon. Groundwater is going to be vital to alleviate a number of the worst drought situations. This

paper analysis relation between the temperature change and ground water to mitigate the likely impacts [17].

Due to the increase in CO_2 and other gases in the atmosphere the climate change occurs which induces the hydrologic balance and water resources. Such changes raise the likelihood of environmental and socioeconomic dislocations, and that they have important implications for future water resources planning and management[18].

Due to the continuous changes in the hydro environment the urban areas are facing water scarcity problem and increases day by day. It consists of least cost design objectives. People driven levels of service have four design parameters which have duration; timings; pressure and connection type for locations [19]**.**

Global problem and response on drinking water and sanitation

There are enough water resources in South America both per capita and per area. However, the water scarcity is increasing rapidly by increasing urbanization and rapid economic growth due to high water demanding industries for example mining and agriculture. The wastewater discharge pollution also largely under control. The water consumption rate is double in United States then the central Europe [20]. Water resource development, Structural flood control, and Centralized drinking and wastewater treatment are the major challenges which are face by the water resources manager of USA in 20^{th} century. But now they uses to prevent the ground water contamination which restore of aquatic ecosystems and promote the ecosystem services [21].

In Denmark, the contingent valuation survey approach is used for the water quality improvements. The implementation of recent water quality legislation by European Union addressing the potential problem in **Eutrophication** of estuarine and coastal waters. They have action plan for improvement of ecological status of the Randers Fjord for benefits and cost of reduced **eutrophication** of it [22].

In the South Africa too there is ground water drought issues. The drought-relief drilling programs, the general lack of routine monitoring and the need for longer term analysis and assessment of groundwater systems are the major difficulties in South Africa [23].

The China also facing the strategic issue in the national sustainable development due to the climate change and its impact on water resources security. The study of the water resources vulnerability and secure the water resources security is two important tools [24]. The surface water resource development increase by 91% over current levels. By using the scientific and technological tools increases the water use ratio, management of water, conservation of water resources and environment and increase the study of water saving techniques [25].

In India also due to the unplanned development of surface and groundwater resources, haphazard disposal of municipal and industrial wastes and application of agricultural inputs induced the water quality deterioration, problem in water management and preservation. The agro climate and the hydrological cycle has been changed due to the human activities of India such as cropping pattern, land use pattern, irrigation and drainage[26].

Although Australia is a continent of extreme water resources the people of tropical north relative abundance whereas the people of south have relative scarcity of water resources in addition both are affected by wet and dry seasonal climatic conditions. In south over allocation of surface and ground water supplies and increase use of water from irrigators, urban, industrial and mining users which impacts on the health of rivers and environments [27].

Regional problem and response on drinking water and sanitation

It is the truth that, "There is water everywhere but not a drop to drink". Nepal is one of the most plentiful water supply country and then Bhutan along with the Maldives are the three least developed countries in the Asian region but the facilities of safe drinking water and for excreta disposal can be woefully inadequate [28]. The review must be done for general guidelines and global problem of drinking water quality and various water treatment technologies which is applicable for increasing the quality of drinking water in the developing countries [30].About 90% of household's water is dependent on rain water as a principal source of drinking water and 30% of population induced from the drinking water scarcity [31].The water contaminated with fecal bacteria is due to cross contamination and water handling mechanism of stored water pollution which is used to develop a hygiene intervention study [32].

In Southwest Sri Lanka, The safest source of water considered is piped network supplies, public taps, and private wells. About 72% of households consider public taps to be safe, some on public wells, rivers, lakes and streams. Most of the households used water after boiling or filtering water before drinking it in Sri Lanka [33].

National problem and response on drinking water and sanitation

Due to the poor infrastructure and high population growth rate in Nepal, there is a challenging to achieve the six targets of United National Sustainable Development Goal of water and sanitation for all people. There is the mitigation option too such as rain water harvesting, use of ground and surface water resources and water demand side management [34].

There is 71% of all water sources have poor water quality and 91% of water used by the poorest quintile have contaminated by E.coli bacteria. Only 25% of water supply is fully functioning [35].In total 11318 drinking water projects running in that districts in which 4530 projects suffered damages and 945 projects ceased completely due to earthquake. The worst damage recorded in Sindhuli, Sindhupalchowk and Kavre [36].

Lakuribhanjyang lies in the Lalitpur District which is 22km from Kathmandu which consists of vulnerable Tamang group. It work with the community to increase the awareness of risk carried out by the dirty water, poor hygiene practices and open defecation to minimize the risk [37]. It can treatment the water source from Godavari River which is also the surface water for 1350 households in the communities by using the tube settler , slow sand filter and chlorination technology[38].

There are several small projects made by locals for drinking water but are not well managed [39]. They formed a local Water Users Committee for the maintenance of the drinking water collection and distribution which collect NRS60 per month as a maintenance fund for ensuring the system [40].

In every year of monsoon, the residents of Pokhara facing the murky drinking water. It supplies about four crore liter water to the locals from the Mardi River per day but the requirement is five crore liter water per day [41]. The pipeline expansion project has been stopped due to the lack of funds. It started to works for installing DI pipes in Pokhara to address the increasing need for drinking water in the city [42].The water crisis occurs in the residents around the Lakeside area .But the private water company fulfill the unprecedented shortage of water in that area by drawing boring water and selling them at excessive prices[43].

Local problem and response on drinking water and sanitation

Nepal is standing among the top ones in terms of water resource globally. Unfortunately the water scarcity problem is a major issue. The Melamchi water project is hope for resort water crisis in Kathmandu valley [44]. Kathmandu Upatyaka Khanepani Limited (KUKL) is the main company which can undertake and manage the water supply and sanitation system in Kathmandu valleyKUKL has 10 Branch Offices for production and operation of drinking water supply among which Tripureshwor Branch Supply the drinking water in Kathmandu Municipality (ward no 11,12,1,14,20,21,22,23) and Nagarjun Municipality (ward no 4,5,12,13,14) [45].

Study Area

Nagarjun Municipality has in total 67420 populations along with 16746 households with total number of 10 wards.. The Major sources of drinking water are public water supply, well, springs and stream water. Nagarjun Municipality of Kathmandu district Nepal as shown in figure 1. Various water resources were used to serve as a source of water in the past. The study focuses the effect on drinking water and sanitation on this municipality due to climate change.

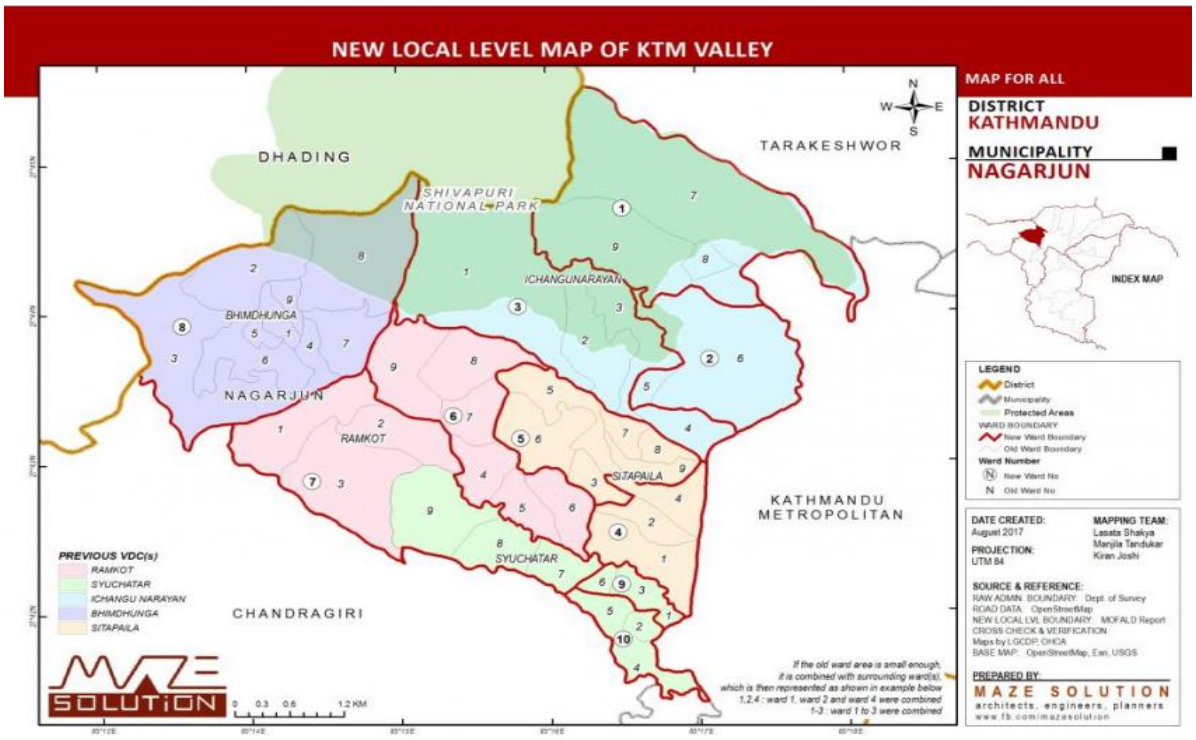

Figure 1 : Map of Nagarjun Municipality

(Source: http://www.nagarjunmun.gov.np/en)

Melamchi Water Supply Project:

The main aim of this project is to supply drinking water to Kathmandu Valley by 170,000,000 liters of water per day which was started in 1998 and fully completed in 2021[46].That project financed by Japan and the Asian Development Bank in which 57% of the cost is loan, 16% from grant and rest 26% financed by government of Nepal [47].But unfortunately, the destructive Melamchi flooding occurs this June 2021, which damage the Melamchi water Supply Project and hundreds of families were displaced by this flooding.

Kathmandu UpatyakaKhanepani Limited (KUKL)

It is the main water utility operator in the Kathmandu Valley. It also operate and manage the Melamchi Drinking Water Project to Kathmandu valley. Month-wise Average Daily Water Production (Source Based) for F.Y. 2076/77.

(Million Liters per Day)

Months	Surface	Ground	Total
Shrawan	82.59	37.07	119.66
Bhadra	92.62	37.24	129.85
Ashwin	98.45	34.51	132.96
Kartik	86.60	36.79	123.39
Mangsir	81.27	36.47	117.73
Paush	72.22	38.99	111.21
Magh	70.57	39.59	110.16
Falgun	65.62	37.83	103.45
Chaitra	63.69	39.66	103.34
Baisakh	59.89	40.55	100.44
Jestha	72.93	40.74	113.67
Asadh	61.39	42.83	104.23
Average Production	75.65	38.52	114.17

Figure 2: Source KUKL annual report, 2077

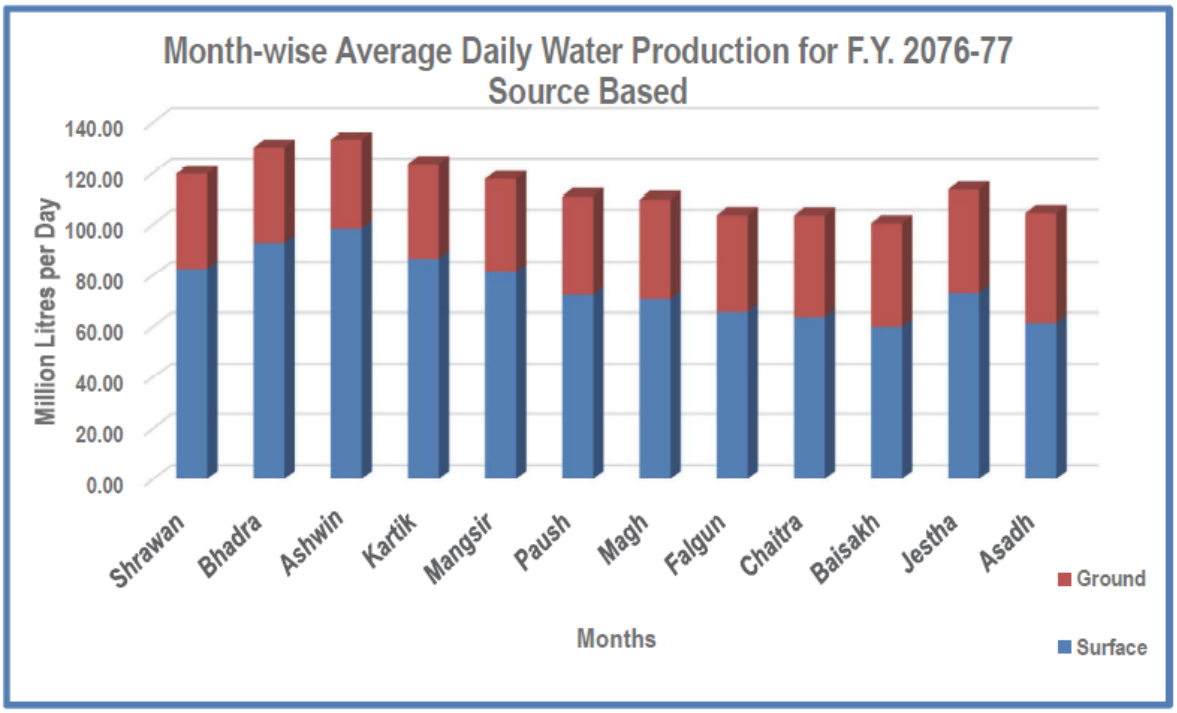

Figure 3: Source KUKL Annual Report, 2077

In the past, Stone Spout was generally used for drinking water to the community and there are in total 237 Stone Spout available in Kathmandu Valley. In the ancient time, the irrigation canals are used for recharging the ground water in this valley [48].

Conclusion

As the climate change rate increases rapidly globally, it effects the human life and habitat directly and indirectly. The average water consumption rate increased day by day due to the urbanization of the land and the population growth. Due to the expansion of the road also causes the climate change and water scarcity problem. Some other facts is due to the unmanaged ground water extraction process also causes the scarcity of water in the Nagarjun Municipality of Kathmandu valley. The Major sources of drinking water are public water supply, well, springs and stream water. It depends on the sewer system more than half population able to access it but it has lack of treatment facilities for waste water and faecal sludge. These things are directly discharge through Manmati and Bhadramati Rivers.

References

[1] Where is Earth's water ? USGS Water-Science School. (2013, December 14). https://web.archive.org/web/20131214091601/http://ga.water.usgs.gov/edu/earthwherewater.html

[2] Karki, M., Mool, P., & Shrestha, A. (2009). Climate Change and its Increasing Impacts in Nepal. *The Initiation*, *3*, 30–37. https://doi.org/10.3126/init.v3i0.2425

[3] The Impact of Climate Change on Water Resources. (2018, October 11). Water Footprint Calculator.https://www.watercalculator.org/water-use/climate-change-water-resources/

[4] A Review of Climate Change Impacts on the Built Environment: Ingenta Connect. (2007).

[5] E. ENPHO, "Nagarjun," 2020. https://sfd.susana.org/about/worldwide-projects/city/170-nagarjun .

[6] M. D. Acharya, "Progress of Water Environment Governance in Nepal," p. 24, 2019.

[7] Sivakumar, B. (2011). Global climate change and its impacts on water resources planning and management: Assessment and challenges. *Stochastic Environmental Research and Risk Assessment*, *25*(4), 583–600. https://doi.org/10.1007/s00477-010-0423-y

[8] van Vliet, M. T. H., Franssen, W. H. P., Yearsley, J. R., Ludwig, F., Haddeland, I., Lettenmaier, D. P., & Kabat, P. (2013). Global river discharge and water temperature under climate change. *Global Environmental Change*, *23*(2), 450–464. https://doi.org/10.1016/j.gloenvcha.2012.11.002

[9] Delpla I, Jung AV, Baures E, Clement M, Thomas O. Impacts of climate change on surface water quality in relation to drinking water production. Environ Int. 2009 Nov;35(8):1225-33. doi: 10.1016/j.envint.2009.07.001. Epub 2009 Jul 29. PMID: 19640587.

[10] Dinka, M. O. (2018). Safe Drinking Water: Concepts, Benefits, Principles and Standards. *Water Challenges of an Urbanizing World*. https://doi.org/10.5772/intechopen.71352

[11] B. Herman, "Integrated water management: emerging issues and challenges - ScienceDirect," 2000. https://www.sciencedirect.com/science/article/abs/pii/

[12] G.Wade Miller, "Integrated concepts in water reuse: managing global water needs - ScienceDirect," 2006. https://www.sciencedirect.com/science/article/abs/pii/S0011916405007216

[13] Kari L. Vigerstol and Juliann E. Aukema, "A comparison of tools for modeling freshwater ecosystem services - ScienceDirect," 2011. https://www.sciencedirect.com/science/article/pii/S0301479711002374

[14] Wilby, R.L, "A Review of Climate Change Impacts on the Built Environment: Ingenta Connect,"2007.https://www.ingentaconnect.com/content/alex/benv/2007/00000033/00000001/art00003

[15] P. G. Whitehead, A. J. Wade, and M.Kernen, "A review of the potential impacts of climate change on surface water quality: Hydrological Sciences Journal: Vol 54, No 1," 2008. https://www.tandfonline.com/doi/abs/10.1623/hysj.54.1.101

[16] Sheila M. Olmstead, "Climate change adaptation and water resource management: A review of the literature - ScienceDirect," 2014. https://www.sciencedirect.com/science/article/pii/S0140988313002004

[17] W. Dragoni and B. S. Sukhija, "Climate change and groundwater: a short review | Geological Society, London, Special Publications," 2008. https://sp.lyellcollection.org/content/288/1/1.short

[18] Peter H. Gleick, "Climate change, hydrology, and water resources - Gleick - 1989 - Reviews of Geophysics - Wiley Online Library," 2019. https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/RG027i003p00329

[19] Kala Vairavamoorthy, Sunil D. Gorantiwar, and AsselaPathirana, "Managing urban water supplies in developing countries – Climate change and water scarcity scenarios - ScienceDirect,"2008.https://www.sciencedirect.com/science/article/pii/S1474706508000223[20] Drinking water supply and sanitation in the United States. (2020). In *Wikipedia*. https://en.wikipedia.org/w/index.php?title=Drinking_water_supply_and_sanitation_in_the_United_States&oldid=956382398

[21]Lant, C. L. (n.d.). *Watershed Governance in the United States: The Challenges Ahead*. 9.

[22]Atkins, J. P., & Burdon, D. (2006). An initial economic evaluation of water quality improvements in the Randers Fjord, Denmark. *Marine Pollution Bulletin*, *53*(1), 195–204. https://doi.org/10.1016/j.marpolbul.2005.09.024

[23]Groundwater Management in Drought-prone Areas of Africa: International Journal of Water Resources Development: Vol *13, No 2*. (2010).

[24]Opportunity and Challenge of the Climate Change Impact on the Water Resource of China—《Advances in Earth Science》(*2011).*

[25]Feng, Q., Cheng, G. D., & Masao, M. K. (2000). Trends of water resource development and utilization in arid north-west China. *Environmental Geology*, *39*(8), 831–838. https://doi.org/10.1007/s002549900062

[26] Mall, R. K., Bhatla, R., & Pandey, S. N. (2007). *WATER RESOURCES IN INDIA AND IMPACT OF CLIMATE CHANGE*.

[27]Chartres, C., & Williams, J. (2006). Can Australia Overcome its Water Scarcity Problems? *Journal of Developments in Sustainable Agriculture*, *1*(1), 17–24. https://doi.org/10.11178/jdsa.1.17

[28]The cost of water | SpringerLink. (1983).

[29]Bartram, J., Brocklehurst, C., Fisher, M. B., Luyendijk, R., Hossain, R., Wardlaw, T., & Gordon, B. (2014). Global Monitoring of Water Supply and Sanitation: History, Methods and Future Challenges. *International Journal of Environmental Research and Public Health*, *11*(8), 8137–8165. https://doi.org/10.3390/ijerph110808137

[30]DRINKING WATER IN DEVELOPING COUNTRIES | *Annual Review of Environment and Resources*. (1998).

[31]Alexander, R., & Group, D. C. (2007)Evaluation Report Supplementary Water Supply System, IFRC, Maldives. *Executive Summary*. 28.

[32]Faecal contamination of water and fingertip-rinses as a method for evaluating the effect of low-cost water supply and *sanitation activities on faeco-oral disease transmission. I. A case study in rural north-east Thailand | Epidemiology & Infection | Cambridge Core*. (1990).

[33]Perception of Health Risk and Averting Behavior*: An Analysis of Household Water Consumption in Southwest Sri Lanka—Toulouse Capitole Publications*. (2009).

[34]Udmale, P., Ishidaira, H., Thapa, B. R., & Shakya, N. M. (2016). The Status of Domestic Water Demand: Supply Deficit in the Kathmandu Valley, Nepal. *Water*, *8*(5), 196. https://doi.org/10.3390/w8050196

[35]KPanday, U. (2015). *Water and Sanitation (WASH) | UNICEF Nepal*. https://www.unicef.org/nepal/water-and-sanitation-wash

[36]Rai, R., July 14, & 2015. (2015). Nepal struggles to repair water systems destroyed by quake. *The Third Pole*. https://www.thethirdpole.net/2015/07/14/nepal-struggles-to-repair-water-systems-destroyed-by-quake/

[37]FRANK Water. (2010). *Lalitpur*. https://www.frankwater.com/lalitpur

[38]C. Visvanathan, M. K. (2007). *NewTap | Network on Water Technology in Asia and Pacific*. http://www.jwrc-net.or.jp/aswin/en/newtap/report/NewTap_027.pdf

[39]Republica. (2019). *My City—Solving drinking water woes of Bhaktapur*. https://myrepublica.nagariknetwork.com/mycity/news/solving-drinking-water-woes-of-bhaktapur

[40]World Vision International. (2010). *Drinking Water Project, Bhaktapur*. https://www.wvi.org/nepal/gallery/drinking-water-project-bhaktapur

[41]HIMALAYAN NEWS SERVICE. (2017, August 18). *Pokhara residents demand clean drinking water*. The Himalayan Times. https://thehimalayantimes.com/nepal/pokhara-residents-demand-clean-drinking-water/

[42]DHAN BASNET. (2018). *Drinking water pipeline expansion halted in Pokhara—MyRepublica—The New York Times Partner, Latest news of Nepal in English, Latest News Articles*. Drinking Water Pipeline Expansion Halted in Pokhara. https://myrepublica.nagariknetwork.com/news/drinking-water-pipeline-expansion-halted-in-pokhara/

[43]Pokhara facing water crisis. (2016). https://thehimalayantimes.com/nepal/pokhara-facing-water-crisis/

[44] Bipul Raj Manandhar, "The water situation in Kathmandu Valley," 2016, Available: https://smartpaani.com/the-water-situation-in-kathmandu-valley/

[45] KUKL, "Kathmandu UpatyakaKhanepani Limited (KUKL) – Water," 2021. https://kathmanduwater.org

[46] "Project Description | Melamchi Water Supply Development Board". www.melamchiwater.gov.np,2021

[47]"Sweden withdraws aid commitment to Nepal water project - Nepal". ReliefWeb. 2006.

[48]Shrestha, R., &Dahal, K. R. (2020). Disaster Resilient Construction of Water Spouts in Kathmandu Valley of Nepal. Journal of Civil, Construction and Environmental Engineering, 5(4), 72.