Study of Climatic Pattern and Water Resources from Citizen Science's Perspective in Namobuddha Municipality, Kavre, Nepal [1]

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Abstract

This study has been initiated to carry out the research on climatic patterns along with water resources from local communities' perspectives in Namobuddha Municipality, Kavre, Nepal. The study area is located in the eastern part of Kathmandu which is about 35 km away from it. This study has focused on investigating climatic patterns and water resources available in the study area. It was especially carried out utilizing citizens' perspectives. Mixed qualitative and quantitative methods were used in this study. Total 66 questionnaire surveys and two key informant interviews were conducted in the Simalchaur Sympati area of Namobuddha Municipality which has about 600 households. Required Meteorological data were taken from the Department of Hydrology and Meteorology, Nepal. Results from this study showed that the average, minimum and maximum temperatures were in the increasing trend. However, the average annual along with the monsoon rainfalls were in the decreasing trend. The inhabitants have experienced warmer summer and winter, scarcity of water for domestic as well as for agriculture purposes. Local communities also deplored less ground water flow in their springs. This study has clearly signified the drying up of surface and ground water resources. In overall context, this study output was similar to the global pattern as temperatures are in increasing trend whereas precipitation is in decreasing trend. It signified the need for effective adaptation strategies to combat against the adverse

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impacts of changing climatic patterns especially for the management of water resources in the study area.

***Keywords*:** Citizen Science, Climatic patterns, Namobuddha, Water resources

Introduction

Nepal is considered as one of the vulnerable countries in the world from the perspectives of climatic impacts. The average maximum temperature of Nepal has increased by 0.056° C/year (DHM, 2012). Shrestha et al., (1999) reports a trend varying between 0.4 and 0.9 °C/decade in the mean annual maximum temperature across different ecological belts of Nepal. The temperature pattern has shown the highest increasing trend in the high Trans-Himalayan region and it has shown the lowest increasing trend in the Terai (lowland region). Similarly, Tse-ring et al. (2010) also reported the similar temperature trend as of Shrestha et al. (1999) for a slightly different time period.

The people of rural areas are at high risk because their livelihood options which depend on water sources are affected by climate change. Climate induced water stress directly affects agricultural productivity, malnutrition, human health and sanitation. Too much water has negative impacts on human settlements, infrastructure and agricultural land (MoE, 2010). Under climate change, water, its availability and quality, will be the most pressing pressures on, and concerns for, societies and the environment (IPCC, 2007). Maharjan et al. (2011) also accepted from a case study of Nepal that climate change is recognized as a major threat to the communities in the rural areas who are more dependent on the natural resources.

Rainfall is the only source of ground water recharge in the hills and highlands. More heavy rainfall, on the other hand, results in less infiltration and groundwater replenishment. This reduces the amount of spring water available (Chaulagain, 2003). The change in rainfall pattern, deficit of water supply to agriculture, increasing temperature, influx of pests and crop diseases are directly affecting agricultural crop and food security. The vegetative state of winter crops would be shorter with higher temperatures, thus lowering productivity (Gautam, 2014). This kind of situation was also reported by Bhatta et al. (2014) in the case of Koshi Basin. They observed warming trends in the growing season of rice, maize and wheat over the last few decades with clear evidence of negative impacts on yields. Poudel (2010) also agreed on the fact that climate change has affected food safety and food security in Nepal.

Rural communities of the hills and mountains, experiencing the impact of climate change on various sectors including water resources. Some of the evidence can be given as drying of water sources, groundwater depletion, irregular rainfall, high intensity of rainfall leading to high runoff and less infiltration. This effect has adversely affected the livelihood of the local people (Practical Action Nepal, 2010). This kind of fact has been found by Gentle and Maraseni (2012) from the study of Jumla district. They have concluded that changing weather patterns have significantly challenged the livelihoods of a community, experiencing resource degradation, food scarcity, lack of basic services, and increasing social inequalities.

Agriculture is extremely vulnerable to climate change. The change in precipitation pattern and increase in evaporation directly affect crop production. It is a fact that the frequency of extreme events like floods and droughts are increasing due to climate change. Sudemeier-Rieux et al. (2012) investigated the number of hazard events such as droughts, floods, and landslides. They have concluded increasing tendencies of above events and accounted for approximately 100 deaths in Nepal annually. Thagunna et al. (2022) found an increasing tendency of floods, droughts, landslides, hailstorms, and forest fires even in low land area that is Kanchanpur district of Nepal. The irrigation system is also affected due to changes in the river flow regimes. Warmer temperature has increased water holding capacity of the atmosphere and evapotranspiration potential (WECS, 2011). Agriculture is a traditional occupation of Namobuddha Municipality. Most of the households are involved in vegetable and cattle farming (Global Green Growth Institute, 2018).

Study area and scope of the work

This research was carried out in Kavrepalanchowk district's Namobuddha Municipality ward no. 11, SimalchaurSympati. It is located in Nepal's Bagmati province. SimalchaurSympati is located at 27°34'13.8"N and 85°34'53.8"E and covers a total area of 9.05 km^2. Namobuddha Municipality has a total area of 102.38 km^2. In the Municipality, the elevation ranges from 914 meters to 1828 meters above sea level. We have chosen this study area as we found water stress problems from various mediums. In this connection, we investigated climatic patterns with respect to water resources. We applied Hydro-Meteorological data analyses as well as citizen science's perspectives in this study.

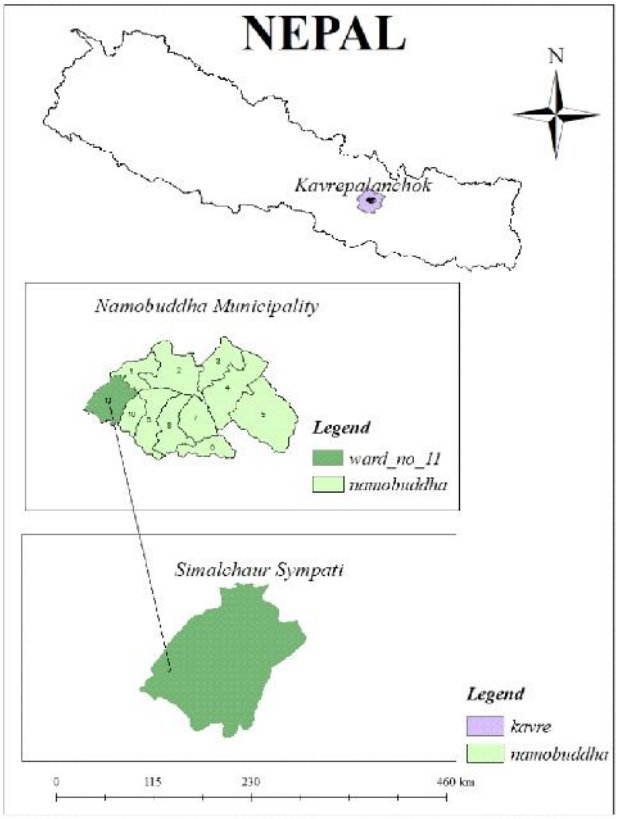

Figure 1. Location map of the study area

Table 1 suggests population status of the study area. We see its importance to enhance further works based on citizen's perspectives and so on.

Table 1

Demographic details of Namobuddha Municipality and ward no. 11, SimalchaurSympati (CBS, 2011)

Demographic Profile	Namobuddha Municipality	SimalchaurSympati (ward no. 11)
Households	6584	600
Total Population	29519	2793
Male Population	13604	1299

Female Population	15915	1494
Average Households Size	4.48	4.65
Area (km^2)	102.38	9.05
Population Density	288	308

Methodology

In this study, qualitative and quantitative data were collected. Collected qualitative data included the field observations, household surveys and informal discussions with key informants in the study area. Temperature and rainfall data were taken from the Department of Hydrology and Meteorology (DHM), and GPS coordinates of major water resources of the study area were included in the quantitative data. In order to achieve proper feedback on climatic issues, the questionnaire survey was conducted for considering different age groups.

We tried to represent ward no 11 of the SimalchaurSympati. We believe that this study will be a sample research on climatic patterns as well as water resources in the study area. Hence we randomly selected the households taken from each small area (Tole in Nepali) of the SimalchaurSympati are given below:

Table 2

List of Samples for Household Survey

S.N.	Name of the small area *(Tole)*	No. of Household Selected
1	Tallobhauukhark	8
2	Mathillobhaukhark	10
3	Kaparedhunga	11
4	Kurgaun	7
5	Bimire	9
6	Swara	9
7	Dadhakateri	8
8	Chinde	4
	Total	**66**

We applied MS Excel to analyze and interpret the climatic data acquired from various sources. We used statistical tools such as mean, median, standard deviation for analyzing the climatic data. We have deleted outliers from the climatic data set. We applied Arc-GIS 10.4 in order to create a map of major water resources and a location map of the study area.

Socioeconomic characteristics of sample population

Among the 66 respondents interviewed, the highest percentage of respondents fall in the age group of 51-60 years (29%), followed by 41-50 years (25%), 31-40 years (21%) and 61-70 years (17%). There was a very small portion of people under 30 and more than 70.

The numbers of male respondents were found to be higher (47) and female respondents were (19). Figure-3 shows the distribution of gender and caste of the respondents. The highest numbers of respondents were Tamang (30). Beyond the Tamang community others were Newar (16), Dalit (10), Chhetri (7) and Bramin (3).

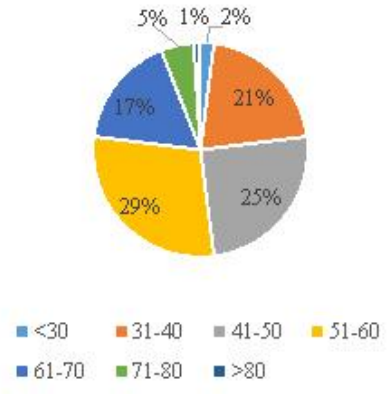

Figure 2: Age-group of Respondents

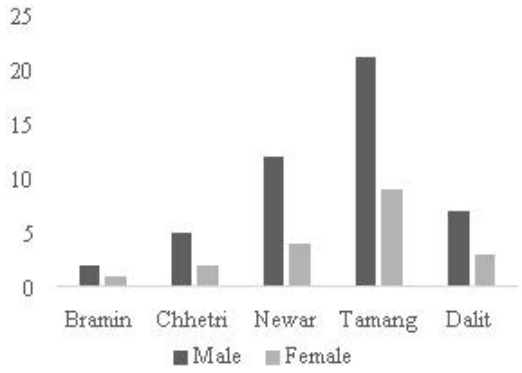

Figure 3. Gender and Caste of Respondents

Results and discussion

Temperature and rainfall trends

The trend analyses of temperature were conducted by taking 30 years of data (1989-2018) of the nearest station (i.e. Panchakhal Station) from the study area. The analysis of temperature showed a significantly positive trend. The average annual temperature is 21.27°C. The average annual lowest temperature is 14.17°C, while the average highest temperature is 28.49°C. The average temperature increases at a rate of 0.021°C every year (Fig 4). Similarly, the average annual minimum temperature and average annual maximum temperature increased at 0.014°C and 0.041°C every year respectively. It shows the average maximum temperature increasing pattern is comparatively higher than the average minimum temperature. This kind of phenomena

justifies the global temperature increasing tendency. The results of these analyses are summarized in Table-3.

Table 3

Summary of Trends of Temperature (1989-2018)

S.N	Changes in mean annual temperature (^{O}C /year)	Changes in annual maximum temperature (^{O}C /year)	Changes in annual minimum temperature (^{O}C /year)
1.	+0.021	+0.041	+0.014

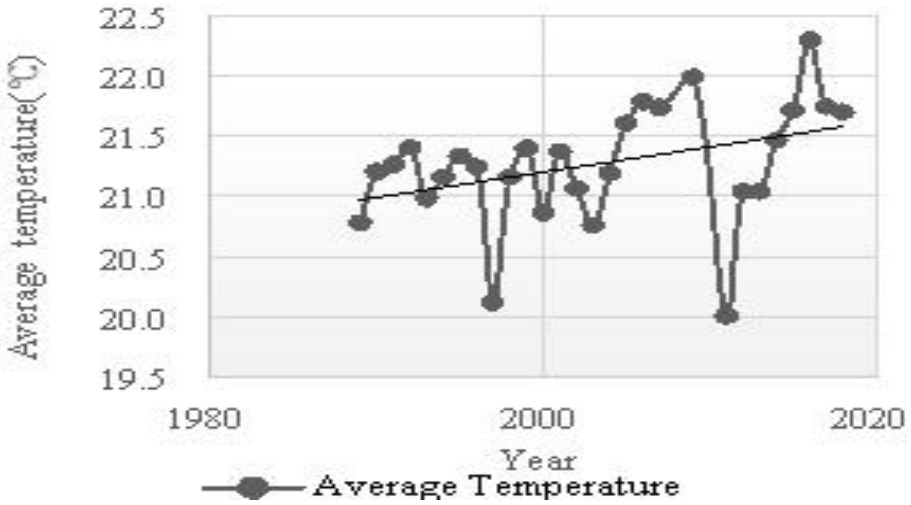

Figure 4. Average Annual Temperature (1989-2018)

Average, minimum and maximum patterns of temperature have shown increasing tendency in the study area. It justified the temperature increasing phenomenon in the mid-mountainous region of Nepal similar to the Maharjan et al. (2011). It is advisable to utilize the resources (natural) for considering the changing climatic pattern in the SimalchaurSympati area of Namobuddh Municipality.

Similarly, we have analyzed the past 30 years (1989-2018) of precipitation data. The highest annual rainfall of 1676mm occurred in the year 1999 and the lowest annual rainfall of 695.7mm occurred in the year 2015. The trend of annual rainfall shows that it is in decreasing condition at the rate of 9.484mm/year (Fig-5).

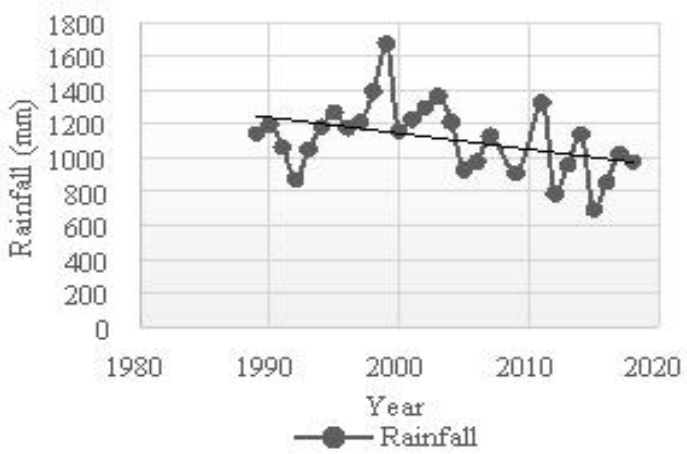

Figure 5. Annual Rainfall (1989-2018)

Rainfall trend has shown a severe situation in front of the SimalchaurSympati communities. Decreasing trend of rainfall causes decrease in availability of water resources in the study area. In such a decreasing precipitation pattern, there will be less chance to enhance irrigation facilities, commercial as well as domestic water use and other water related activities in the study area. It ultimately adversely affects the overall economic development of the local communities.

Results obtained from field visits and citizens' participation

The questionnaire survey was conducted in the study area to understand the people's experience about climatic variability. After a questionnaire survey, it was analyzed that most of the respondents have experienced the changes in annual temperature. About 77 percent of the respondents claimed that summer temperature has been increasing in the recent years, 12% said the summer temperature had decreased, 3% said no change in temperature and 8% of the respondents do not have any idea about the climatic matters. Similarly, 67% of the respondents claimed that winter temperature has been becoming warmer than before and 27% of the respondents felt that the winter temperature was becoming colder than previous year.

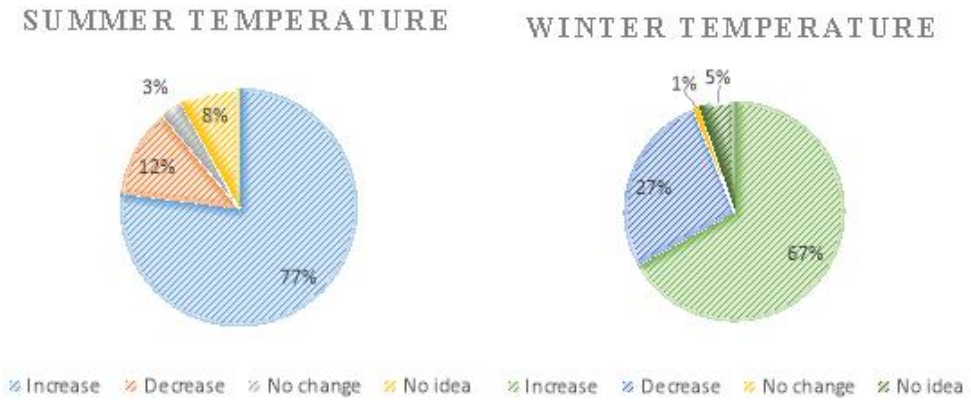

Figure 6a and 6b. People's perception on summer and winter temperature

Local citizens' verdict signified that local communities have experienced a warming trend in recent years. This result is quite close to the outcome obtained from the 44 year's Meteorological data analyses published by the National Planning Commission (NPC) of Nepal, 2022. Recent report published by the National Planning Commission of Nepal has shown temperature increasing patterns of 0.037^{o}C, 0.057 ^{o}C and 0.056 ^{o}C per year in the neighboring districts as Sindhuli, Okhaldhunga and Ramechhap respectively (NPC, 2022). Such a situation has shown clear evidence of changing climatic patterns in the study area which was also experienced by common people.

We did a questionnaire survey regarding the rainfall situation. Sixty nine percent of the respondents said that they observed a decreasing trend in monsoon rainfall and 13 % of the respondents thought that the monsoon rainfall is in an increasing pattern. Similarly, 68% respondents claimed that the pre-monsoon rainfall is in increasing trend and 21% said it is in decreasing condition. It is a fact that June to September months belong to monsoon, October and November as post-monsoon, December to February are winter and March to May belong to pre-monsoon seasons in Nepal.

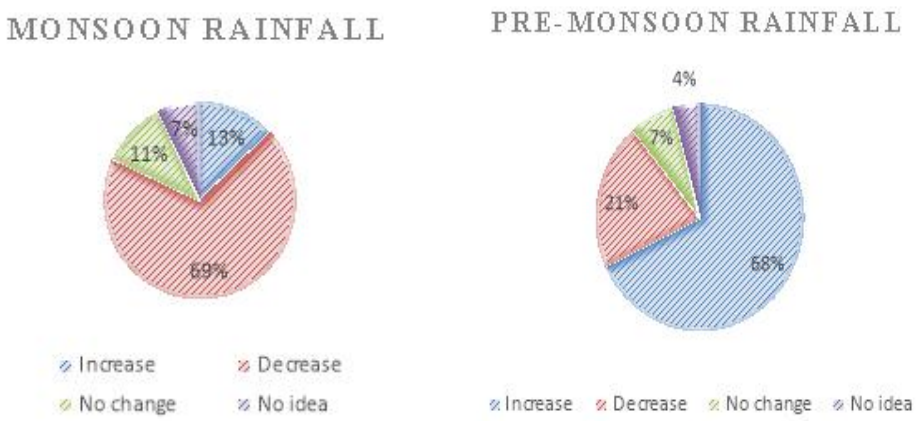

Figure 7a and 7b. People's perception on monsoon and pre-monsoon rainfall

It is observed that local communities' responses were also similar to the rainfall trend as obtained from the DHM's data. The National Planning Commission's report of 2022 has also shown a decreasing trend of precipitation at the rate of 8.144mm per year in Sindhuli district. This type of phenomena has shown clear evidence of adverse impacts of climate change in the mid-mountainous part of Nepal. In order to address such a phenomena, it is better to prefer adaptation strategies in the study area.

In the case of springs, we conducted a household survey. During the survey, Major portion of the respondents, nearly 89%, said that most of the springs are drying up. 9% of the respondents claimed that the springs are not drying. Two percent of the respondents do not have an idea about it.

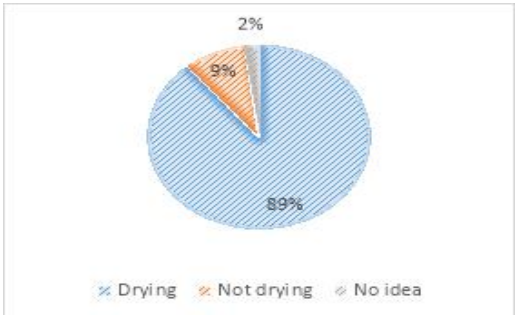

Figure 8 Peoples' perception on spring drying

Increasing tendency of drying springs in the study area logically signified from the decreasing pattern of rainfall as well as the increasing pattern of the temperature trend. Further increasing temperature trend and decreasing rainfall pattern, influences negatively to the natural springs. Such a condition will create a severe situation in future especially related to water and water associated development works in the study area.

One of the main objectives of this study is to investigate climatic patterns with water resources. Thus, we have investigated the main sources of water availed in the study area. Those sources are wells, springs, streams, and ponds. Four ponds, three wells, two springs, two streams and one river were identified from our field observation and they are delineated in Figure-9.

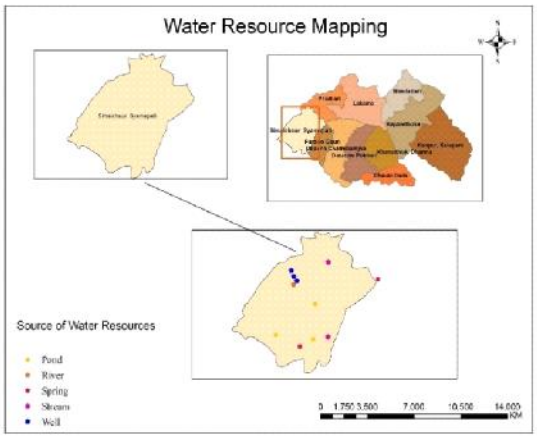

Figure 9. Map of major water resources

This study has shown negative consequences in connection to water resources in the study area. It is better to apply water conservation practices, water recharge systems along with other adaptation modalities for effective use of water resources in the SimalchaurSimpati area of the Namobuddh Municipality.

This study has been carried out to further inspect effects of climatic variability in water at the study area. During a household survey, 69% of the respondents said that access to water has become very difficult than previous years, while it was less difficult for 23% of the respondents. Similarly 7% of the respondents said that it is easier to access water than previous years. Only 1% felt that it is very easy to access water. In our

observation, most of the people are facing water scarce conditions in the study area. Some of the exceptional cases may have appeared due to shifting of water springs, geological conditions and so on.

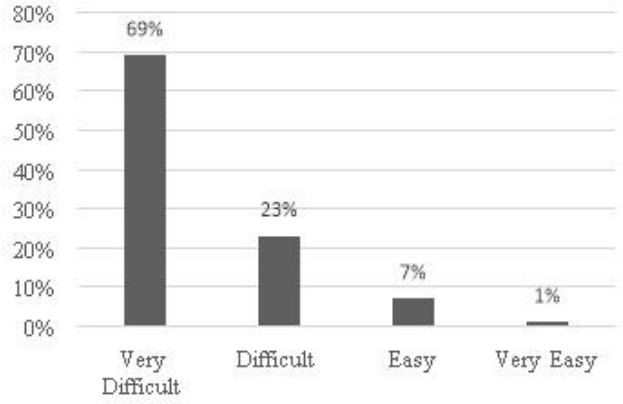

Figure 10. People's perception on access to water

It has also shown difficulty to get water for individual as well as community use. Water conservation practices like rainwater harvesting, promoting ponds, drip irrigation facilities along with increasing recharge zones need to be enhanced for the long-term availability of the water in the study area.

This study has been carried out to acquaint availability of water resources for the major occupation that is farming in the study area. According to household survey, almost all people in the study area are depending on agriculture for their livelihood. 73% of the respondents said that they depend on rain water for irrigation, 24% of the respondent said that they pumped water from nearest streams/rivers for irrigation and only a few farmers had wells in their field for irrigation.

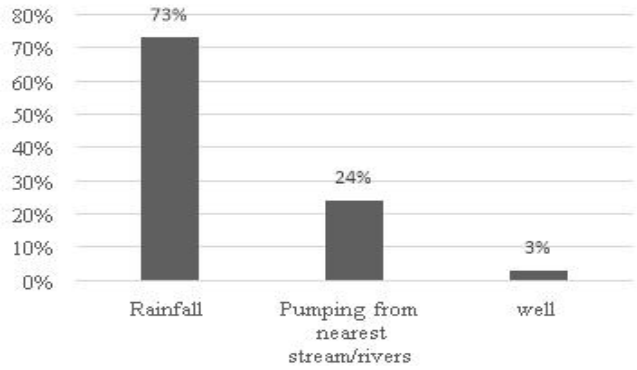

Figure 11.People's practices on sources of irrigation

Results from Figure-11 also justified the need for effective water conservation practices in the study area. Holistic water management programs need to be implemented for the long-term plan in the SimalchaurSympati area.

We also carried out a study considering climate change impacts on crop production and livestock. It is observed the increasing tendency of the use of pesticides and diseases in agricultural crops. Local weeds such as ghandejhar (*Ageratum conyzoides*) are examples for the main reason in reduction of yields like rice and pulses. The flowering and ripening time of fruits have changed. It is a fact that the temperature increasing situation enhances various types of diseases in many parts of the country including the Mid-Mountains. Gautam, (2014) also found a similar type of situation in Mustang region of Nepal.

We also investigated impacts of climate change on sources of water in local communities of SimalchaurSympati area. Multiple response questions were asked to local people about the impacts on sources of water as the consequences of climate change in Namobuddha Municipality. Majority of the respondents (37%) answered about the drying up of springs and ponds. 21% respondents informed no or less flow in stream/river, 31% of respondents answered there was severe water scarcity and minimum flow of water in rivers/streams during dry season. 11% answered that frequent drought has been occurring as consequences of climate change.

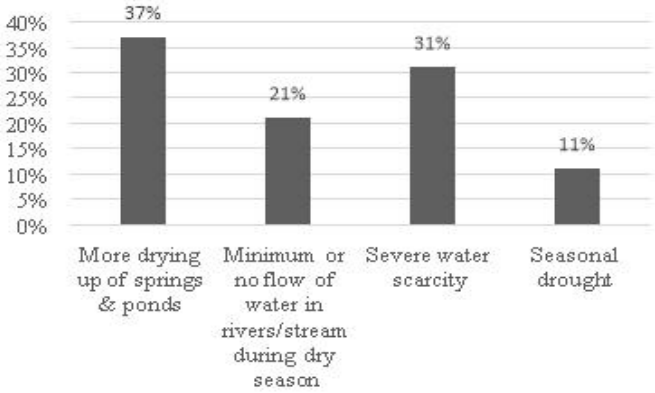

Figure 12. Impacts of climate change on sources of water

Mostly, the responses showed drying of water sources in the study area, it is also justified by the availed various scientific studies. It is better to conserve the availed water resources and implement integrated water management practices in the SimalchaurSympati area of the Namobuddh Municipality. Similarly, local communities also need to promote mitigation/adaptation measure programs to address changing climatic patterns and reducing greenhouse gas (GHGs) emission even from the study area.

Conclusions

Considering the socio-economic findings from this study, the local people complained about the increasing tendency of the water shortages. Most of their sources of water had dried up. They also deplored that due to the degraded forests in the past, landslides, gully formations and less ground water flow occurred in their springs. Scarcity of water has affected people, livestock and agriculture of the local communities. Women and children are burdened by fetching water from far distance's water sources. More crop diseases have been increasing in the study area.

Apart from local peoples' perceptions, we analyzed annual temperature around the study area and it has been increasing at the rate of 0.021^{o}C/year. The maximum and minimum annual temperature has been increasing at the rates of 0.041^{o}C/year and 0.014^{o}C/year respectively. Similarly, we analyzed the annual rainfall trend and it has shown the decreasing condition at the rate of 9.484mm/year. The increasing temperature trend along with decreasing rainfall patterns enhanced evaporation losses from the water sources of the study area. Due to this reason, water sources such as ponds, springs, wells

and streams have been drying up. Hence, the meteorological data analyses also justified the local citizens' perception about climate variability and their adverse impacts in the study area.

From the findings of increasing temperature and decreasing rainfall along with drying up of many sources of water, people of the study area are in the grip of shortage of water. They need to enhance holistic development of watersheds in the study area. Local communities need to scientifically manage the use of available natural resources including water for long-term use. Some of the widely used techniques for water management such as storage for water retention, recharge and dry season supply, rainwater harvesting at household and communal basis, appropriate designs for sanitation facilities can be applied for the sustainable use of water in the study area. Water scarcity problem will get worse, if they do not act to solve it through coordination as well as cooperation among all stakeholders. In this connection, Local people need to raise concern from local to province along with central level organizations/institutions. Technical as well financial support need to be implemented to achieve the sustainable solution especially considering changing climatic patterns in this study area.

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