Climate change trends in the Mountains of Nepal: Implications for Traditional Crops

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Introduction
Climate change has been observed in Nepal in varying levels (Paudel, 2010). A rapid change in climate patterns potentially driven by global warming is considered to be greatest threats to agriculture (Paudel and Kotani, 2013). Nepal has experienced an average maximum annual temperature increase of 0.06°C (Shrestha et al., 1999) with 0.09°C in the Himalayan region and 0.64°C in the terai belt (Practical Action, 2007). Plant diseases are one of the important factors which have a direct impact on global agricultural productivity and climate change will further aggravate the situation (IPCC, 2007) or may have positive, negative or neutral impact (Chakraborty et al., 2000). All phases of disease cycle, from the germination of spores to the development of lesions, are considerably influenced by climatic factors (temperature, humidity, precipitation, or deposition of dew). These factors may be modified by climate change (Beverton and Ghini, 2014).

Methodology
This study was carried out in four mountain locations of Nepal: Jiri, Dolakha, Lamjung and Humla maintained by the Department of Hydrology and Meteorology (DHMI); were utilized (Figure 1).

Trend analysis of climatic data
➢ The seasonal and annual trends were analyzed for the following climate variables:
➢ Temperature (monthly and annual maximum and minimum)
➢ Precipitation (monthly and annual accumulated quantities)
➢ Relative humidity (monthly and annual average)
➢ MS-Excel program called MAKESENS version 1.0 developed by FMI in 2002 (Salim et al., 2002) was used to calculate magnitude, and Sen’s slope method for trend analysis.

Results and Discussion
Changing trends in climatic parameters:
➢ The average annual maximum and minimum were in increasing trends at all study sites.
➢ The annual rainfall was in decreasing trend at Lamjung, Jumla and Humla whereas was in increasing trend at Dolakha.
➢ The result shows an increase in average temperature of approximately 0.03°C to 0.11°C per year in different locations in different locations and a mixed trend in precipitation. (Table 1)

Conclusions and Recommendation
This study concludes that climate change varies over time and space. Temperature is increasing at higher level in higher altitude of Nepal (e.g. Humla) as compared middle and lower altitude. However, the changes of rainfall pattern varies by locations with declining rainfall in western part of Nepal and some increase in the eastern part over the years. This has important implications for cultivation, conservation, and promotion of mountain crops. Focus should be given for more drought tolerant crops and varieties adapted to western mountains. In higher altitude of the Himalayan mountains, more heat tolerant crops and varieties to be promoted. The results of this research can be used by organizations and researchers to intervene relevant R&D activities including disease and pest management.

Table 1: Average annual Maximum and Minimum temperature (ºC) and Rainfall (mm) and changing pattern

<table>
<thead>
<tr>
<th>Location</th>
<th>Average Change</th>
<th>Change</th>
<th>Average Change</th>
<th>Change</th>
<th>Humla</th>
<th>20.72</th>
<th>0.11</th>
<th>8.14</th>
<th>0.31</th>
<th>65.33</th>
<th>-3.47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jumla</td>
<td>21.81</td>
<td>0.04</td>
<td>7.45</td>
<td>-0.01</td>
<td>73.05</td>
<td>-4.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Lamjung</td>
<td>27.55</td>
<td>0.05</td>
<td>15.52</td>
<td>0.01</td>
<td>65.33</td>
<td>-12.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Dolakha</td>
<td>20.72</td>
<td>0.03</td>
<td>8.14</td>
<td>0.03</td>
<td>204.85</td>
<td>8.85</td>
<td></td>
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</tbody>
</table>

➢ Increasing trend of temperature in the study location is the evident of climate change over the Nepal. This finding shows that warming is more pronounced in high-altitude region such as Simikot (Humla) at 3000 msl as compared to lower altitude. This finding is also supported by earlier studies (Selvaraju et al., 2014). Findings also confirmed the variation of climate change over space time as evident from increasing rainfall pattern in eastern Nepal (Jiri), while declining rainfall in the western part of Nepal. This finding is also supported by earlier studies by Selvaraju et al. (2014).

Figure 1: Study sites and location of meteorological station

Figure 2: Changing trends in climatic parameters in Simikot, Humla over 29 years (1989-2017)

Figure 3: Changing trends in climatic parameters in Depalgaun, Jumla over 31 years (1987-2017)

Figure 4: Changing trends in climatic parameters in Khudi bazar, Lamjung over 30 years (1988-2017)

Figure 5: Changing trends in climatic parameters in Jiri, Dolakha over 30 years (1988-2017)