Adaptation for Climate Change by Livestock Smallholders in Gandaki River Basin

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Introduction

Himalayan region is critical to regional water resources, with often heavy precipitation supplying river flow to extensive downstream reservoirs, and is also vulnerable to hydrological hazards, such as flooding and drought (Krakauer, Lakhekar, Pradhanang, & Jha, 2015). The majority of precipitation studies of southern Asia have excluded the Himalayan belt due to the region’s extreme, complex topography and lack of adequate rain-gauge data (Shrestha M., 2002). Due to the steep slopes and rugged topography, rainfall estimation in Nepal is very difficult. In this paper, we analyze the trend of precipitation, its changing nature and future projection to the Gandaki River basin (GRB) and on the other hand how the local smallholder farmers are adapting the water availability to the policy makers will hand better information for decision support system and smallholder farmers can develop their resiliency accordingly.

Study Area

The Gandaki River basin (Fig. 1) lies in the central part of Nepal and is one of the three major river basins of Nepal. The Gandaki River flows on to India, where it drains into the Ganges River. The spatial area covered by the basin in Nepal is around 35000 sq kilometers. It covers a variety of physiographic regions from High Mountain to the low lands, including some rain-shadow valleys like Mustang and Manang in the north that are particularly prone to drought. The Gandaki river network comprises the Trishuli, Budhi Gandaki, Marsyangdi, Rapti, Kali Gandaki, Maidi and Darasu-dar rivers.

Very few precipitation measuring stations are in the high lands (above 2500 meters above) and none beyond 4000 meters (Fig 1). Therefore, existing rain-gauges that have limited ability to capture changes in the water inputs to the basin. The climate of Gandaki river basin ranges from humid sub-tropical to arctic high Himalaya.

Data and Methodology

The below is the list and their details used for the purpose of the study.

Table 1: Data use and their details

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Time Period</th>
<th>Resolution</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall (mm)</td>
<td>1981-2011</td>
<td>Daily</td>
<td>DEBI</td>
</tr>
<tr>
<td>Certified precipitation (mm)</td>
<td>1971-2009</td>
<td>Rainfall observation</td>
<td>ADPC/DHM, BMH/GRB</td>
</tr>
<tr>
<td>Climate model (PRECIS-Basin, MM2005)</td>
<td>2000m</td>
<td>25 KM, monthly</td>
<td>DEBI</td>
</tr>
<tr>
<td>AIB-SSB Scenario for precipitation</td>
<td>2025-2090</td>
<td>DEBI</td>
<td></td>
</tr>
<tr>
<td>Digital Elevation Model (DEM)</td>
<td>2000</td>
<td>30m</td>
<td>SRTM/USGS</td>
</tr>
<tr>
<td>Monsoon onset and withdrawal date</td>
<td>1984-2012</td>
<td>Precip data</td>
<td>DBM</td>
</tr>
<tr>
<td>Farmer’s adaptation practices</td>
<td>2013</td>
<td>Survey data</td>
<td></td>
</tr>
</tbody>
</table>

Precipitation Trends and Implications for Agricultural Adaptation Needs in Gandaki River Basin, Nepal

The precipitation data were analyzed to see their past trend. The change in precipitation in past was analyzed by assuming 1971 to 1999 observation as baseline to which 2000 to 2009. For analyzing the future precipitation change, PRECIS global climate model simulations downscaled over Nepal were analyzed with 1971 to 2000 as baseline period and 2020 to 2050 as the future period. Consecutive dry day statistics were calculated using the 21 stations daily observation data, those stations were selected on the basis of data homogeneity.

Result and Discussions

Precipitation trend in the GRB

The average annual precipitation in the Gandaki river basin ranges from 160.03 mm in the northern dry parts to 4279.38 mm in the middle part of the basin. The central part of the region (Kaski, Lamjung districts) receives highest rainfall whereas the upper part (Mustang, Manang districts) receives the lowest rainfall amount as shown below (Fig 2). As of the national trend, the rainfall is dominated by monsoon as 80% of the rainfall is received in the monsoon season (June-September). The spatial distribution of rainfall in monsoon and non-monsoon seasons follows the same pattern as in the annual total.

Monsoon onset and withdrawal

It has been assumed that the monsoon onset data for Nepal is 10 and withdrawal date is September 23. This analysis above shows that the monsoon is arriving quite earlier and departing late, therefore, the duration of the monsoon is increasing.

Extreme rainfall events

The extreme analysis of the observed precipitation data from the 21 stations based on the data homogeneity of the GRB depicts that all the stations show positive trend of Consecutive Dry Days (CDD) which means maximum number of consecutive days (with RR<1 mm) and most of the stations show trends of increasing rainfall.

Projected change in precipitation

The model (PRECIS) did not show any significant linear trend in the annual precipitation in the GRB as a whole. However, the models agree to a point that the annual precipitation in high lands is decreasing and that in lower lands is increasing. Thus, observation (through 2009) and model projections (through 2060) agree that dry areas with the GRB are becoming dryer and wet areas are becoming wetter.

Adaptation practices

Because of the water stress is the region, community people are adjusting their lifestyles with various adaptation techniques. Household and community level water harvesting systems, and collection and use of grey water in a tank for kitchen gardening are water collection techniques. Few autonomous adaptations measures have been initiated like the application of efficient irrigation technologies (drip/spinklirie irrigation etc). Farmers are pugging and adopting new timing according to the monsoon and rainfall calendar. In the north eastern part of the basin farmers have started cultivating millet, maize instead of rice. Only cultivars are like crop sowing time shifting, drought resilient seeds, and new hybrid crops, crop rotation (legume and cereal) and inter-cropping to manage soil nutrients. Terrace farming is indigenous practices in slope lands and sloping agriculture land technology (SALT) have been practices in some of the areas of the basin. Some other initiatives are mulching (plastic and other agriculture residue) that covers soil controlling the loss of soil moisture. Livestock smallholders are adopting and storing green fodder available in monsoon season for the use in dry season.

Conclusion

Both RCM data and observations agree that the annual precipitation in the lower part of Gandaki river basin is increasing whereas it is decreasing in the upper part. The situation of dry to dryer and wet to weather may lead to worsening drought and flooding in the basin. The PRECIS regional climate model’s precipitation outputs are not robust for estimating the exact amount of precipitation, as shown by their generally poor correlation with station observations, but are useful for estimating the direction of change. The variation of attitude within a short spatial range and rugged topography of the region may be the reason behind the poor performance of RCMs in modeling the absolute precipitation amounts measured at individual stations.

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Reference


Figure 1: Study area-Gandaki River basin and precipitation measuring stations

Figure 2: (A) Mean annual total precipitation in GRB and (C) Average annual non-monsoon precipitation in GRB

Figure 3: (A) Change in annual precipitation(B) Monsoon precipitation and (C) non-monsoon precipitation with the PRECIS-A2B

Figure 4: Trend of monsoon onset, withdrawal and duration

Figure 5: Increasing number of consecutive dry day in different altitude

Figure 6: (A) Change in annual precipitation (B) Monsoon precipitation and (C) non-monsoon precipitation with the PRECIS-A2B

Figure 7: Adaptation practices to mitigate water stress by local communities

Figure 8: Spatial variation of summer monsoon rainfall