Chapter 2

Climate change in the Himalayas

2.1. Introduction

Gaining an overview of climate change in south Asia is complicated by its variety of geographical regimes, from Bangladesh, virtually at sea level, to the Himalayas, the highest mountain range on earth. The greater Himalayan region covers some 7 million km^2 at an altitude above 1000m[1]. Models predicting climatic trends later into this century show relatively weak consistency, although sharing a general agreement as to the likelihood of increased winter warming.[2] Furthermore, understanding these changes is complicated by the latitudinal tilt of the Himalayas, which have different weather systems operating between the east and the west of the range. Because of this diversity, attempting to downscale generalisations from IPCC Assessment Reports will run into difficulty.

The Himalayas are the world's youngest and steepest mountain chain. It is still forming, presently extending 2500km west to east and 150 – 300km north to south. Slope angles are often of the order of 60-80°. It is an area of high erosion and frequent seismic events.[3]

Together, these factors produce an extraordinary diversity of environments with annual rainfall varying between a very few centimetres and six metres in regions just 80km apart.[4] The Himalayan region contains the third largest ice mass on the earth, including well over 14,500 glaciers[5] whose melt water sustains hundreds of millions of people. One estimate suggested that, during low flows, 70% of the Ganges water derives from Himalayan melt water.

[1] Xu, J. *et al.*2009.
[2] Shrestha, M.L. & Shrestha, A.B. 2005.
[3] Singh, R. 2005.
[4] Chalise, S. *et al*. 1996.
[5] This figure is confined to the following countries: Nepal, 3252 (Mool *et al*. 2001 A); Pakistan, 5218, India, 3993, China/TAR 1578 (Campbell *et al.* 2005; These authors report that further quantification is needed); Bhutan, 677 (Mool *et al.* 2001 B.)

> …(T)here may (for the next several decades) appear to be normal, even increased, amounts of available melt water to satisfy dry season needs. The shortage, when it comes, will likely arrive much more abruptly in time; with water systems going from plenty to want in perhaps a few decades or less.[6]

There is also a wide spectrum of cultural and ethnic groupings, making the Himalayas perhaps the most multifaceted region in the world.

Rapid atmospheric warming is already dramatically affecting the Himalayas and its communities. Given that greenhouse gases (GHGs) and aerosol-related atmospheric pollution are set to rise, there is good reason to suppose that we are in the early stages of this process and that more dramatic changes are already foreseeable in the near and medium term. Mean annual temperatures (MAT) have risen as fast as anywhere in the world, which should make this region a laboratory for the study of climate change. Yet data are in very short supply. Weather stations are nowhere near as densely distributed as they need to be in order to give a clear picture.[7] These problems increase with altitude, where weather conditions can easily put stations out of action. Altitude and inaccessibility ensure that regional-scale higher altitude development initiatives are virtually non existent.

2.2 Some background information on Nepal

Nepal's elongated rectangular shape has a strong latitudinal tilt. However, for the sake of simplicity, its topographical relief system is usually described horizontally, as from the bottom of the rectangle, rather than in terms of latitude. A 'horizontal' geological and climatological picture of Nepal is given in the following table:

Table 2.1: Geographical regions of Nepal

Region	Geology and soil	Elevation (masl)	Climate	Average Temp
Terai	Gently sloping, recently deposited alluvium	200	Humid tropical	> 25^{O}C
Siwaliks	Testing mudstone, siltstone, sandstone. Steep slopes and weakly consolidated bedrock. Tends to promote surface erosion despite thick Vegetation	200-1500	Moist subtropical	25^{O}C
Middle Mountains	Phyllite, schists, quartzite, granite, limestone. Stony and course textured soil. Conifer forests commonly found associated with quartzite	1000-2500	Temperate	20^{O}C
High Mountains	Phyllite, schists, quartzite. Soil is generally shallow and resistant to weathering	2200-4000	Cool to sub-alpine	10-15^{O}C
High Himalayas	Limestone and shale. Physical weathering predominates, stony soils	> 4000	Alpine to arctic	< 0 to 5^{O}C

Source: Agrawala *et al.* 2003 p. 11, citing CST Nepal 1997 (presumably Country Technical Services Team for South and West Asia).

[6] Barnett, T. *et al.* 2005 p. 306. In this article, quantification of the content Ganges low flows has been cited from papers by Singh, P. However there is ongoing discussion on this subject.
[7] Fowler, H. & Archer, D. 2006; Archer, D. & Fowler, H. 2004.

This 'horizontal' stratification of Nepal can be enhanced by information given by Carson.

Table 2.2: Characteristics of Nepal's topography.

Region	Area km²	% of Nepal's land area	Relief (m) approx	Vegetation /crop	Comment
Terai	2122	14	270	Rice + others	Varies according to flood risk or porosity of ground conditions
Siwalik	1879	12.7	700	Dun valleys provide some of the best agri land	Variety of slope angle, soil depth and stability make forest & agriculture sustainability variable
Middle Mountains	4450	29.5	1000 – 2000	Forest/ terrace	Gentler relief & higher population densities
High Mountains	2899	19	2000	Forest/ terrace	V-shaped valleys. Cultivation of landslide debris /glacier till
High Himalayas	3447	23.7	3000	Forest <4300m	Lower more concentrated population

Source: Carson 1992.

The country is further divided vertically by three major river systems: Karnali in the west, The Narayani (which becomes the Gandak in India) in the centre and the Sapata (=seven tributaries) Koshi, in the east. The Arun, which rises on the Tibetan Plateau is the most important of these tributaries. All these ultimately feed the Ganges.[8]

Nepal's population is now approaching 28 million[9]. According to UK Department for International Development figures for 2007, Nepal is the poorest country in South Asia, with a rural population of 80%, producing only 30% of gross domestic product (GDP) with a per capita GDP of $270.[10] In 1981 the population was 15 million. The proportion of population living in hill and mountain regions in 1991 was 56.4%.[11] If this proportion has been maintained (it may have shrunk to some degree) the hill and mountain population would be in the order of 15 million in 2011. Biomass is the main energy source for the majority of the rural population, frequently burnt on open stoves in poorly ventilated kitchens.[12]

Nearly half of government expenditure comes from foreign aid.[13] Since 80% of the country is mountainous, communications are crippled by a lack of infrastructure. One in five of Nepal's districts have no roads,[14] a figure which belies the large proportion of the population that lives more than a day's walk from any road or airstrip. However the rapidly expanding road-building programme is likely to change this in the foreseeable future.

[8] Anon, 1991.
[9] Ministry of the Environment, 2010.
[10] DfID 2007.
[11] Anon, 1991.
[12] Luitel, A. nd.
[13] Agrawala, S. *et al.* 2003.
[14] Luitel, A. nd.

Nepal's MAT is often given as 15°C,[15] providing a textbook example of how misleading a mean average value can be. Equally misleading is the statistic sometimes given for mean annual precipitation as 1.5m.[16] The same source provides projections of atmospheric warming as 1.2°C by 2030 and 3°C by 2100. This may possibly prove to be accurate but it also has no meaning, because of the high variability of warming rates at different altitudes. Shrestha[17] has shown that over a 17-year period the mean annual maximum temperature in the Middle Mountains has increased at nearly twice the rate of those in the Siwaliks and Terai.

2.3 Local effects of climate change in Nepal's mountains

Even on the basis of Shrestha's evidence, it would be wrong to draw too much by way of generalisation. The following table is drawn from a report by the NGO Practical Action in 2009:

Table 2.2 Sites selected for Practical Action's 2007–8 study

Village	District	Altit. m asl.	Approx latitude	Approx longitude	Selection criteria
Depalgaun	Jumla	2450	29° 15' 50"	82° 12' 40"	Annual rainfall decreasing
Kalena	Doti	1500	29° 16' 52"	80° 58' 30"	Annual temperature decreasing
Tikapur	Kailali	150	28° 30' 00"	81° 10' 00"	Annual rainfall slightly decreasing
Khalanga	Salyan	1500	28° 25' 00"	82° 12' 00"	Annual rainfall slightly decreasing
Semaran	Rupandehi	120	27° 30' 00"	83° 15' 00"	Annual rainfall decreasing
Lumle	Kaski	1700	28° 15' 00"	83° 50' 00"	Annual rainfall increasing
Khudi	Lamjung	850	28° 17'00"	84° 22' 00"	Annual temperature increasing
Pragatinagar	Nawalparasi	150	27° 40' 00"	84° 11' 15"	Annual rainfall increasing
Ramche	Rasuwa	2000	28° 02' 30"	85° 12' 30"	Pre-monsoon and monsoon temperature decreasing
Jibjibe	Rasuwa		27° 58' 30"	85° 14' 00"	Pre-monsoon and monsoon temperature decreasing
Khanigaun	Dhading	1023	27° 52' 10"	84° 52' 10"	Annual rainfall decreasing
Jhule	Dolakha	2000			Annual rainfall decreasing
Bhimphendi	Makawanpur		27° 35' 00"	85° 08' 00	Annual rainfall increasing
Khadbari	Sankhuwasabha	1038	27° 20' 00"	87° 15' 00"	Annual temperature decreasing

Source: Practical Action[18] (In some cases data are not available.)

A further survey in the same report suggested that several communities examined (not necessarily those above) reported summers starting earlier and finishing later; some reported reduced winter periods. However winters start earlier and finish later in Dolakha, where summer temperatures also seem to have fallen. The fact that a Helvetas[19] report indicated a trend of increasing temperatures for that district does not invalidate the Practical Action data. It only underscores the enormous complexity of local trends and the importance of in-depth local understanding before any interventions are contemplated. Both the Practical Action and the Helvetas reports underscore the most commonly heard complaint from hill farmers, that of the increasing unpredictability both of intensity and seasonality of rainfall outside the summer monsoon in recent years. This seems to be corroborated by a recent ICIMOD report dealing with 'too little and too much water.'[20]

[15] Agrawala, S. *et al.* 2003.
[16] Agrawala, S. [Ed.] 2005.
[17] Shrestha, A.B. *et al*. 1999.
[18] Gurung *et al.* 2010.
[19] Dhital, S. & McCarthy, T. 2010.
[20] ICIMOD 2009.

The alarming extent of atmospheric warming in the Himalayas in recent years will be discussed in the next chapter.

2.4 Climate change as a priority in development in Nepal pre-2010

In 2001 ICIMOD published an inventory of Nepal's glaciers and glacier lakes, identifying 20 potentially dangerous glacial lakes resulting from rapid glacier melt.[21] While it is possible to criticise the risk assessment criteria[22] used in this document as being too narrowly based, it effectively set the country's climate change agenda for nearly a decade.

Nepal's tenth Five-Year Programme (2002–7) placed emphasis on disaster risk reduction, but it also attracted criticism because of scant attention to other climate change issues.[23] A 2003 report from the Organisation of Economic Cooperation and Development (OECD) criticised the lack of awareness of climate change issues not only in government policy but also among intergovernmental and non-governmental agencies. It shows that a raft of recent development programme reports in Nepal fail to understand or to confront issues of climate change in their programmes. However, in reality, this same report exacerbates the situation by playing down, and failing to research, impacts of climate change on agriculture, human health and biodiversity, while focussing its attention on water resource issues and glacier lake outburst floods (GLOFs).[24]

Table 2.3: The ranking of climate risks at country level in Nepal in a report produced by OECD, 2003.

Resource/ranking	Certainty of impact	Relative timeframe of impact	Severity of impact	Importance of resource
Water resources and hydropower	High	Soon	High	High
Agriculture	Medium-Low	Medium-far	Medium	High
Human health	Low	Medium	Uncertain	High
Ecosystems/ biodiversity	Low	Uncertain	Uncertain	Medium-high

Source: Agrawala *et al.* 2003, p. 17

Because of this, human health and ecosystem/biodiversity are given lower ranking as a result of 'so-called' uncertainty in their assessment. Furthermore, the predictions relating to agriculture (in the Himalayas if not the Terai) are poorly considered and hardly justified in the light of literature already published. While GLOFs remain a major threat both to life and infrastructure, most would now agree that the threats posed to mountain agriculture by climate change are on a national and indeed regional scale.

[21] Mool, P.K. *et al.* 2001.
[22] These were mainly topographical and historical criteria.
[23] Luitel, A. nd.
[24] Agrawala, S. *et al.* 2003.

A further OECD publication of 2005[25] absorbed much of the thinking of the 2003 report but sought to establish why climate change should have priority over other aspects of development. For climate may take a considerable time to alter the environment while the immediate issues of gender, food security, sanitation and health may become overridden. When this question is answered, one should then consider what adaptation strategies should be followed and what ranking priorities should be given within the various climate change scenarios: *(i)* to current variability; *(ii)* to observed medium- and long-term trends, or *(iii)* anticipatory planning in response to model-based scenarios of long-term trends.

Response to other trends, stresses and considerations	↔	Adaptation to scenarios of projected climate change ↕
	↔	Adaptation to observed climate trends ↕
	↔	Adaptation to current climate variability

Figure 2.1: Levels of adaptation responses and links to other priorities[26]

But even when climate change awareness is central to the thinking of development agencies, the problem is far from solved because donor awareness is still lacking. Indeed there appears to be an increasing desire for donors to see a rapid return on their funds in terms of impact. In consequence, longer term integrated projects have become increasingly difficult to effect.[27]

2.5 Climate change as a priority in development in Nepal post-2010

Nepal's National Adaptation Programme of Action to Climate Change (NAPA) was published in September 2010. It was formed by consultation with a range of stakeholders, and is the product of six thematic working groups, each from a different line ministry, such as 'Forests and Biodiversity' and 'Water Resources and Energy', whose consultation developed a shortlist of adaptation priorities. In its three-year plan (2010 – 2012) the Ministry of Environment has been given overall responsibility for coordinating climate change issues into the relevant government policy areas.

[25] Agrawala, S. [Ed.] 2005.
[26] Agrawala, S. [Ed.] 2005 p.39.
[27] Luitel, A. nd, p.9.

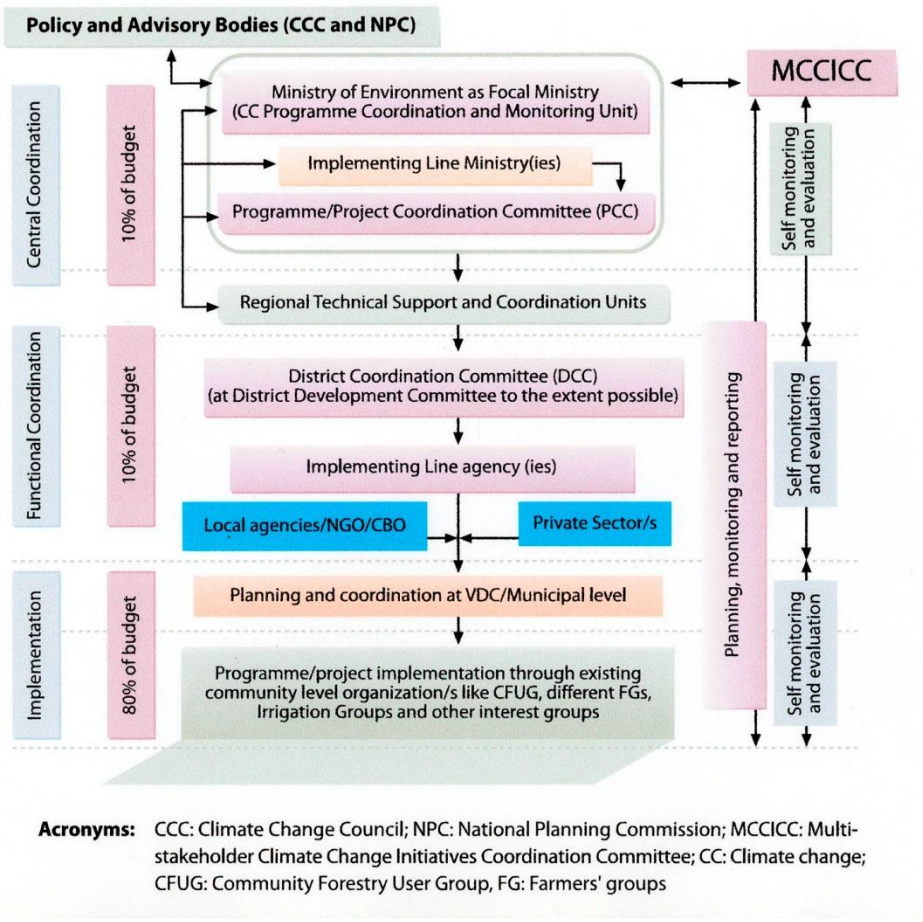

Figure 2.2: Nepal's new climate change industry. The NAPA programme[28]

The NAPA report represents a fundamental shift from the previous OECD reports in that Agriculture and Food security has risen to be the first mentioned adaptation priority.

> In the mid-hills and high mountain regions increasing temperature has led to the expansion of agro-ecological belts into higher altitudes and increased length of growing period for some crop species. Conversely, high hill animal herders have reported decline in fodder and forage production that has aggravated the presence of livestock parasites. In the mid-hills, decreasing soil moisture availability (due to changes in rainfall and temperature) resulted in early maturation of crops, crop failures and reduced agricultural productivity. In addition, decreasing run-off water to feed natural streams (used for irrigation) and re-charging natural ponds, reservoirs and lakes have been reported
>
> Data revealed that some 30845 hectares of land owned by 4.7 percent of households became uncultivated in the previous decade due to climate induced disasters.[29]

The NAPA report goes on to identify priorities in a series of combined profiles such as management of agriculture, water, forest and biodiversity; disaster management; public health and suchlike under nine different headings. Long and short term objectives are identified with timeframes and budgets. A useful series of annexes *inter alia* identifies perceptions of hazards

[28] Ministry of the Environment, 2101, p.21.
[29] Ministry of the Environment, 2101, p.24.

and climatic changes across various transects. It also provides a series of country wide hazard maps and identifies local perceptions of climate change impacts.

2.6 Summary

While remoteness and a high degree of topographical variability are key factors in attracting tourist income to Nepal, they are also the chief factors that maintain the country's grinding poverty. Because access to markets is so difficult for the majority of mountain farmers they tend to survive at subsistence level with low durations of food security. Therefore the building of any cash reserves to help over a crisis is difficult and any crop failure will have major impact.

The hazard of GLOFs should not be understated, but in respect of the vulnerability of the wider mountain population the focus appears to have been misplaced in pre-NAPA reports. Lack of data played a part in this lacuna, a problem which persists today. Because of Nepal's extraordinarily variable environments, it is evident that 'climate change' will mean different things in different places, even a few kilometres apart. While climate change presents an infinite range of variables in the Himalayas, longer periods of drought with shorter, more intense periods of precipitation are often reported together with a high degree of variability of non-summer monsoon rainfall.

Nepal's belated National Adaptation Programme of Action is greatly to be welcomed. But in a country where government struggles to achieve a clear mandate, there is now the worry that a growing panegyric for the climate change industry may begin to effect inappropriate interventions either for lack of data or for reasons of bureaucratic fulfilment.

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