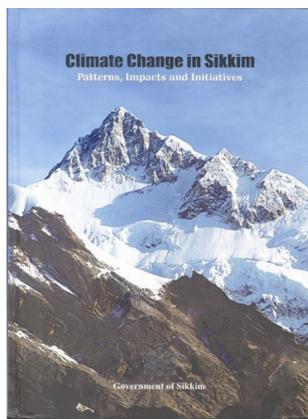


interest groups and the impact of populist decisions weigh heavy on policy process. Covering a vast canvas, including policy theory, social dynamics, methodological choices, politics and guidelines for policy makers, this book is a useful intervention.

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**Climate Change in Sikkim: Patterns, Impacts and Initiatives.** M. L. Arrawatia and Sandeep Tambe (eds). Information and Public Relations Department, Government of Sikkim, Gangtok. 2012. 424 pp. Price: Rs 2000.

The book under review is the best example of how a group of knowledgeable people belonging to the wide spectrum of society can develop a database in the form of a coffee-table book. It has happened mainly because of the direct encouragement and help from the state government of the day. The plethora of knowledge is put in the form of an easy reading consisting of high-resolution photographs, tables, figures and sketches. The happening of a book of this type today demonstrates that the science of climate change has reached the homes of the common masses. It is heartening to learn that the book is conceptualized by none other than the Chief Minister of the state, Pawan Chamling and also published by the Government of Sikkim. The book is divided into four parts: Patterns and evidence of climate change, Impacts of climate change, Climate change related vulnerability assessment and cli-

mate change initiatives in Sikkim. In total there are 23 chapters written by eminent personalities consisting of scientists, academicians, scientific officers and current and former bureaucrats. These authors belong to institutions from across the country, including Sikkim. A couple of articles are also contributed by experts from outside India.

The first part deals with the climate change in the capital city of Gangtok, analysis of past three decades of weather in the mid-hills of Sikkim and the historical perspectives on climate change in the whole of Sikkim in general. Although it sounds alarming, it is important for everybody to note that the warming over the Himalayas is much more (about three times) than the global average value. Based on the data archived by India Meteorological Department (IMD), the first paper infers that the maximum and minimum temperatures during 1957–2005 have annually decreased and increased by 0.02°C and 0.06°C respectively, compared to the baseline period of 1961–1990. Warming is found to be more pronounced during winter months. In the recent past, during 2006–2010, there has been a decrease in rainfall, decrease in maximum temperature and increase in minimum temperature by 9%, 2% and 1.6% respectively. The second paper is based on the observations during 1981–2012 made at the Met observatory in Tandong. Analysis of data shows that the increase in the minimum temperature during October (0.04°C/yr) and November (0.07°C/yr) may affect germination of rabi crops like wheat and barley. The expected insufficient rainfall at 50% and 80% in November and December respectively, may give rise to the need for supplementary irrigation in Sikkim. The third paper highlights the good aspects of the age-old practice of conserving the ecosystem and thereby contributing to the mitigation efforts.

The second part of the book dwells on the impacts of climate change and therefore rightly constitutes a major part of the book. This part includes the retreat of the East Rathong glacier in the Rangit basin in the west Sikkim; monitoring the seasonal snow cover in Sikkim Himalaya; the phenomenon of glacier lake outburst floods (GLOFs); alpine flora; characteristics of forests in general; birds and butterflies; biodiversity in the Kangchenjunga landscape; biogeographic response of rhododendrons; sustainability of agro-

diversity in traditional farming; adaptation measures in dairy sector and forest fire events. This part encompasses almost all important aspects of an impact study in a state like Sikkim. East Rathong glacier is a small glacier of 5.12 km length and average width of 1.5 km. It is south facing and its accumulation zone is on steep slope. It has retreated by 460 m during 1976–2009. If one considers the later period of 1997–2009, it shows faster retreat of 234 m in 12 years. On the other hand, the larger glacier Zemu, which is about 12 times larger than East Rathong, does not show consistent retreat, since it has east-facing aspect and gentle slope. Study of distribution of snow cover in Teesta Basin during 2004–2008, indicates that in Sikkim the maximum snow cover of 50% is in February, which is attributed to the western disturbances. Even in summer there is high extent of snow up to 40% because of the advantageous location of Sikkim. The snow pattern in Sikkim suggests different accumulation and ablation patterns compared to other places in the western Himalayas. The study of satellite imageries during the period 1965–2010 indicates that many glacier lakes have expanded leading to potential cause for GLOFs. Since our knowledge of GLOFs is limited, advanced research needs to be undertaken to predict and reduce their destructive effects. Alpine flora exhibit great variety of plant diversity in Sikkim, representing nearly 30% of the total flora. The warming of Sikkim during the last century has resulted in upward migration of the species from the lower altitudinal alpine zone AB1, shifts in the distribution of species across a broad range and late flowering.

About 82.3% of the geographical area in Sikkim is covered by forests. The paper dealing with the Sikkim forests based on climate model output indicates that the forest sector is unlikely to be adversely affected by climate change in the short and medium terms. However, considering the uncertainties in the climate model output, it is essential to examine the output of several other models. The study on Sikkim fauna indicates that many species have extended or shifted their range upwards along the elevation gradient. Since higher temperature suits the female snakes, a biased ratio has been observed towards them. Study shows large migration of birds and butterflies. The study on the linkage

between climate change and biodiversity shows that the Kangchenjunga landscape has signs of reduction in rainfall months, increase in rainfall intensity and marked decline in winter rains. Winters have become warmer and drier. These changes have led to disappearance of high-altitude alpine species, advancement in the timing of bud-burst and shifting in flowering activities, especially in *Rhododendron arboretum*. The impact of climate change on the genus *Rhododendron* has been examined using GPS at about 112 locations. Suitable bioclimatic envelope for this plant species has shrunk considerably.

In Sikkim, the agro-ecological knowledge base of the farmers has been helping them in developing coping mechanisms against the emergence of crop diseases and pests. In the paper on traditional farming, nine types of rain according to the local definition and two traditional land-use practices are studied and it has been pointed out that there is need for scientific and technical support for strengthening the traditional knowledge base. It is known that the small-holding dairy farming is the backbone of dairy sector in Sikkim. This sector is largely affected by global warming having an adverse impact on the economy of the rural people. In Sikkim, although the land area available for farming is small, it is basically an agrarian economy. About two-thirds of the rural population depend on agriculture and allied activities for its livelihood. Hence, the rural economy is largely affected by changes



Plants such as *Saussurea* spp are sensitive to climate and are endangered by changing climate.

in the land use and land cover. In this second part of the book, suggestions are also given for adapting to changes in simple ways. There are ongoing government programmes for the benefit of the rural people, but those need to be strengthened and new innovative methods adopted. Events such as erratic rainfall, extensive dry spells during winter, early summers and decrease in rainfall have all led to increased incidents of forest fire. One important aspect of such articles is that the state-of-the-art remote sensing and GIS techniques are used for obtaining the scientific information and then inferences are drawn.

The third part of the book deals with the vulnerability assessment studies related to climate change. This includes the cost-effective assessment for the rural communities; groundwater resources and spring hydrogeology in southern Sikkim; the practices of the indigenous people and a case study of resilience building in southern Sikkim. Cost-effective assessment of vulnerability has been done at high spatial resolution and it includes all the 163 villages of the state. This is stated to be a preliminary study completed in only a few months time; however, this study shows promise for the future. Detailed study of the aquifers shows reduction in spring discharge and hence in the groundwater resources. An interesting case study reveals that there is wealth of information available with the people of the land. Also, there are enough traditional practices adopted by the people. The resource management strategies adopted by the people under adverse conditions need to be analysed in detail and scientifically improved upon for the benefit of the society. A case study on how vulnerability can be reduced by building resilience basically through participatory approaches has been described.

The final part of the book is on the most important aspect of the initiatives undertaken so far. These include the strategies for adaptation; reviving the dying springs; case study of grazing exclusion policy in West Sikkim and finally the synthesis of climate change in the state. Some important changes such as those in forest vegetation types, geographic distribution of flora and fauna, timings of seasonal events, species interaction, etc. are identified and strategies to ensure food and livelihood security are mentioned. Methods are described as to

how by practising rainwater harvesting, dying springs have been revived. It is also discussed as to how the grazing exclusion policy implemented by the Government of Sikkim since 1998, has yielded good results. A specific study has estimated a difference of 585,000 tonnes of carbon sequestration in Barsey sanctuary in a period of 12 years. Such a study extended to the entire state of Sikkim will highlight the benefits of proper policies adopted by the government. Several initiatives have been undertaken by the Sikkim Government so as to help the people of the state adapt to the adverse situation caused due to global warming.

Although the book is a welcome step with regards to the generation of awareness regarding climate change issues, it has a number of flaws both scientific and presentation-wise. Since it is written in the format of a coffee-table book, enough care should have been taken while editing. There are many beautiful photographs, figures, tables and sketches. However, it is hard to distinguish which photographs are parts of the articles and which are used in the book in the form of separators. No systematic approach has been followed while putting the figure and table captions. In some articles (e.g. chapter 7), most captions are given below the figures and in others above. Even the table number is repeated in one article (chapter 8). The last but one chapter ends suddenly without the address of the authors as given in all other earlier chapters. There are also incomplete and nonstandard references, which makes it difficult to trace the source. Overall, the editing could have been done more carefully. Scientifically, the book lacks clarity on certain issues and there are also some factual mistakes. It gives the impression that no distinction is made between the changes seen in the current climate and the future projections due to different scenarios of climate change. There should have been a separate chapter entirely devoted to the uncertainties in climate change and their projections.

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