CLIMATIC AND HYDROLOGICAL ATLAS OF NEPAL

International Centre for Integrated Mountain Development
Kathmandu, Nepal
1996

Printed at:
Nepal Lithographing Co. Pvt. Ltd.
Goldhunga (Balaju), Kathmandu, Nepal.
Tel: 227975 Fax: 413641

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International Centre for Integrated Mountain Development
GPO Box 3226, Kathmandu, Nepal

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ISBN 92-9115-600-0

Published by
International Centre for Integrated Mountain Development
GPO Box 3226, Kathmandu,
Nepal

Typesetting at ICIMOD Publications' Unit

Climatic and Hydrological Atlas of Nepal

A Project Undertaken by ICIMOD under Its Programme on Landslide Hazard Management and Control with the Assistance of the Government of Japan

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Abbreviations

DHM	Department of Hydrology and Meteorology
HMG/N	His Majesty's Government of Nepal
ICIMOD	International Centre for Integrated Mountain Development
MENRIS	Mountain Environment and Natural Resources' Information Service
UTC	Universal Time Coordinated (Equivalent to GMT)
WMO	World Meteorological Organisation

Foreword

Climate plays a very important part in the life of the people, particularly in the harsh and high mountain environments and hilly slopes of the Hindu Kush-Himalayas (HKH). Apart from its influence on agricultural and sociocultural practices, it also acts as a cyclical triggering factor for various natural disasters in the mountains. Whether as a causative factor in Glacial Lake Outburst Floods in the higher altitude snowy regions, or in landslides and debris flows in the middle hills or floods in the lower basins, climatic factors play a very important role. These disasters cause regularly widespread damage to life and property all over the HKH and also destroy vital infrastructure such as roads, bridges, and power plants built at substantial cost. For both agriculture and tourism, which are so important for the people and economy of the region, climate is of critical importance too. The wide climatic variety in this region, both from south to north and from east to west, contributes also to its great biological and ecological diversity.

Recently, the frequency of occurrence of extreme weather events has been found to be on the increase in these mountains. Again, one of the principal climatic parameters - viz., precipitation and its seasonal character, greatly influences the hydrological regimes of the glaciers, rivers, and streams and determines the degree of availability of water in different seasons.

Both climatic and hydrological information are equally important and indispensible for planning for and development of agriculture, modern infrastructure, and tourism. Thus, for all of us engaged in the search for ecological and economically sustainable development of the HKH mountains as well as sustainable options for better livelihoods for the people inhabiting these mountains, the importance of climatic and hydrological information cannot be overemphasised.

Since its inception, ICIMOD has been promoting the development of a better understanding of natural hazards. Various activities have been completed so far, and these include several training programmes dealing with mountain risk engineering, focussing on improving road construction along unstable mountain slopes, and reviews of landslide hazard management activities in China, India, Nepal, and Pakistan.

One of the goals set by ICIMOD in its Regional Collaborative Programme for the Sustainable Development of the Hindu Kush-Himalayas under its Mountain Natural Resources' Programme is to improve the conditions of mountain resources and environments through various programme activities including:

- a better understanding of mountain hazards and identification of mitigation measures; and
- a better understanding of mountain climatic changes.

ICIMOD's programme on "Landslide Hazard Management and Control" focusses on these concerns and the relationships between mountain climate, mountain hydrology, and natural hazards in the Hindu Kush-Himalayas. This programme, which was developed on the basis of the previous activities of ICIMOD in the field, has received support from the Government of Japan since the end of 1993.

The unprecedented intense rainfall that took place during July 1993 caused a terrible disaster in south-central Nepal. ICIMOD undertook a field study of this disastrous event. The results of this study were presented at a special workshop in November 1993 in which the National Planning Commission and key institutions from Nepal concerned with natural hazards participated. One of the major recommendations of this national workshop was the need for ICIMOD to prepare a Climatic Atlas for Nepal, and this provided the main incentive for producing this Atlas.

The Atlas is the result of fruitful and close collaboration between ICIMOD and the Department of Hydrology and Meteorology (DHM) of the Ministry of Water Resources of His Majesty's Government of Nepal and the Central Department of Meteorology of Tribhuvan University, Nepal. All the relevant data for its preparation were made available by DHM and both the institutions also made available the services of their experts for this project.

This work is also an example of inter-divisional collaboration between different divisions and services of ICIMOD. It was undertaken by the Mountain Natural Resources' Division of ICIMOD within its programme on Mountain Risks and Hazards and Mountain Hydrology and Climate Change under the project on Landslide Hazard Management and Control. The Mountain Environment and Natural Resources' Information Service (MENRIS) provided all the technical inputs for preparation and printing of the maps. The financial support of the Government of Japan is gratefully acknowledged. The Mountain Environment and Natural Resources' Information Service (MENRIS) of ICIMOD provided all the technical assistance for the analysis of data (furnished by the DHM and other line agencies in Nepal). MENRIS also carried out the spatial analysis that has been presented in the form of maps which can be visualised as an excellent representation of the existing information in a comprehensive manner. It is hoped that such visualisation can be widely used for planning the use of natural resources for sustainable development.

Considering the multifarious needs of climatic and hydrologic information for various sectors and development activities, it is hoped that this Atlas will be a useful addition to the knowledge and information on the climate and hydrology of Nepal. Hopefully, it will serve as a useful guide and reference material not only for planners and technical experts but also for general readers who are interested in the climate and hydrology of Nepal. It is also hoped that it may help to reduce the impact of extreme weather events on life and property.

Thanks are due to all those who worked in various capacities to complete this Atlas. Any comments and suggestions for its improvement are most welcome and will help us to improve this and similar work undertaken for other countries of the Hindu Kush-Himalayas.

Egbert Pelinck
Director General

Preface

This Atlas has two sections. The first section contains the climatic maps and diagrammes. A brief introduction to these two sections follows. Explanatory notes on each thematic map and chart for each section are provided at the end. For easy reference, a transparency with district boundaries and major towns and cities is provided with this Atlas. This is placed in a folder inside the back cover.

All the meteorological and hydrological data were made available by the Department of Hydrology and Meteorology of the Ministry of Water Resources of His Majesty's Government of Nepal.

Climate, in general terms, is the summary of the day-to-day weather in any place or region which affects the daily life of the inhabitants. In a country like Nepal, dominated by mountains, the study of climate requires access to records of meteorological parameters and networking among many stations over a long period of time. According to the World Meteorological Organisation (WMO), a standard average of 30 years of continuous records is considered normal. Unfortunately, only a few stations in Nepal have records for such a long period of time, mainly due to the topographical and also, of course, owing to the economic constraints. Natural phenomena such as droughts, floods, heat waves, and cold spells can only be studied with reference to climatic norms. Such studies are important in planning for the socioeconomic development of the country.

In this atlas, available data based on meteorological parameters, such as temperature, precipitation, relative humidity, duration of sunshine, and frequency of fog, are used to prepare the climatic maps and diagrammes. The database used here includes climatic data for some stations commencing in 1947 and ending in 1990. The period for which records are available for different meteorological parameters is not the same for all stations. For example, for the precipitation maps the number of stations used is 264 with records for more than five years. It is to be noted that, among these, there are 13 stations with records going back less than 10 years. According to the WMO standard, precipitation records for 30 years or more are needed to prepare a normal climatological map for precipitation. In Nepal, there are only 89 stations with precipitation records going back 30 years and more. Therefore, to produce a spatially normal climatological map, many other stations with records going back less than 30 years have been included. This scarcity of data is evident in all other meteorological parameters. As mentioned in the explanatory notes, in preparing maps some compromises have been made between the number of stations and the number of years of record, without, of course, losing the main characteristics of the parameters.

In the case of temperature, which is in general controlled by variables such as elevation, latitude and longitude, a model has been developed so that temperature can be generated from information about the elevation, latitude, and longitude. This aspect has been covered in the explanatory notes.

In preparing the climatic maps, actual averages are used, except in the case of temperature for which the data generated, as mentioned above, are being used.. During the computer analysis and mapping procedures, software packages such as Win-surfer and GIS-arc/info were used. The Programme Win-Surfer was used for the preparation of a digital surface that could generate regions for various climatic and hydrological parameters, e.g., temperature, precipitation, humidity, sunshine duration, and fog frequency. The GIS analysis was carried out using the work-station version of ARC/Info on an IBM RISC 6000 platform which involved integration of such digital surfaces with relevant attribute data. Finally, the automated maps thus prepared were printed using the latest Tektronix Colour Printer.

In the hydrologic section, the availability of data is still more limited. Prior to 1960, very little work on hydrology was carried out in Nepal. The Swiss Mission had collected data for the Rosi Khola at Panauti. The Government of India had collected data for the Trisuli River at the proposed power site, for the Koshi River at Barahkshetra, and for the Sarada River at Banbasa. However, the data were only available for those agencies that collected the data.

Detailed hydrologic surveys and investigations began on November 17, 1960, following an agreement between His Majesty's Government (HMG) and the United Nations Development Programme. A systematic hydrological data collection network was established in 1962, following an agreement between HMG and the United States Agency for International Development (USAID). This marked the beginning of the establishment of the present Department of Hydrology and Meteorology.

Thus, Nepal has a relatively short history in the field of hydrology. A systematic hydrologic data collection network was introduced only in 1962, the main obstacles being remoteness of gauging sites and economic constraints. Because of data constraints, the hydrologic section of the climatic atlas, therefore, consists of maps and figures that give general information only for some drainage basins and rivers.

The river network map shows the main catchment boundaries and regularly operating stations, including stations that have been operating for at least ten years. River characteristics such as: i) hydrographic schemes for three major river systems, ii) drainage density, iii) monthly distribution of flow for different types of rivers, iv) water availability for rivers on an annual as well as on a seasonal basis, and the v) average monthly flow and average annual flow for major rivers are included. The water balance is presented for some typical stations only.

High and low flows are also important hydrologic information for planning water resources' projects. The flow duration curves for typical Himalayan rivers like the Karnali have been presented. Estimated and recorded high flows in Nepal have been plotted on envelope curves together with those from other regions of the world for comparison. Flood frequency curves have also been presented for some rivers. Rivers at higher altitudes and those originating in the Siwalik ranges have not been included due to inconsistency in data.

In both sections, individual maps do not provide information on the location of towns, districts, or prominent peaks. A transparency containing this information has been provided, and it can be overlaid on all the maps; it is placed in an envelope inside the back cover.

This work took longer to complete than anticipated. This was due to the fact that colour schemes were revised following comments and suggestions received on the first draft. It is hoped that colour schemes will be further improved in the next edition.

In addition to the principal members, the project team also consisted of other experts and individuals without whose contributions and inputs this Atlas could not have been completed. Mr. Kiran Shankar Yogacharya, presently Director General, Department of Hydrology and Meteoroogy, Nepal, provided substantial inputs in the preparation of the hydrological section of the Atlas. Similarly, Dr. Bidur P. Upadhyaya, Professor and Head, Central Department of Meteorology, Tribhuvan University, Kathmandu, has also contributed significantly to the hydrological section of the Atlas. Mr. Lochan M. Acharya, presently Deputy Director General, Department of Hydrology and Meteorology, Nepal, has contributed to the Climatic Section. Messers Ratna P. Nayaju, Mani R. Chitrakar, Sarju Baidya, Ramesh K. Regmi, Gautam Rajkarnikar, and Ms.Samita Shrestha of the Department of Hydrology and Meteorology also provided inputs to the preparation of this Atlas. Mr. Govind Joshi of MENRIS, ICIMOD, provided excellent support in computer processing throughout the work period.

For most of the project team members, it was a learning process in working together, as the team consisted of members drawn from various institutions, most of whom were not on a full-time basis, and the demands of parent institutions could not be ignored. However, the lessons have been valuable and all the members of the project team have contributed their best to complete this work. It is hoped that this Atlas will be of some use not only to planners and development practitioners engaged in the development of Nepal, but also to researchers and students interested in the climate and hydrology of Nepal. Comments and suggestions for improvement are expected from readers and will be incorporated in the next edition.

Suresh R. Chalise
Project Team Leader

Acknowledgements

This project was undertaken with financial assistance from the Government of Japan. The excellent support and cooperation from His Majesty's Government of Nepal, Ministry of Water Resources, Department of Hydrology and Meteorology, and Tribhuvan University, Department of Meteorology, throughout the project period in providing the necessary data and the services of their experts and staff were critical to the successful completion of this project. Thanks are due to the members of the Advisory Committee who provided valuable inputs and guidance at all stages of the Project. Thanks are also due to Dr. Harka Gurung, Director, Asia and Pacific Development Centre (APDC); Prof. M. S. Manandhar, Head, Central Department of Geography, Tribhuvan University; and Dr. M. Spreafico, Swiss National Hydrological and Geological Survey for reviewing the Atlas and providing their valuable comments and suggestions for its improvement. Thanks are also due to Dr. Rolf Weingartner, Department of Geography, University of Berne, for his valuable comments and inputs during the course of the preparation of this Atlas.

The project could not have been completed without the encouragement and valuable inputs and advice from Mr. Egbert Pelinck, Director General, and Dr. Mahesh Banskota, Deputy Director General of ICIMOD. Suggestions and comments from all the professional staff of ICIMOD were available during the preparation of this Atlas and specific comments from Mr. Hubert Trapp (MENRIS) and Mr. P. B. Shah (MNR) were helpful in finalising it. Thanks are also due to Mr. Narendra Khanal, Lecturer, Central Department of Geography, for his comments and suggestions at various stages during the preparation of this document.

Mrs. Reeta Rana and Mrs. Sarita Joshi of MNR Division, ICIMOD, provided secretarial support with patience and speed during the preparation of this document. The Publications' staff of ICIMOD's Documentation, Information, and Training Service looked after the editing and preparation for printing.

The project has also benefitted from the comments and suggestions from several experts from Nepal and abroad whose names are not mentioned but to whom grateful thanks and acknowledgement are due.

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