1. Introduction

There are five chapters in this discussion paper, the first four describe a particular aspect of the hydrological and meteorological components in the People and Resource Dynamics' Project (PARDYP). The fifth chapter is a short conclusion.

Chapter 1 introduces the PARDYP project in general terms of background, objectives, *modus operandi*, and complexity, and then proceeds to define the hydrometeorological component in somewhat more detail, focussing on questions posed by the project document.

Chapter 2 describes the hydromet measurement network in terms of the design philosophy and as it exists in the Yarsha *Khola* watershed in Nepal.

Chapter 3 covers the data handling procedures, and describes the types and frequency of measurement recorded at the field stations, the important role played by the field teams maintaining the stations and recording the results, and the means through which quality data collection, recording, management, and storage are ensured.

Chapter 4 is the longest chapter; it tackles the challenges facing project staff in the analysis of all the results collected from the PARDYP research networks – networks which cover five watersheds in four countries. In Chapter 4, both the theory and practice of analysis are covered in the context of PARDYP. Four levels of analysis are presented, described, and discussed – data compilation, disciplinary analysis, watershed synthesis, and regional synthesis. Sub-sections describe the analytical tasks that need to be carried out at each of the four levels.

Chapter 5 is a short conclusion to the discussion paper.

1.1 Objectives and Challenges of Pardyp

This chapter provides a general introduction to the PARDYP project and then focusses on the questions related to the hydrological and meteorological elements which are posed by the project document. The Pardyp project (people and resource dynamics in mountain watersheds of the Hindu Kush-Himalayan region) officially started in October 1996. It evolved from two successful ICIMOD projects: 'Mountain Resource Management' and 'Rehabilitation of Degraded Lands in Mountain Ecosystems'. The present project is jointly funded by the Swiss Agency for Development and Cooperation (SDC), the International Development Research Centre (IDRC) of Canada, and ICIMOD.

The Pardyp-project is a highly interdisciplinary exercise with a wide thematical framework. According to the project document (ICIMOD 1996), the project goal is 'to further improve the understanding of environmental and socioeconomic processes associated with degradation and rehabilitation of mountain ecosystems and to generate wider adoption and adaptation of proposed solutions by stakeholders in the HKH'.

The overall objective of Pardyp is 'to provide a basic understanding of natural resources' degradation processes and to recommend proven strategies and programmes for community - and farm - based prevention of degradation, and rehabilitation of natural resources in the HKH

region'. In view of the very broad formulation of the project objective, it is evident that many disciplines, from the physical as well as from the social side, are involved: geology, geomorphology, meteorology, hydrology, soil and water conservation, soil sciences, forestry, agronomy, socioeconomics, etc. Furthermore, a number of different methods has to be combined in order to achieve the goals: measurements, interviews, PRA, mapping, GIS, conservation activities, rehabilitation measures (Fig. 1), training, etc. With all these issues involved, PARDYP is a watershed management research as well as a development project.

Figure 1: The Rehabilitation Site in Kubindegaun, Jhikhu *Khola* Watershed, Nepal (photo: March 1998)

PARDYP operates in five watersheds in four of ICIMOD's partner countries along a west-east transect through the Himalayas (Fig. 2): Pakistan (Hilkot-Sharkool watershed, Manshera district, see Fig. 3), India (Beta Gad-Garur Ganga watershed, near Almora), Nepal (Jhikhu *Khola* watershed, Yarsha *Khola* watershed), and China (Xi Zhuang watershed, Western Yunnan Province in Baoshan County). All these watersheds are located in the Middle Mountains of the Himalayas where the pressure on the natural resources is, in places, very high (Fig. 4). The altitude of the watersheds roughly ranges from 1,000 to 3,000masl and the size from 30 to 100sq.km. In each country a local team is responsible for all the project operations in the respective watershed.

In view of the interdisciplinary focus of the project as well as the number of watersheds involved, the comparability of data collection and outputs in the different disciplines and the different watersheds is very important and a big challenge. To achieve this goal, common concepts, methodologies, and procedures for data handling as well as analysis have to be developed. Such common methodologies are a condition for comparing the different watersheds with each other and for streamlining the project synthesis.

This discussion paper concentrates on the hydrology and meteorology components of the project. It provides guidelines for focussed, transparent data collection and analysis which is driven by the wide range of topics required to achieve the project goals. In addition, the document discusses the contribution of hydrology and meteorology to the overall aims of PARDYP. Finally, it provides ideas and strategies for the synthesis of PARDYP from the viewpoint of hydrology and meteorology. The discussion paper provides general guidelines for the hydrological and meteorological activities; certain elements may have to be adapted to the specific conditions of an individual watershed. The paper is based on one and a half years' experience of the PARDYP project. Its content may be modified or revised in future. Created originally as a

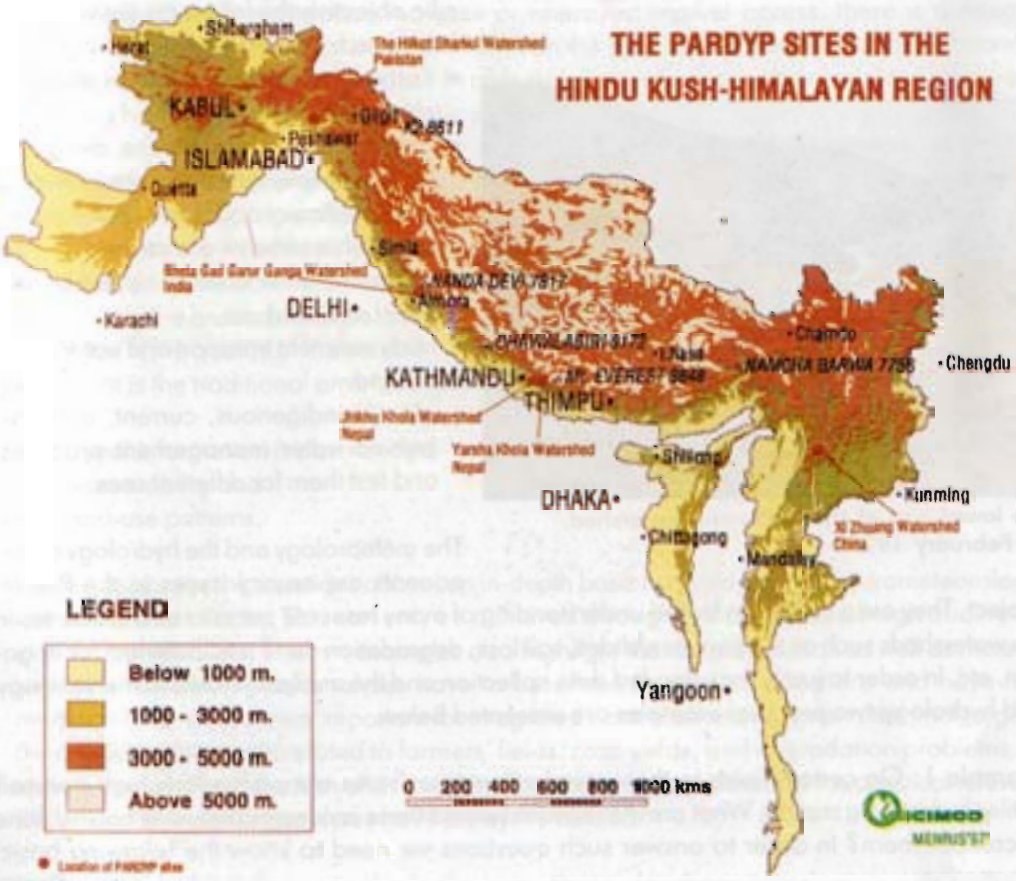

Figure 2: The PARDYP watersheds in the Hindu Kush-Himalayan Region (source: ICIMOD, 1997)

strategy document for PARDYP, this discussion paper may be useful also for other projects related to integrated watershed research and management.

1.2 The Hydrology and Meteorology Component of Pardyp

The first listed output of PARDYP as recorded in the Project Document concerns hydrology and meteorology and specifies the generation of relevant and representative information and technologies about water balance and sediment transport related to degradation on a watershed basis (ICIMOD 1996). Under this spe-

Figure 3: Landscape in the Hilkot Watershed, Pakistan (photo: October 1996)

Figure 4: The lower part of the Xi Zhuang watershed, China (photo: February 1998)

cific objective the following activities are formulated:

- carry out resource inventories of watershed areas,
- determine and update the design of hydrometeorological stations including water sediment and quality monitoring,
- establish a network of stations,
- determine water balance by season and event and land use,
- study sediment transport and water quality, and
- identify indigenous, current, and improved water management practices and test them for different uses.

The meteorology and the hydrology components are crucial issues in the PARDYP project. They are a condition for the understanding of many resource patterns and processes in the watersheds such as erosion, landslides, soil loss, degradation, land use, potential for irrigation, etc. In order to justify the extended data collection and the analysis related to meteorology and hydrology, two practical examples are presented below.

Example 1: On certain fields in the watershed, erosion rates are particularly high and soil fertility is declining rapidly. What are the reasons behind these processes and what can be done to combat them? In order to answer such questions we need to know the following basic information:

- which fields are particularly affected?
- how much soil is eroded?
- which time of year is the most critical for erosion? and
- what is the cropping pattern and agricultural practice on the respective fields?

Information from hydrology and meteorology:

- how much runoff/nutrient loss is occurring (per season, per event)?
- what are the critical rainfall intensities? and
- from which areas is the sediment output particularly high?
- which areas in the watershed might be similarly prone to soil erosion, based on the rainfall patterns?

and information from other components:

- aspect and slope,
- geology,
- soil types,
- land-use patterns, crop rotation,
- vegetation types, and
- results of trials against degradation processes.

Example 2: Due to population increase or improved market access, there is a need for extension and intensification of irrigation. How can this goal be achieved without overexploitation and degradation of water resources? In order to answer such questions we need to know the following hydrological and meteorological facts.

- What is the spatial and temporal pattern of rainfall?
- How are the hydrographs characterised on an annual as well as on a seasonal basis?
- When are the flood flows and the peak flows?
- What does the water balance look like?
- What is the groundwater potential and where are the major recharge areas?
- What is the quality of the water?
- What is the traditional arrangement for water use and what is the system of water rights?

Additional information is also needed - this concerns components of:

- slope stability and
- land-use patterns.

In order to answer the questions above, an in-depth basic knowledge of the hydrometeorological processes is necessary. This can only be achieved through the collection of high quality data and through analysis. The two examples also highlight that data collection as well as meteorological and hydrological analyses have to be driven by applied questions and have to be related to other parameters important for integrated watershed management: the final targets of the project activities are related to farmers' fields, crop yields, and degradation problems. The reasons behind the collection of different hydrometeorological data and the practical relevance and implications of the analyses have always to be clear.

As PARDYP operates in five watersheds, the importance of hydrometeorological data collection and analysis in a specific watershed goes far beyond this particular watershed. The results provide information on the processes and key issues in the Middle Hills of the Himalayas in an east-west transect in general, and they contribute to the understanding of mountain ecology. In this light, PARDYP is an important element in the implementation of Chapter 13 of the Rio Agenda which is concerned with sustainable mountain development (UNCED 1993).