Annex 1
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Annex 2
Programme

Regional Workshop on the
Hydrology of the Hindu Kush-Himalayan Region
Venue: ICIMOD Conference Hall, Jawalakhel

Day 1 - 23 March 1996 (Saturday)

Inaugural Session

8:30	Registration	
9:05	Welcome Address:	Mr. Egbert Pelinck Director General
9:15	Background to the Workshop:	Mr. Kiran Shankar Yogacharya
9:20	Address by:	Mr. L.A. Mandalia, UNESCO Representative
	Address by:	Dr. Z.W. Kundzewicz, WMO Representative
	Address by:	Prof. A. Herrmann, Representative German IHP/OHP Committee
9:30	Inauguration & Inaugural Address by the Chief Guest:	Dr. D.N. Dhungel, Secretary, HMG/N Ministry of Water Resources
9:40	Vote of Thanks:	Professor S.R. Chalise ICIMOD
9:45	*Refreshments*	

Session 1

10:15	Background to the Regional Working Group on Mountain Hydrology	S.R. Chalise
10:30	Report of the July 1995 Preparatory Meeting	L.A. Mandalia
10:45	The FRIEND Project: Conceptual Background	A. Gustard
11:30	Some Prospects of the Proposed FRIEND-HKH	A. Herrmann
11:50	Discussions	
12:05	Proposed FRIEND-type Project for the HKH	K.S. Yogacharya
12:45	Discussions on the Proposed FRIEND-Type Project	
13:00	*Lunch Break*	

Session 2

14:00 Continued:

a) Responses by Representatives of the HKH Countries (Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan)
b) Responses by Representatives of Collaborating Institutions (WMO, German IHP/OHP Committee GRDC, Slovak IHP/OHP Committee)
c) General discussions

15:30 *Tea*

16:00 Discussions and Finalisation of the FRIEND-Type Project Proposal

Day 2 - 24 March 1996 (Sunday)

Session 3

09:00 Discussions and Finalisation of Recommendations for the Implementation of the Hindu Kush-Himalayan FRIEND Project

a) Project Implementation: Identification of Priority Activities
b) Regional Working Group Membership
c) Project Secretariat

10:45 *Tea*

Session 4

11:00 Concluding Session

Chairman: Mr. Egbert Pelinck
Director General

Endorsement of Recommendations for Launching the Hindu Kush-Himalayan FRIEND

Annex 3
Proposal for Launching a FRIEND Project for the Hindu Kush-Himalayan Region

Submitted by
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Proposal for Launching a FRIEND Project for the Hindu Kush-Himalayan Region

Background

The FRIEND (Flow Regimes from International Experimental and Network Data) Project is a contribution to the International Hydrological Programme (IHP) of UNESCO to facilitate research on understanding the hydrological behaviour of river basins located in different regions. FRIEND Projects are active in western, northern, and central Europe; the Mediterranean region; and western and southern Africa. The FRIEND Project is strongly supported by Phases IV and V of the IHP/UNESCO.

A preparatory meeting to launch a FRIEND Project for the Hindu Kush-Himalayan Region was held from 18 to 20 July, 1995, in New Delhi under the sponsorship of UNESCO, the International Centre for Integrated Mountain Development (ICIMOD), and the German IHP/OHP[1] National Committee. Delegates from Afghanistan, Bangladesh, China, Myanmar, and Nepal attended the meeting and agreed unanimously to launch a FRIEND Project for the Hindu Kush-Himalayan Region. The delegates then worked out a preliminary proposal. An interim working committee to finalise the proposal was also constituted by the meeting. The committee is comprised of Mr. Kiran Shankar Yogacharya (Interim Coordinator), Professor M.F. Bari (Interim Member), Mr. Ji Xue Wu (Interim Member subject to the approval of the Chinese Government), Professor S.R. Chalise (ICIMOD), Professor A. Herrmann (German IHP/OHP National Committee and European FRIEND), and Mr. L.A. Mandalia (UNESCO Secretariat).

The meeting also decided that the proposal would be circulated to the member countries for their comments and suggestions by 30 November, 1995. This proposal was formally presented at the Regional Workshop held in Kathmandu from 23 to 24, March, 1996. The workshop approved the principle of the project and authorised Mr. K. Shankar Yogacharya to continue as Interim Coordinator until the project proposal is finalised. The draft proposal presented at the workshop is given below. This proposal will be amended and refined according to the directives and suggestions of the participants at the workshop.

The Hindu Kush-Himalayan Region

The Hindu Kush-Himalayan region is a mountain range, 3,500km in length, stretching from Afghanistan in the west to China and Myanmar in the east. Developmental processes over the past few decades involved intensive use of natural resources and improper planning and management, resulting in rapid degradation of resources. Thus, the region is facing ecological and developmental problems along with widespread and deep-rooted poverty.

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[1] OHP means the Operational Hydrology Programme of the World Meteorological Organisation (WMO)

Natural factors that are causing land degradation in the mountains consist of steep slopes, unstable geology, floods, droughts, high speed winds, heavy precipitation, and so on. Among the several natural resources, water is one of the most important. In mountainous areas such as the Hindu Kush-Himalayan region, there is a great potential for developing and harnessing water resources, especially in the form of hydropower. This region is very rich in water resources. But to plan for development activities, hydrological data and information are needed on a long-term basis. This means that long-term hydrological investigation is essential before actual planning and designing of a water resources' development project takes place. To this effect, every country has some form of activity for collecting hydrological information. But, there is no mechanism among the countries of the region for exchange, even for the limited data and information available.

Rivers and river basins do not follow the national boundaries. Rivers may flow through more than one country. It is more significant to understand the hydrological complexities of such rivers and river basins on a catchment basis. Hence, the importance of regional collaboration in studies to understand the flow regimes of such rivers needs no explanation. It is too difficult to undertake such studies on a larger scale due to several limiting factors. It is, therefore, proposed that some small experimental catchments of the region for study under a FRIEND Project be selected in order to cover different physiographic and climatic zones of the region.

Name of the Project

The suggested name of the project is the 'Hindu Kush Himalayan Flow Regimes from International Experiment and Network Data' with the abbreviation 'HKH FRIEND'.

Objectives

The general objective of the HKH FRIEND project is to create a common database in the Hindu Kush-Himalayan region to facilitate research into the hydrological behaviour of representative river basins located in different physiographic and climatic zones. On completion of the project, the common database will be made accessible to all the participating countries, thereby providing a valuable resource for future hydrological studies, particularly when data from two or more HKH countries are required.

The specific objectives of the project are enlisted below.

- To monitor the existing institutional framework and research project within the field of HKH FRIEND
- To locate all the hydrological and meteorological stations which could be incorporated into the HKH FRIEND project framework on a suitable common map
- To bring together existing datasets and catchment characteristics from the participating countries of the region
- To identify areas in which new hydrological and meteorological stations need to be established or existing ones rehabilitated with the aim of covering different physiographic and climatic zones of the region
- To analyse the database in order to develop procedures that will enable

local staff to estimate flood frequency and low flow relationships throughout the region
- To analyse snow/glacier melt contributions
- To use and develop rainfall-runoff models that will form a basis for more detailed design studies and to address problems of the impact of change in land use
- To train local staff in the above-mentioned fields

Participating Countries, Cooperating Organisations, and the Regional Centre

The Hindu Kush-Himalayan Region consists of eight countries, namely, Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. Out of these countries, five countries who participated in the July 1995 meeting have agreed to launch a FRIEND Project in the region. It is hoped that the remaining countries will also participate in the Project. All these participating countries seem to have similar central agencies to the Department of Hydrology and Meteorology of His Majesty's Government of Nepal (DHM/HMG). These agencies collect, systematise, and publish hydro-meteorological data and information. It is envisaged that these agencies and non-government agencies will cooperate to provide data to the Regional Centre and to facilitate the establishment of new hydrological and meteorological stations or rehabilitation of the existing ones that are appropriate for the project to study.

The most appropriate body for the Regional Database Centre is the International Centre for Integrated Mountain Development (ICIMOD) in Kathmandu, which has representation from the countries of the Hindu Kush-Himalayan region.

Project Administration

The work of the Secretariat has so far been carried out jointly by ICIMOD and ROSTSCA/UNESCO. Hence, it is suggested that the UNESCO Secretariat for this project should be located at ICIMOD to ensure efficient project coordination and administration. The HKH FRIEND Project will be implemented primarily with financial support from UNESCO under the IHP. It is also expected that ICIMOD, Kathmandu, will be able to find some resources (probably in kind) to support the project. There is also a possibility that the other International Funding Agencies involved in FRIEND-type projects, including the German and Slovak IHP/OHP, can provide some form of assistance.

For project administration, a Secretariat for the Regional Database Centre has to be created. It is envisaged that this Centre will be operated within ICIMOD and will be headed by the HKH FRIEND Project Coordinator.

A Project Steering Committee (PSC), with representatives from the cooperating agencies, will be formed to facilitate collection of the existing datasets at the Regional Database Centre, to provide suggestions, and to provide expert manpower on an as and when necessary basis. The PSC will be responsible for selecting gauging stations/catchments and suggesting establishment/rehabilitation of the stations for inclusion in the HKH FRIEND Project. The PSC will also invite experts engaged in similar FRIEND projects from other regions to its meetings to benefit from their expert advice. A simplified structure for project administration has been proposed as annexed.

The Programme

The HKH FRIEND programme will cover only those basins with catchment areas less than 500sq.km. and should be implemented in the sequence detailed below.

- All the existing hydrological and meteorological stations in the participating countries will be located on a reasonably scaled common map.
- Catchment characteristics of all these stations will be tabulated.
- Selection of basins for inclusion in HKH FRIEND will be made from the existing stations. If these stations are inadequate for the envisaged study, new gauging stations will be established or existing non-functional stations rehabilitated. This will be carried out giving due consideration to coverage of different physiographic and climatic conditions; the network will also include information on snow and glaciers.
- Detailed long-term data of selected existing stations will be collected and analysed. In the mean time, data from newly established/ rehabilitated stations will be collected. Even the short-term data from these stations will be used to complete the analysis. The database will be continuously updated.
- Different existing analytical tools will be used to conduct the analysis; and, based on the analysis, applicable models for the HKH region will be selected and developed.
- By conducting seminars/workshops, the necessary modifications/refinements of analytical techniques and models to be used for estimating hydrological parameters for the rivers of the region will be identified and disseminated to users, particularly in participating countries.

Such a study will require continuous data for at least five years. Considering the paucity of data available in some of the countries of the region, a provision for collecting data from newly established/rehabilitated stations is required. Thus, in the initial phase, the programme should be for a five-year period.

The time required for each of the steps tentatively considered above can be decided at meetings of the Project Steering Committee with the cooperation of experts engaged in similar FRIEND Projects in other regions.

Actions Proposed Prior to the Introduction of the HKH FRIEND Project

To realise the 'HKH FRIEND' project, certain preparatory activities were proposed for implementation between July 1995 and March 1996.

- Collect comments on the proposal from the five countries that have already agreed to participate in the project (by December 1995)

- Secure the consent/comments on the proposal from the three countries of the region that were not represented at the July 1995 preparatory meeting (by the end of December 1995)
- Finalise the proposal by incorporating all the relevant comments (by the end of February 1996)
- Secure approval in principle on the HKH FRIEND Project during the International Conference on Ecohydrology scheduled to be held from 23 to 28 March 1996 in Kathmandu
- Receive nominations for the Project Steering Committee from cooperating agencies from all the countries of the Hindu Kush-Himalayan region (by the end of April 1996)
- Assess the resources and funding for the project
- Continue the formal dialogue with UNESCO and ICIMOD to acquire logistics' and other support to house the Secretariat and Regional Database Centre within ICIMOD
- Appoint a Project Coordinator for the Secretariat

Budget and Detailed Workplan

The total project budget would depend on a number of factors; viz., resource availability, field activities, Regional Database Centre, and the Secretariat. Once the Project Steering Committee is formed, through a series of meetings and/or other types of interaction, a detailed workplan for the project period can be framed and the corresponding budget requirements for the field activities in each of the participating countries estimated.

Apart from this component, there are establishment and running costs for the Secretariat and Regional Database Centre. Since ICIMOD is likely to contribute, the detailed budgetting for this component of the project can be carried out in association with ICIMOD and UNESCO. The salaries and fringe and other benefits for the Project Coordinator and staff of the Secretariat, should be at par with those of ICIMOD staff. Office equipment, stationery, fuel, vehicle, and so on should be similar to those of FRIEND projects in other regions. Also, a lump sum budget will be required to hold the Project Steering Committee meetings.

Initially, a budget estimate and approval will be essential in order to establish and run the Secretariat and Regional Database Centre for one year in the preparatory phase. During this preparatory phase, the first and second steps of the programme, as outlined in this paper, will have to be completed and selection of catchments for inclusion in the project carried out. To do this, the Project Steering Committee meetings of the participating countries should take place more frequently. In addition, the PSC meetings will finalise the detailed workplan and budget for the next five years.

Annex 4
Implementation, Achievements and Further Plans for the Northern European FRIEND Project***

Alan Gustard

Abstract

This paper reviews the development of the Northern and Western European FRIEND (Flow Regimes from International Experimental and Network Data) project since its inception in 1985. The project was established by the International Hydrological Programme of UNESCO in order to improve international cooperation in research in regional hydrology. The paper describes the implementation and organisation of the project which is carried out by a steering committee with support from the project secretariat. Some of the problems associated with developing the project are described in the paper, together with a review of the achievements. A number of opportunities for further research in the areas of hydrological extremes, catchment modelling, and process studies are summarised.

*** *Published in 1995 in the Proceedings of the UNESCO IHP International Symposium on Rivers and People in Southeast Asia and the Pacific - Partnership for the 21st Century, pp 163 - 171. Tokyo: United Nations University.*
Minimal editorial inputs only have been carried out at ICIMOD.

Introduction

The FRIEND - Flow Regimes from International Experimental and Network Data - research programme is an international collaborative study in regional hydrology. It is a recognised contribution to UNESCO's Fourth International Hydrological Programme. The primary objective of the FRIEND project has been to improve the understanding of hydrological variability and similarity across time and space, in order to develop hydrological science and practical design methods. To achieve this, it has been essential to permit hydrological research to cross national boundaries. This has been carried out in two ways. First, by developing international hydrological databases of time series and spatial data, including catchment boundaries, climate, land use, and soil types held in vector or raster form. Second, by establishing project groups that could exchange models and analysis techniques and interpret the results using a common approach to analysing data derived from different hydrological regions. The FRIEND project was initially established in Northern and Western Europe (Figure 1), but groups have now been established in the Mediterranean and Alpine regions of Europe, in Southern Africa, and in West Africa and research programmes are being planned in the Hindu-Kush Himalayan region, in Asia, South America, and the Nile region. This paper reviews the development of the FRIEND project, summarises some of the achievements, and presents a forward look of how the project may develop.

Implementation

The Northern and Western European FRIEND project was initiated by the IHP committees of the U.K., Germany, The Netherlands, and Norway, who seconded full-time scientists for a period of three years to collaborate in an international project group based at the Institute of Hydrology in Wallingford. They were soon joined by hydrologists seconded for shorter periods from a number of European countries, and the project was supported by the provision of hydrological data from all European countries in the project area. The first phase of the project was completed in 1989. At this stage the database contained river flow data from 1,350 gauging stations from 13 countries in northern and western Europe. The second and third phases of the project have extended the geographical area to eastern Europe and increased the database to over 4,000 flow records from 17 countries.

FRIEND research is carried out by five individual project groups with approximately ten participants from different European countries in each group. The five projects established are:

- Database,
- Low Flows,
- Large-scale Variations in River Flow Characteristics,
- Techniques for Extreme Rainfall and Runoff Estimation, and
- Processes of Streamflow Generation in Small Basins.

These projects are overseen by the FRIEND Steering Committee which meets annually and is made up of country representatives, nominated by

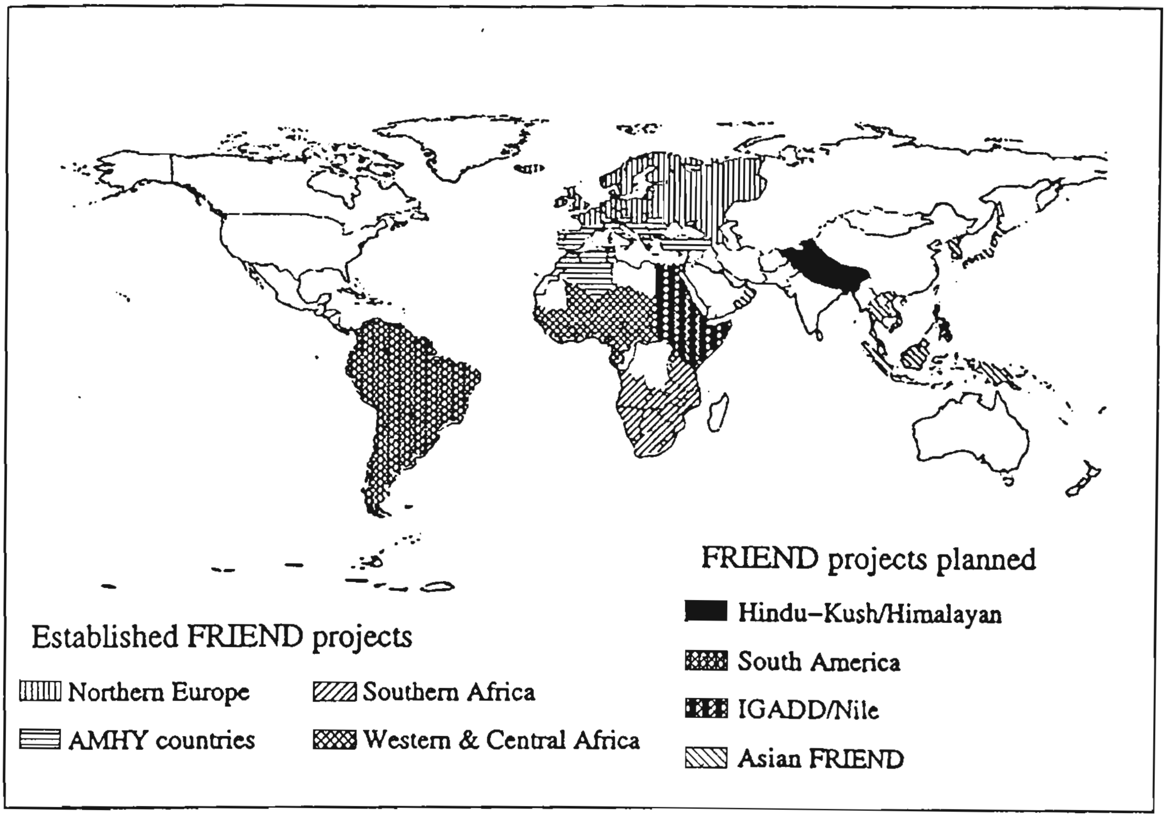

Figure 1: Global Perspective of FRIEND participation

national IHP committees, and representatives from UNESCO, WMO, GRID (the Global Resource Information Database of the United Nations Environment Programme [UNEP]), and the European Environment Agency. The project secretariat is based at the Institute of Hydrology and coordinates the activities of the project groups and provides administrative support to the steering committee.

Results of the FRIEND project have been presented in the proceedings of two conferences. The first was held in Norway in 1989 and was published in IAHS Publication No. 187 (Roald et al. 1989), the second was held in Germany in 1993 and published in IAHS publication No. 221 (Seuna et al.), a three-volume report has also been published (Gustard 1993). Key achievements of the project are summarised in the following passages.

Difficulties in Project Implementation

The establishment of the FRIEND project requires a lead organisation. The lead organisation introduces the project and solicits the support of at least two other countries in order to develop an international research programme. It is often this first step which is the most difficult stage in the project, because it requires a financial and resource commitment from one country to a project which is dependent for its success on the active participation of other agencies. This is often perceived as a high risk in an environment where funds for hydrological research are limited. The second key difficulty is that of data security. The policy which has been approved by each international FRIEND group is that the common international database can only be used within the FRIEND project. There are understandable concerns that the transfer of part of a national data archive to a coordinating centre leads to a loss of control in terms of who has access to the data. Despite these early concerns, participating countries have contributed extensively to the database and safeguards on data security have been maintained over ten years. A third problem which must be addressed is that of agreeing on a common work programme using or developing common methods or models of analysis. There is also a need for good communications within project groups. This can be difficult if there are linguistic problems, and, if project groups include several members, there is an inevitable administrative overhead of communicating between FRIEND participants, in addition to that of supporting a steering committee. Finally, and inevitably, the resources available for the project will limit project activities, although resources from related ongoing national research programmes can be used to support the project.

Achievements of the FRIEND Project

The European Water Archive

A key achievement of the FRIEND project has been the development of an international hydrological database by collecting flow data from over 4,000 small research basins and national network stations from northern and western Europe. In addition, an inventory of catchment characteristics has been compiled using digital cartographic techniques by overlaying basin boundaries on vector and grid thematic databases. The European Water Archive has been a major focus of the project, initially in data archiving and subsequently in data analysis. Station details, flow statistics and time series' data are now held on an ORACLE database management system, while the vector and grid thematic data are held on an ARC INFO Geographical Information System.

Catchment and Regional Modelling of Low Flows

The low flow investigations have ranged from physically based and conceptual modelling studies to multivariate low flow studies on regional and European scale. The groundwater modelling studies identified the importance of catchment hydrogeology in controlling the detailed spatial variation in low flows. Simple distributed models and single cell models have been used to show that there is no dominant model parameter controlling low flows, and they were also used to assess the impact of groundwater pumping on low flows. The impact of coniferous afforestation was evaluated by using two different rainfall runoff models, both of which demonstrated a decrease in the mean and low flows following afforestation.

The detailed modelling studies of individual catchments were complemented by three regional investigations. In the U.K., a twelve class classification of soils was used to predict the mean of the seven-day annual minima and the flow duration curve at the ungauged site. In southwest Germany, a hydrogeological index was developed from a knowledge of the hydrogeology of different rock types. This was based on 14 classes (compared to 12 in the U.K.) using observed flow data from 58 catchments and enabled a method to be developed for estimating base flow at ungauged sites. In order to develop a consistent procedure on the European scale, a digital European soil map was classified into nine groups and related to the Base Flow Index (BFI), the 95 percentile from the flow duration curve, and the 10- and 180-day mean annual minima.

Large-scale Variations in River Flow Characteristics

The overall objective of this sub-project was to define and map spatial and temporal patterns in river flow regimes in northern and western Europe. Work focussed on the definition of representative flow regimes, the presentation of runoff data on a grid, and the examination of temporal patterns in flow regime class and seasonal runoff volumes. Two different approaches have been adopted in the project to present average annual runoff on a grid framework. The first was based on objective methods for statistical interpolation along a river network, by analogy with the procedures used to interpolate meteorological observations. Several variants of this approach were examined using data from southern Norway. The second approach was based on producing a 'mosaic' map of runoff depth by catchment area and superimposing a regular grid to calculate grid cell averages. This approach was implemented using data from western Europe. A map of average annual runoff for the whole of Europe at a resolution of 0.5 × 0.5 was also produced, using a range of methods.

Floods

Both flood frequency analysis and rainfall/runoff analysis methods of flood estimation were reviewed in the FRIEND project. The index flood method seems basically to be a sound and robust approach, provided homogeneous regions can be established. This method is not very sensitive to change in estimation methods and yields comparable results for climatically similar regions in Norway and Britain. It can be difficult to apply in boundary zones between regions. Both Czech and Norwegian experiences indicate that estimating flood statistics by regression on catchment characteristics alone can lead to large errors. French methodology for flood estimation has for a long time been based on a combination of rainfall and runoff flood frequency analysis. The AGREGEE development of the traditional GRADEX method yields smoother and more plausible growth curves. The choice between possible transition models from the observed flood frequency growth curve to the asymptotically limiting rainfall growth rate is primarily based on considerations of the robustness and stability of the results.

Physical Processes of Streamflow Generation in Small Basins

The project is developing closer links between field workers and physical hydrologists and mathematical modellers. It is very important that contact be encouraged between those whose work is 'data-driven' and those whose approach is rather more conceptual. The development of models (and the correct interpretation of their results) requires a proper understanding of the physical processes operating in the system of interest. Similarly, there is little point in site-specific empirical studies without the development of conceptual (even if not mathematical) models of the processes operating and how they change and interact. It is hoped that the inventory of small research basins, which was published in the FRIEND report, will stimulate a more integrated approach to research basin studies.

Directions for Further Research

Low Flows

There is a need for further research to improve understanding of the interaction between hydrogeology and low flows. It is proposed that groundwater models be applied to a number of catchments with contrasting climate, land use, soil type, and hydrogeology, using observed precipitation, evaporation, streamflow and estimated transmissivity, and storativity. A subsequent sensitivity analysis would enable a better understanding of the dominant processes which influence the low flow regime of rivers in different climate and hydrological regions. Improvements in indexing the influence of storage characteristics (hydrogeology and lakes) on low flows is one of the main areas of research which will lead to improvements in relating low flows to basin properties and enable practical design techniques to be used with greater confidence. Although studies of the impact of land-use change on streamflow response has been a major research area, the further extension of this work to provide design techniques for estimating the impact of afforestation on low flows is a high priority. This work could usefully include the calibration of a simple conceptual model at a large number of sites to provide a readily available and consistent technique for estimating the time series of flows across the study area. The final recommendations for further research relate to the spatial and temporal variability of droughts and are important in the context of identifying changes in low flow regimes. Further work needs to be done on defining indices of drought and describing the temporal variability of these indices and the spatial coherence of droughts, as well as the relationship between droughts and synoptic weather patterns and catchment hydrogeology.

Large-scale Variation

Further research is warranted in a number of areas. First, flow regime classifications need refinement to discriminate better between Atlantic and south European flow regime types. It will be necessary to use daily data or at least some key statistics derived from daily data and to explore further the use of statistical clustering tools. Second, the theoretical and practical issues posed by the use of objective methods for the interpolation of runoff along a river network need to be further addressed. Third, the method for producing grid maps based on overlaying a grid on a mosaic map of catchment runoff needs to be refined and applied to seasonal and monthly data. It could also be used to present time series of monthly or seasonal data in order to portray the spatial evolution of, for example, a drought. Finally, and most generally, there is a clear need for investigations into the links between atmospheric circulation patterns and hydrological regimes.

Techniques for Extreme Rainfall and Runoff Estimation

The flood studies in the first FRIEND project period focussed primarily on identifying and describing characteristic regional patterns in the flood regimes of northwestern Europe, with the index flood method as the basic analytical approach. The second and third phases have been devoted to the description and comparison of some of the different methods and approaches in development and use in the region. The logical continuation of the work is to systematically test and compare the methods on the regional dataset. Such comparisons will throw more light on the strength and weaknesses of the different methods, and they would be an important step in the difficult process of establishing optimal methodologies for combining information from flood and rainfall series, catchment characteristics, and regional information. There is hardly any doubt that methods that combine all available information hold greater potential for the difficult task of reliable extrapolation of flood frequency curves to the high return periods and for flood estimation at ungauged sites. More research on how to integrate the physics of the rainfall/runoff process in this transition would strengthen the confidence in the model extrapolations and enhance the transferability of the method to other hydrological regimes.

Physical Processes of Streamflow Generation in Small Basins

This project brought together the knowledge (both conceptual and data) from a wide range of basin studies and research workers in countries across western and northern Europe. This has involved compiling an international inventory of small basin studies (FRIEND Vol. III); the important criteria for inclusion being that they provide measurements and understanding of hydrological processes. In addition to standard hydrological records of precipitation and streamflow, there were additional measurements in each basin, such as soil water conditions (contents and fluxes) and water quality parameters (such as chemistry and isotope concentrations), which help to develop an understanding of water pathways and residence times.

One important new initiative is to extend the FRIEND concept to ecohydrology and progress has been made in establishing a European group in this area. The group will use a physical habitat simulation model (PHABSIM) developed by the U.S. Fish and Wildlife Service. Opportunities will be explored for cooperative software development, carrying out sensitivity analysis of changing flow regimes on habitat availability in Europe, and, by comparison with detailed habitat investigations, evaluating the potential for producing regional relationships between species preference and hydraulic parameters.

Development of Links with Other International Programmes

At the outset of the FRIEND project, it was considered important to maintain close links with related international research programmes. For example, this included the World Meteorological Organisation and the European Union's CORINNE programme which produced digital spatial data and includes flow archives for Europe and the European Research Basin network. More recently, the newly-established European Environmental Agency has been assisted by the network of FRIEND organisations with experience of cooperation in the area of surface water. The establishment of the Global Runoff Data Centre at Koblenz in Germany can also be assisted by close cooperation with FRIEND database development. Opportunities exist for input from regional FRIEND groups into the WMO WHYCOS programme which is aimed at developing real-time data collection programmes. For example, FRIEND could provide both experience and software for the analysis and display of real-time data in the context of historical flood and drought frequencies. The United Nations Environment Programme, through their GRID (Global Resource Information Database) project, has also expressed an interest in following developments in FRIEND data and analysis techniques. There are clear benefits to both the FRIEND project and national and international operational and research projects in developing closer links.

Conclusions

The FRIEND project has demonstrated many of the advantages of international cooperation in hydrological research. First, by using the resources of large project teams, it has been possible to assemble extensive international databases. Second, models, analysis techniques, and particular specialisations from different countries have been applied to this data. Third, regional studies have benefitted from applying analysis techniques to datasets not constrained by national boundaries and from using research basin data which provided most of the data from small basins. Finally, the project has brought together hydrologists with different experiences ranging from hydrogeologists to regional surface water hydrologists.

The understanding of hydrological variability and similarity on a regional basis has improved considerably due to the work of the FRIEND project. The application of regional datasets in hydrological analysis has brought about an improved appreciation of hydrological behaviour and contributes significantly to the characterisation of flows at ungauged sites. Introduced in 1985, the FRIEND project originally involved 13 nations in northern and western Europe. The growth of interest in the FRIEND project has been such that now over forty countries collaborate in the research activities of the four international FRIEND research programmes. FRIEND was recently designated Project 1.1 of IHP-V for adoption by the Intergovernmental Council of UNESCO's IHP in February 1995, and it is anticipated that this will encourage further developments in the scientific and geographical extension of the international research programme.

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Annex 5
Some Prospects of the Proposed FRIEND HKH

Andreas Herrmann

Background

The Hindu Kush-Himalayan (HKH) region, extending over 2,500km and 3.4 million sq.km. from Afghanistan in the west to Myanmar in the east (Chalise 1993), is an important fresh-water reservoir for the lower altitudes and also the source area of some major rivers of the world and their tributaries, e.g., the Indus, Ganga, and Yarlung-Tsangpo-Brahmaputra. Population pressure in the region, where the present population of more than 120 million is expected to double after 35 years, is already tremendous, thus causing both considerable socioeconomic and environmental problems.

In this context it is really remarkable that the supply of drinking water, for instance, is a most serious problem, not only in the urbanised but also in the extended rural areas of the region, and lack of electricity is a main obstacle to improvement of living conditions. As a matter of fact, only a negligible fraction of the theoretical hydropower potential, which amounts to 83,000 MW in Nepal alone (Gyawali 1989), is actually being used, e.g., 235 MW in Nepal in 1990 (Chalise et al. 1993). The same is true for the river flows from the Himalayas, which altogether are estimated to amount to 8,634km^3 per annum. Such facts indicate the various kinds of serious water problems in the Hindu Kush-Himalayan region and also in the piedmont alluvial plains, which, of course, are of vital significance to the population. As a consequence, one should also recognise that environmental problems, which are often interrelated with quantitative and qualitative water problems, and their solutions are frequently considered to be of secondary importance in the region itself.

With regard to hydrology, which is the main topic here, the HKH shares several common problems with rapidly developing mountainous regions, and these have been summarised comprehensively by Shankar (1991). They include:

- lack of a reasonably accurate assessment of water resources; mainly because there are no consistent and dense hydrological and climatological networks in extended remote areas and difficult terrain—these problems are frequently combined with a need for more experienced authorities and well-trained staff;
- deficits in knowledge of relevant hydrological processes;
- considerable human impacts which are, in this context, mainly due to factors of poverty and rapid population growth;
- frequent hydrological disasters which can hardly be controlled, e.g., cloudbursts and flashfloods, glacial lake outburst floods, rock and landslides, debris flows, and soil erosion;
- considerable bedload transportation, outburst, and deposition;
- degradation of water quality; and
- need for knowledge and information (transfer) and expertise along with tackling the specific problems caused by technology transfer from the

plains to the mountains without considering different boundary conditions (not specific for developing countries alone).

As emphasised by Chalise (1993), the controversial discussion of highland-lowland relationships, as far as the impacts of degraded uplands on lowland flood generation are concerned, shows the need for proper hydrological investigation and data acquisition across the HKH; including assessment of relevant processes and downstream impacts. Reduction of uncertainty with respect to adequate management of water-induced hazards and water resources and their sustainable development remain major tasks for the HKH region.

However, despite a general lack of basic hydrological, climatological, and long-term data series compared to most developed countries, one should realise that the data situation is not too bad at all in the HKH region. Nevertheless, lack of long-term data and a reliable database for the hydrological core regions of windward slopes and glaciated and snow-covered high altitudes makes it difficult to reliably assess the impacts of climatic warming on hydrology, water resources, and the related development of complex mountainous environmental systems.

As a consequence, the following would encourage the HKH countries to commence regional cooperation in the field of regional hydrology immediately by using the FRIEND idea as a basis for developing their own strategies.

Some Aspects of a Basic Framework for a Regional FRIEND HKH

A regional FRIEND (Flow Regimes from International Experimental and Network Data) project could help to intensify regional cooperation and facilitate systematic collection and documentation of hydrological and catchment data. This optimistic prognosis is mainly founded on existing scientific and practical know-how, data availability, and the administrative and experimental infrastructure and experience in the region itself compared to other regional FRIEND programmes such as the Northern and Western European (NWE) FRIEND core project, the Alpine and Mediterranean Hydrology (AMHY) project, and the recently established Western (WA) and Southern African (SA) FRIEND projects.

The HKH region can be proud of its Working Group (WG) on Hydrology which met for the first time in December 1989 in Kathmandu. After five meetings and extended and careful preparations, it is time now to launch a FRIEND-type programme within the framework of the Regional Working Group (RWG). A favourable condition is the offer made earlier by the International Centre for Integrated Mountain Development (ICIMOD) in Kathmandu, Nepal, to host the project's secretariat and database centre. Considering the close regional cooperation between ICIMOD and UNESCO under its IHP programme (Chalise 1993), this is encouraging.

There are several hydrological (and climatological) agencies in the HKH member countries (Shankar 1991), although gauging networks are as yet insufficient. Apart from Bhutan, however, the regional countries have a number of competent authorities.

Climatological and hydrometric networks are extremely sparse in mountainous areas. On the other hand, information (see Alford 1992) on relevant hydrological aspects of the HKH region is available. The data on sediment transport, quantity, and quality are quite substantive, at least for certain stations and regions. Alford's study is largely confined to macro- and meso-scales, thus leaving out the micro-scale on which study is necessary in order to understand environmental systems, including hydrological sub-systems.

A special case in this context is Afghanistan which, since the early eighties, has been affected by continuous abandonment and even destruction of the climatological and hydrometric networks that were established from the fifties to the early seventies. Today, even Kabul airport does not have functional meteorological equipment, and most of the 150 hydrometric stations are in a deplorable state. Therefore, hydrological and meteorological services in this country will have to be reintroduced: basic measuring and data processing and documentation equipment, staff education and training, and expertise on water resources' assessment and local water supply systems are essential. For complete rehabilitation of hydrological and meteorological services, a tremendous international effort is necessary. A FRIEND Project in the HKH could make a substantial contribution to the amelioration of this situation.

There are some very promising and encouraging examples, for instance, the undertaking of HMG/Nepal's Department of Hydrology and Meteorology in cooperation with the German Agency for Technical Cooperation (GTZ) to set up a special Snow and Glacier Hydrology Unit (SGHU) in 1987 (Grabs and Pokhrel 1993). Today, the SGHU has staff, modern data acquisition and processing systems' equipment, and six small, glaciated high-mountain pilot basins of 148-725sq.km. located above 2,600-4,375masl. Similar basins are already available in most other HKH countries (Chalise 1993), or could at least be launched by following specific criteria which do not necessarily need to follow the regulations of the other regional FRIEND projects.

Finally, apart from the national hydrological and climatological services, the numerous state research and university institutes in the HKH region are willing to contribute their rich resources in know-how, staff, and scientists and contribute to the establishment of a regional FRIEND project within the given RWG. It seems that there is a surprisingly large number of small-scale hydrological research and monitoring activities within the region. One of the important initial activities to be undertaken by a regional FRIEND group is, therefore, a region-wide enquiry to assess the information and databases available. The following European experience is meant to give an example of the possibilities of small-scale hydrological research and monitoring activities.

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Small Basins' Inventory: The Case of ERB-ICARE

A European Network of Experimental and Representative Basins (ERB) was recommended by the European Council and established in 1986. The main objectives of the ERB network are to (i) increase relationships between members, research teams, and basin managers through exchange of information, visits, and meetings; and (ii) to facilitate joint operations of common interest between members. Information is disseminated through the ERB Newsletter Bi-annual, and the ERB Conference (together with the General Assembly) takes place every two years.

The ERB Steering Committee (SC) meets once a year. It consists of national correspondents nominated by the national UNESCO-IHP committees and is chaired by the ERB coordinator.[2] The following 13 countries are members of ERB: Belgium, The Czech Republic, France, Germany, Italy, The Netherlands, Poland, Romania, Russia, Slovakia, Spain, Switzerland, and The United Kingdom. ERB has cooperated with other international programmes such as FRIEND of the UNESCO-IHP. Several ERB SC members are also members of the NWE or AMHY FRIEND SC.

The network's core tool is the research basin inventory ICARE (Inventory of Catchments for Research in Europe) which is located in France.[3] ICARE is a relational database which is continuously being updated. It consists of these entities: ERB codes (nos. of attributes: 1-7), objectives (8-26), administration (21-29), station (30-34), data (35-40), equipment (41-46), hydrology (47-55), geomorphology/morphometry (56-60), geo-biochemistry (67-74), and updating (75-76). Accordingly, ICARE gives information on anything of interest on management and administration; research objectives; basin physiography—including geology and soils, instrumentation, and water quantity and quality; data availability; maps; and publications.

The responsibility of proposing which basin should be included in ICARE remains with the member country. Access to ICARE is open to scientists from member countries, provided that the information is for scientific use only, and information is free of charge. In future, an interactive (telemetric) database systems' access is planned.

One major prospect for similar regional databases is easy documentation of all or selected information stored about research activities on a small basin scale. Examples for multipurpose use are (i) planning of multilateral cooperation in education, research, monitoring and expense, regionalisation tasks, (ii) assessment of research potentials, (iii) staff and equipment, (iv) orientation for potential donors, and so on. Therefore, the German National IHP/OHP Committee has recently decided to update the German basin inventory which was established under its auspices. It is available in hard copy only (IHP/OHP 1983). East German research basins are not included.

Option for Operational Hydrological Reference Basins

With respect to the need for more practical hydrological networks for small basins, the following suggestions are made by Spreafico (1994), to be applied in the initial stages of the FRIEND HKH project. Table 1 gives a rough idea of the two different subtypes of Small Hydrological Basins (SHB):

viz., Hydrological Research Basins (HRB) and Operational Hydrological Reference Basins (OHRB), with the specific tasks, aims, and requirements.

Table 1: Criteria for different small hydrological basins

Operational Hydrological Reference Basins (OHRB)		Small Hydrological Basins (SHB)		Hydrological Research Basins (HRB)
Long term	←	Operation period	→	Short term
A few with a high degree of accuracy	←	Number of observation parameters	→	A large number of detailed investigations
As little staff as possible	←	Requirements of time, costs, and staff	→	Depending on the aim of the research
Operational hydrological service	←	Operating body	→	Research institute

Source: Spreafico 1994

In the case of the HKH region, with its rather restricted number of small hydrological study basins, compared to the situation in Switzerland to which the study by Spreafico (1994) mainly refers, a similar focus could be used to propagate combined operational (including monitoring) and scientific purposes in order to increase the benefits from costly observations, investigations, and maintenance. Since the responsibility for running such basins would be first of all in the hands of operational services, continuity of important hydrological data series would be guaranteed as well as permanent access to the basins for researchers. In the meantime, it has been agreed that at international, national, and medium-term levels, a strategy, which aims at bringing research and practice closer to each other, is desirable, especially for the International Hydrological Programme (IHP) of UNESCO and the Operational Hydrology Programme (OHP) of WMO.

As a result, to take such considerations into account, a newly-established regional FRIEND project is strongly recommended, particularly as profit from small multipurpose basins is out of proportion. This is also due to the fact that basic observations of hydrological variables, including sediment transport, which is explicitly mentioned by Spreafico (1994) as a routine task of operational authorities, and assessment of basic physiographic basin parameters; considering variability as a common task of both scientific and operational basin approaches; are essential.

Propagating a Regional FRIEND in the Hindu Kush-Himalayas (HKH)

In view of the main results of the Fourth Consultative Meeting/Workshop of the RWG in New Delhi in July 1995, which are summarised in Figure 1, one believes that a regional FRIEND in the HKH will fulfill several basic requirements for solving some of the regional problems mentioned in the beginning. This expectation is above all due to the fact that the country representatives have really focussed on major regional deficiencies and problems in making the regional project proposal which has just now been accepted during the March 1996 Workshop (cf. Figure 1, Annex 4).

Database project (1) as a core task, small research basins' establishment practices, (2) definition and assessment of hydrological regions, (3) application of existing and development of new rainfall runoff models if necessary, (4) a snow and glacier hydrological project component, and (5) which can profit from of the experiences of SGHU at the Department of Hydrology and Meteorology (DHM) in Kathmandu and from many other similar and famous institutions in the region which specialise in this important hydrological field. Finally, the training component (6) is considered to be most important to meet the need for experienced and qualified field and indoor staff.

By taking the experience of the other regional FRIEND projects into account, one can expect substantial progress in problem and project definition and handling from the beginning, once the project is established, provided that well-elaborated terms of reference and a workplan exist. Furthermore, according to Bullock et al. (1996) the potential benefits of participation in a regional FRIEND will encourage research groups to join it.

Creation of international time series' databases comprised of new consistent, regional spatial databases; data exchange facilities across administrative and international borders; basic software exchange and upgrading in national services and authorities, research centres, and university institutes; knowledge and technology transfer for theoretical considerations, i.e., mathematical modelling; experimental measuring and network design practices; exchange of hydrological models; comparison of statistical methods for predicting hydrological extremes (floods, low flows); short-duration training courses; scientific exchange visits of short to long duration; scientific meetings; and workshops and regional conferences are among the benefits to be realised.

A regional FRIEND HKH project will give the existing regional cooperation a new quality. Therefore, it is strongly recommended that the proposed project draft outlined in Figure 2 be followed, developed, and fulfilled through substantial working results. In this case, the worldwide growing FRIEND family will feel proud of its new member.

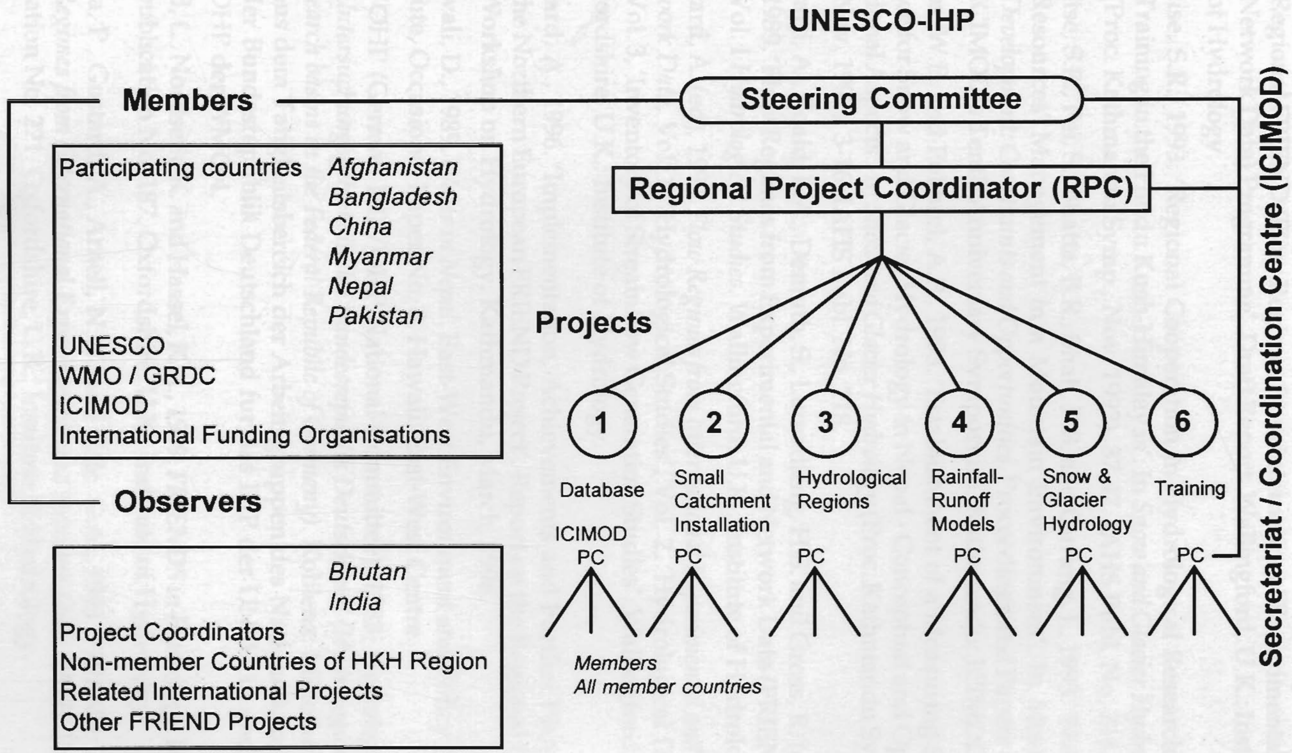

Figure 2: Organisational structure of the future FRIEND HKH project as developed during the 4th RWG, HKH Consultative Meeting, New Delhi, July 1995, taking into consideration the outcome of the March 1996 launching of the project at the RWG, HKH Workshop in Kathmandu