LINKING HIMALAYAN AND ANDEAN WATERSHEDS USING INFORMATION TECHNOLOGY TOOLS

H. Schreier,
S. Brown,
R. Quiroz

Introduction

The Himalayan-Andean project is using information technology (IT) tools to connect research teams in remote mountain areas of the world in an effort to build a network to conduct collaborative research, share experiences, compare approaches, and learn from each other how to address the complex resource issues in different parts of the world. With the Internet technology it is now possible to provide better linkages between mountain regions and to explore new approaches for data sharing and data visualization. The aims of this project are to compare watersheds in the Himalayan and Andean mountain regions and to explore common approaches that focus on emerging resource degradation issues that dominate mountain regions (Schreier et al., 2000). Water is clearly one of the most important and problematic resources, and mountain headwaters play a particularly critical role in the delivery of this resource (Liniger et al., 1998.; Gleick, 2000). In view of climatic uncertainty it is becoming even more important that water is used efficiently and conservation is ensured if we hope to increase food production by at least 50% over the next 30 years (Smil, 2000) and at the same time provide more water to the rapidly growing urban centers. New integrating approaches are needed to deal with watershed issues and the scaling problems need to be addressed more effectively (Schreier and Brown, 2001). Land use interactions and their effects on water resources are particularly critical in mountain regions where resilience is low and risks are high. The tools used in this project are not only aimed at improving communication but also aim to improve data access, transform data into information, use models to better understand resource constraints in mountains and develop scenarios that can be used as decision support systems.

Methods and approach

Eight watershed teams are collaborating in this project and each team has developed a multi-media CD-ROM that incorporates essential biophysical and socio-economic information. All teams agreed to follow a common framework (Figure 1) and a set of over 100 common indicators are used to compare the status of the resources between the different watersheds. Information derived from field surveys and remote sensing are incorporated into a Geographic Information System (GIS) that serves as the basis for quantifying the resource status. With this information it is then possible to compare results within and between the two regions, share success stories, highlight failures, and identify approaches that can be transferred from one watershed to another for the mutual benefit of all research teams involved in the project and beyond.

Four Andean watersheds located in Ecuador, Peru (2), and Bolivia, and four Himalayan watersheds located in Nepal (2), Bhutan, and China are used for this comparative project. Research support for all watersheds was provided by the International Development Research Centre (IDRC) in Canada under the CBNRM and MINGA programs, with joint funding for the Himalayan watersheds by the Swiss Agency for Development and Cooperation (SDC). In each watershed the water resources, soil fertility, the socio-economic conditions, forestry and agricultural land uses, and marginal lands were evaluated, and resource degradation rates were quantified. At the same time methods to prevent degradation were highlighted and successful rehabilitation projects were identified. The watersheds selected for the comparison have long research histories and rich databases, which facilitated the comparison. The key natural resource management issues were identified and training was provided to each research team on how to incorporate the data into a multi-media CD-ROM format. An Internet bulletin board is used to assist each team on a continuous basis. All participants can easily share digital material with minimum programming skills and access the information from a distance. Workshops were held in both mountain regions to develop the necessary skills to produce the CD-ROMs and to collaborate in the comparative study.

A common Web site has been created so that each project can be accessed with minimum effort, and common issues and problems can be discussed via an Internet bulletin board. The Web site is accessible at www.ire.ubc.ca/himal/index.htm. The site provides general information for each watershed and informs participants and interested individuals about the main issues and research results. A list of quantitative indicators has also been posted on the Web site and efforts are underway by each research team to provide the final results for the UN International Year of Mountains. The CD-ROM designed for each watershed is in a multi-media format that incorporates text, video, graphics, images, and GIS maps. Each contains GIS-based information on the status of agriculture, forestry, forage, soils and water resources, and evaluates socio-economic conditions, population dynamics, and poverty levels.

A workshop was held with representatives from each team in Lima, Peru in August 2000 during which all indicators were finalized and the framework for the watershed comparison was designed. The comparative CD-ROM will be available by the end of January 2002 and will contain information on what is unique in each watershed as well as the common issues and results. Each team provided examples on how resource issues in their watershed were resolved in a successful manner, what approaches have failed, and explanations why they have failed. This provides us with an opportunity to share experiences, learn from each other, and identify solutions that can be transferred and extrapolated to other mountain regions.

Initial results

A summary and comparison of the eight watersheds is provided in Tables 1 and 2, and although the size of each watershed is very different there are many common as well as unique issues that are of interest.

Table 1. General summary of conditions in the eight watersheds

Indicator	**Nepal 1**	**Nepal 2**	**Bhutan**	**China**	**Ecuador**	**Peru 1**	**Peru 2**	**Bolivia**
Size (ha)	11,141	5,338	3,400	3,456	29,996	15,358	780,000	1,025,632
Elevation (m)	800-2,200	1,000-3,030	1,200-3,000	1,640-3,075	1,500-3,600	2,900-4,400	3,840-5,550	3,810-5,500
Annual rainfall (mm)	1,288	2,286	720	1,180	807	772	600	400
Population density (people/ha)	4.4	3.9	2.5	1.2	0.7	0.4	0.3	0.01
Population growth (%)	2.6	2.6	2.3	0.3	0.6	3.1	3.1	2.0
Land owned per family (ha)	<1	<1	1	0.7	2.2	2	8	27
Land cultivated per family (ha)	<1	<1	<1	0.2	2	1	4	6
Subsistence (%)	70	90	90	40	30	70	95	90
Insufficient food	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Running water in home (%)	56	64	75	75	65	3	11	40
Irrigation water shortages (months)	Yes 2-3	Yes 1-3	Yes 1	Yes 4	Yes 3	Yes 4	No irrigation 0	No irrigation 0

Table 2 Indicators reflecting land use and productivity

Indicator	**Nepal 1**	**Nepal 2**	**Bhutan**	**China**	**Ecuador**	**Peru 1**	**Peru 2**	**Bolivia**
Land Uue								
Irrigation agriculture (%)	9	7	2.1	2.5	>1	5	1	<1
Dryland agriculture (%)	46	44	2.5	14	20	55	4	21
Grassland (%)	6	6	1	30	27	32	55	30
Forests (%)	30	32	89	38	12	1	1	3
Productivity								
Potatoes (T/ha)	20	10	12	15	25	4	6	5
Maize (T/ha)	2.0	1.5	3.4	4.9	2.5	4.1		
Rice (T/ha)	3.0	2.0	4.7	2.0	-	-	-	-
Wheat (T/ha)	1.2	1.5	1.3	3.3	4.8	0.6	-	-
Milk production (L/day)	1-5	1-5	1	0	6.8	6	3	3
Livestock stall feeding (%)	95	80	10	10	10	0	0	0
Inputs								
Fertilizer (kg/ha) N fertilizer	100	20	100	75	90	<20	<20	100
Manure (T/ha)	12	15	1.8	20	> 4	2-4	4	1.4
Pesticide use	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Common trends

Poverty is widespread in all watersheds. Thirty to ninety-five percent of all inhabitants are engaged in subsistence agriculture and there are annual food shortages during the dry season in all watersheds except in Ecuador. The annual population growth rate is high (>2.6%) except in the Chinese and Ecuadorian watersheds. The climate and topography is marginal for agriculture in almost all watersheds and all experience a distinct winter dry season. Water resource management problems seem to be widespread with water shortages for irrigation in 6 of the 8 watersheds. Water pollution is an emerging issue, and the overall crop productivity rates are low. Potatoes are grown in all watersheds but are a relatively new crop in Asia, while a very traditional crop in the Andes. Pesticide problems associated with potatoes are becoming a health concern in all watersheds. The use of fuelwood as the main source of energy is common in all case studies but access to electricity is somewhat more widespread in the Andes than in the Himalayas.

Regional differences

There is a very clear difference in land ownership and land use intensity between the two regions. The average land ownership per family is significantly smaller in the Himalayan watersheds than the land holdings in the Andes (<1 ha vs. >2 ha) and the population density is also significantly higher in Asia (1.2-

4.4 people/ha vs. 0.01-0.7 people/ha). As a result land use intensity and crop rotation are much higher in the Himalayas.

Probably the greatest difference is in terms of land use in the watersheds. There is a substantial amount of forests in all the Himalayan watersheds (30-89%) and very little in the Andes (1-12%). This is in part due to the fact that the Andean sites have a somewhat dryer climate and are at higher elevations. This is also reflected by the fact that about 1/3 of the Andean watersheds are grazing lands while the percentage of grazing land is small in the Himalayan watersheds. A significant amount of livestock production is in the form of stall feeding in all Himalayan watersheds, while most of the livestock production in the Andes is in free rangeland grazing. Similarly crop productivity is generally higher in the Himalayas but milk production is lower than in the Andes. Due to the more intensive agriculture more chemical fertilizer is used in Asia while manure use in agriculture is higher in the Andes. In terms of soil fertility, deficiencies in soil phosphorus seems to be a common problem and soil acidification is a problem in all watersheds except the one in Bolivia, which is in a dry environment and experiencing salinity problems. The knowledge base on agro-biodiversity is much greater in the Andes particularly in terms of tuber crops and beans, while rice is only grown in the Asian watersheds. In addition, the Himalayan region is currently undergoing an interesting forest transformation in that national forests are being transferred to community forests.

Issues that are absent

Tourism which is generally considered an important activity in mountain watersheds is not prevalent in any of the study areas. Also, no large urban centers are directly located in the watersheds and none of the study watersheds are used for the production of hydropower.

Issues that need greater attention

What became apparent during the study is the general absence of reliable data on water resources, particularly stream flow data, information on irrigation and water quality. Also, the conflicts over irrigation water seem to be complex and most institutions are poorly equipped to deal with the complex policy, legal and inequity issues associated with water use. When dealing with water resources, the need for stakeholder processes, community involvement and negotiations is clearly given in almost all case studies.

Benefits from the collaboration

A total of about 100 indicators were developed and these will be summarized in greater detail in the coming months. Together with the information contained in each of the eight CD-ROMs it is now possible not only to compare information but also to share knowledge and learn from each other's experience. Each team is to highlight innovations and success stories on how the conflicts and constraints were overcome. The other teams will then examine if these successful approaches could be transferred to their watersheds. At the same time failures in addressing resource problems and reasons for the failures are also being shared. The positive and negative results are to be shared among the team members in the other watersheds in an effort to learn together.

A GIS-based watershed approach was used because water is clearly becoming a major constraint in all watersheds and this approach allows not only the determination of process dynamics in the watershed (water balance, nutrient budgets, sediment budgets, pollution loadings) but also the determination of land use intensification and its impact on water.

Discussion

The CD-ROMs will be available for wide distribution by November 2001, and the final comparison will be completed in a multi-media CD-ROM format by January 2002. Linked Web sites have been developed for each watershed and the summary results are constantly updated and made available on the Internet. This experiment has shown that using the available information technology tools has many positive advantages. The network built by the 8 teams was extremely useful and beneficial to all team members. They obtained training in how to use the technology, it facilitated the integration, and it allowed the comparison of results across continents, which cannot easily be accomplished by a single team. However, the greatest benefit was achieved through knowledge transfer and the sharing of ideas, methods and successful approaches to resolve resource problems. For the first time, land resource information in each watershed was put together into an integrated watershed framework where all the key resource issues were addressed, degradation rates were quantified, and preventative measures and rehabilitation efforts were highlighted.

In addition, many new topics were addressed, such as the example of obtaining carbon credits in agriculture in the high mountain watersheds. Because of the somewhat harsh seasonal climatic conditions, many of the participating watershed teams feel that the conditions are conducive to sequester carbon, particularly under grazing systems. This is emerging as an opportunity for carbon credit trading and income generation for these watersheds. Another emerging theme discussed was that mountain watersheds should receive economic benefits from the urban population in the lowland for the services they provide (biodiversity, water supplies, etc.). A third example is the progress that has been made in Nepal on water harvesting for drip irrigation in the dry season. All these ideas can now be tested in each watershed and the results can then be shared in an effective manner.

The Internet, the multi-media tools, the CD-ROMs, and e-mail have made the sharing of information and knowledge much easier in these mountain regions, and are clearly benefiting the population in these remote areas. The technology is relatively easy to master, and the costs of conducting such collaborative research between continents are modest. All it takes is teams that are enthusiastic and willing to collaborate and share information in an innovative manner.

Future plans

The project is to be completed by January 2002 and will provide useful educational material for the UN International Year of Mountains. We are currently exploring the possibility of building a global Internet-based network on mountain watersheds, where all interested research groups can interact and share information. This could serve as a very cost-effective platform for knowledge transfer. The Global Mountain Program spearheaded by the CGIAR network (Zandstra, 2001; CGIAR, 2001) could serve as an umbrella for this initiative and preliminary discussions are underway between CIP, CIAT, ICRAF, IWMI, IDRC, and UBC to develop such a network. The Swiss Mountain Symposium would be an excellent forum to discuss this initiative and expand the Himalayan-Andean network into an informal global network.

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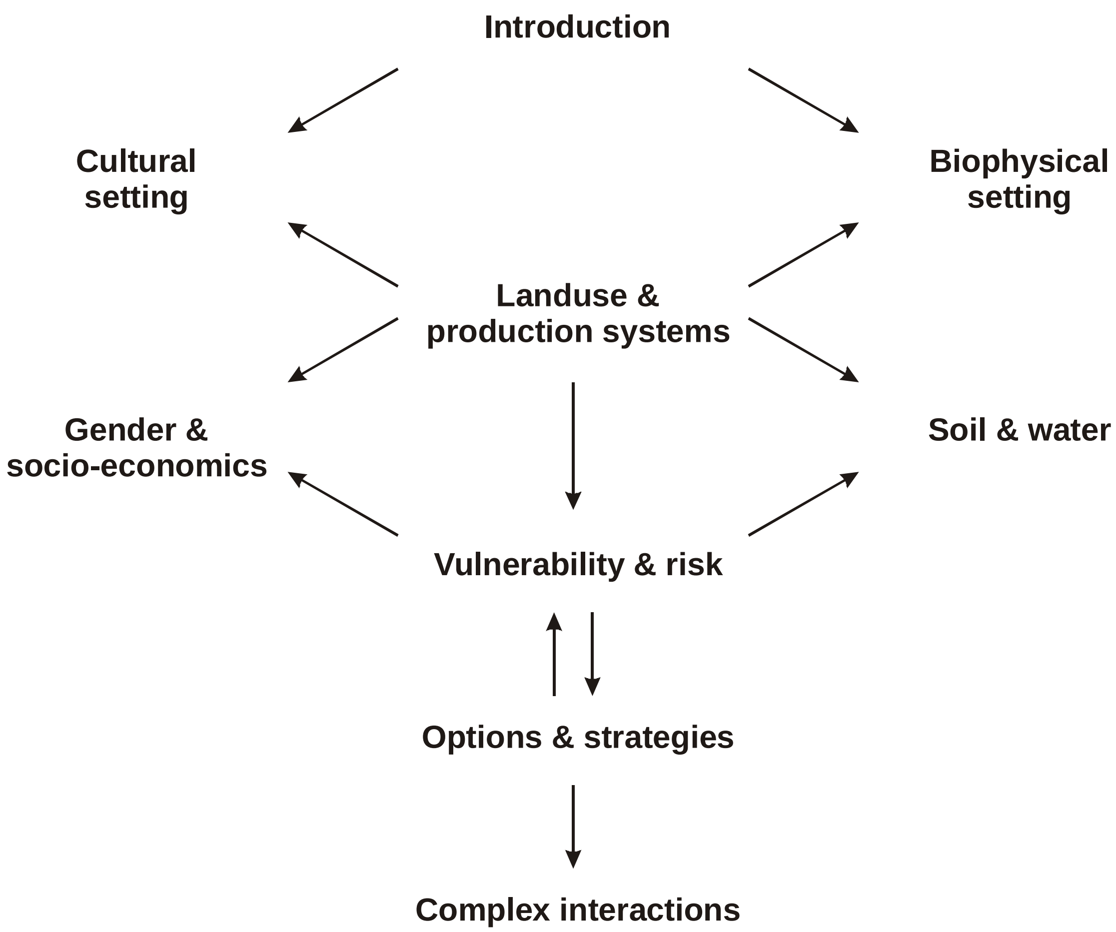

Figure 1: Framework used to evaluate the resource status in eight watersheds