RISK MANAGEMENT AND SUSTAINABLE DEVELOPMENT IN THE MOUNTAINS OF CENTRAL ASIA

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ABSTRACT

In virtually all countries where they are found, mountain communities are marginalized, commonly separated both physically and culturally from the centers of political and economic activity of the country. Risk management and sustainable development are difficult without significant outside assistance. The interrelated nature of hazard, risk and development in environments such as those found in mountains suggests that attempts to undertake either risk management or sustainable development as separate problems will have a limited chance of succeeding. The most effective approach will involve: 1) identification of hazards, risks and development potential, 2) development of integrated risk management and development projects. Such an approach will require a reliable amd accessible data base for project planning and management. An approach to the development of such a data base is presented here, based on studies in the Pamir Mountains of GornoBadakshan Province, Southeastern Tajikistan.

In 1911, a massive landslide on the Murgab River in the Pamir Mountains of southeastern Tajikistan buried the village of Usoi, and began the formation of Lake Sarez, named after a village drowned by the rising waters of the Lake. By 1998, Lake Sarez contained over 17 km^3 of water and was nearing the top of the landslide dam. The possibility of an outburst flood from Lake Sarez and the potential for impacts far downstream on the Panj River, in the countries of Tajikistan and Uzbekistan, focused international attention on the Lake, on the environment of the Pamir Mountains and the people who lived there. Ultimately, this led to three major studies of this problem, undertaken by the United Nations International Decade for Natural Disaster Reduction (UN-IDNDR, 1999-2000), The University of Berne, Centre for Development and Conservation (GIUB-CDE, 2001-2002), and Focus Humanitarian Assistance, Aga Khan Development Network and Stucky Engineering, Switzerland, (2000-2005).

Taken together, these three studies provide a wide range of information from the Pamir region of Tajikistan on which to base strategies of mountain hazard assessment, risk management and mitigation, and economic development. At the present time these studies exist primarily as tabular data at differing, incommensurable scales A fundamental need is development of an information management system that will make possible syntheses of the disparate, but interrelated, data contained in such studies, facilitate the production of outputs such as strategies for managing both disasters and development in the complex mountain environment as well as make possible a better definition of the complexities of the mountain environment. Such an information management system could be build around a digital elevation model, involving a geographic information system of the complex mountain terrain together with relational databases of pertinent attributes. Both now exist separately as a result of the studies mentioned.above. The primary challenge is to couple the GIS and ACCESS data bases in such a way as to create a tool for both those concerned with risk assessment as well as development potential.

I. INTRODUCTION

The peoples of the mountains of Central Asia – the Hindu Kush-Karakoram-Pamir-Tien Shan mountain complex, encompassing portions of Afghanistan, Uzbekistan, Tajikistan, Khyrgystan, Kazakhstan, and the northern provinces of Pakistan - live in one of the most hazardous and complex environments on earth. In spite of this, virtually all land capable of supporting human or animal life is utilized. In many parts of the region, both human and animal populations continue to increase. This increase is largely accommodated by expansion into marginal lands, where the potential for exposure to hazards avoided by earlier arrivals increases. For the most part, those living in these mountains do so in small, widely-separated villages located along valley floor corridors connected to each other by networks of trails or rudimentary road systems.

The hazards faced by these mountain peoples are related in part to the extreme three-dimensional topography in which they live, compounded by the physical isolation associated with this topography. Local relief of between 1000-4000 meters, coupled with frequent cycles of freezing and thawing and unconsolidated geologic materials, produces slope instabilities causing landslides rockfalls, avalanches and debris flows. Seasonal flooding is a common occurrence, as a result of rapid melting of high altitude snowpacks during the spring. Destructive earthquakes are hazards associated with these mountains, as is catastrophic flooding, produced by the failure of landslide or glacier dams.

During 1997 – 2005, an *ad hoc* consortium of international agencies and organizations engaged in risk management and development assistance studies in the valleys of the Pamir Mountains in southeastern Tajikistan[1]. While the primary justification for these studies was the potential for a major outburst flood from Lake Sarez, located at the headwaters of the Murgab river, a large amount of information concerning the problems dealing with the complex issues involved in planning or managing risk and development assistance in a remote, often inaccessible region was obtained. Three major studies were involved:

1. An international team of scientists and engineers was sent to the Pamirs in 1999 by the United Nations International Decade for Natural Disaster Reduction (IDNDR, 2000) to assess the hazard and risk associated with Lake Sarez, a large lake formed by a landslide at the headwaters of the Bartang river, a major tributary to the Panj river in the Pamir mountains, Gorno Badakshan province (GBAO), Tajikistan (Alford and Schuster, eds., 2000).

2. The Centre for Development and Environment (CDE), University of Berne, Switzerland, undertook studies of sustainable development potential in Gorno Badakshan province in 2001 (CDE, 2003)

3. Focus Humanitarian Assistance (FOCUS), a member of the Aga Khan Development Network, in collaboration with the US Geological Survey, the Swiss Firm of Stucky Engineering, and the Usoi and Sarez agencies of the government of Tajikistan studied the biophysical and socio-economic conditions at approximately 90 villages along a 400 km reach of the Bartang and Panj rivers in the province of GornoBadakshan (FOCUS, 2005).

The UN/IDNDR mission found the hazard posed by Lake Sarez to be considerably less than studies during the Soviet era had suggested. The mission team recommended development of a monitoring and early warning system, with additional studies of the villages of the mountain valleys (Alford, D., and Schuster, R., 2000)..

The University of Berne study recommended a course of development assistance activities involving 18 strategic objectives at the provincial level, (*The Tajik Pamirs*, p.63). These objectives were prioritized, “high”, “medium” and “low”, presumably in response to perceived

[1] Focus Humanitarian Assistance, a member of the Aga Han Development Network, The United Nations International Decade for Natural Disaster Reduction, Stucky Engineering Ltd. A Swiss firm, The Centre for Development and Environment, University of Berne, Switzerland , the US Geological Survey.. Funding was provided by The World Bank, The US Agency for International Development, the Aga Khan Foundation, private donations to Focus Humanitarian Assistance, the European Community and the governments of Switzerland and Japan.

needs at the provincial level. Only a limited attempt was made to translate these priorities to needs at the village level, or to the range of probable impacts at the village level by implementation of any given strategy.

FOCUS placed primary emphasis on risk management at the level of individual villages. A problem faced by FOCUS since the beginning of activities in GBAO has been development of a procedure for organizing this information and for performing the analyses necessary for ranking villages in terms of the needs of individual villages for external assistance in the area of risk management for disaster management, or for the determination of development assistance needs and potential at the village level. In efforts to date, FOCUS has undertaken field hazard mapping of individual villages, without developing a procedure for integrating this village-specific information into a province-wide plan, or plans. (FOCUS, 2005).

II. The Problem

On-going or proposed risk management and development activities in GBAO appear to have been based implicitly on the premises that:

1. development efforts at the provincial level will have a generally uniform impact on all villages in the province, (CDE, University of Berne), or

2. all villages deserve equal consideration as candidates for risk management or development projects (Focus Humanitarian Assistance).

For purposes of realistic planning for risk management and sustainable development in a mountainous region such as the Tajik province of GornoBadakshan (GBAO), there are two fundamental factors that must be taken into consideration :

1. The provincial population of approximately 250,000 people is scattered among approximately 300 villages. The villages range in size from more than 40,000 (Khorog, the provincial capital) to many with fewer than 10 inhabitants.

2. These villages exist within a complex three-dimensional environmental mosaic producing wide variations in basic life-support conditions, such as water and energy availability, accessibility, arable land, and site hazard characteristics.

A pressing need is to develop a methodology for characterizing the hazards, and the development potential, of individual villages, or village clusters, in the mountain environment. It is not necessary, nor practical, to attempt to develop causal forecast models to predict the probability and magnitude of potential hazardous events that will be applicable to all mountains. Nor is it realistic to attempt to provide an engineering solution to every hazard experienced, or feared, by each of the 300 villages of the Pamir Mountains. The primary need is to develop an acceptable approach to the problem of ranking hazards and development potential in the Pamir Mountains and, by extension, demonstrating an approach that might have application in other regions. Such a standardized approach is needed for several reasons:

- Many planners and managers of projects in the mountain environment have little, or no, experience of that environment. They are, therefore, unable to assess accurately the project implications of the complex mountain environmental mosaic.

- Much of the early planning and studies for mountain risk assessment or development assistance planning is undertaken by NGO’s or development funding organizations, or consultants employed by these groups.. Commonly, these individuals have little, or no, training in the relevant skills, but are advocates of personal or organizational agenda..

- There is often a large amount of data that might be used to inform the planning or management of mountain projects, but generally-accepted procedures for analyzing, or interpreting, these data for operational purposes do not exist.

- There is a need to develop comparative statistics for mountain regions, both in order to more accurately assess the probability for success of projects in the mountain environment, as well as provide a clearer picture of the differences among mountain ranges and regions for policy makers.

- In developing design criteria for mountain environments, it will be useful to define the extremes in the environment, in order to develop a first approximation of what is, and is not, developable. These definitions must be arrived at in terms of specific project requirements, but will, in all cases, benefit from a better understanding of the spatial heterogeneity of the mountains. At a minimum, an elementary Geographic Information System (GIS) is essential to assess spatial relationships existing between hazards and risks (e.g., McHarg, 1995).

Derivation of comparative statistics for the villages of the Pamir Mountains, based on the pre-existing data available from government agencies, the literature, and academic sources, could lead to a more realistic, effective use of resources in planning and managing for integrated risk management and sustainable development.

- These data could be historical records of disasters, socioeconomic and demographic records, climatological and hydrologic records, geologic and topographic information from existing maps and satellite imagery, interviews with villagers, etc.

- Using such data, simple statistical models could be developed. The primary challenge will be to determine the principal factors and relationships defining hazard, risk, vulnerability and development potential.

- Using such models, a preliminary ranking of villages would be possible, in terms of hazards, development potential, and impact of proposed strategic initiatives,

- This ranking could then be used to refine needs for additional information, and to prioritize and plan risk management and development assistance projects.

III. Mountain Perspectives

Mountains may be studied, and defined, from two primary perspectives:

<u>The Lowland Perspective</u>: There is the lowland perspective, in which mountains are viewed as a resource base, providing necessities such as water, timber, and minerals, and creating major barriers to transcontinental surface travel. This was the perspective most in evidence at the recent Bishkek Global Mountain Summit, the concluding event of the International Year of the Mountains 2002. From this perspective, the most common definition of a mountain is an elevated landform, and the most definitive measure of a mountain is altitude above sea level (e.g., UNEP, 2002). The properties and processes of mountain ranges are defined, for the most part, in terms of gross aggregate means. Mountain regions are seen as being largely homogenous, with major variations occurring only among regions, and not within individual mountain ranges. Based largely upon altitude, UNEP (2002) has divided the mountain regions of the globe into 6 or 7 classes (the exact number based on qualifications described in the text accompanying the classification), representing between 24% and 27% of the land surface. This is the traditional perspective from which risk assessment or development assistance planning is undertaken.

The Mountain Perspective: From the perspective of the inhabitants of the mountains, the mountains are defined primarily by a diversity of biophysical environments, produced by interactions among terrain, geology and meteorology. The homogeneity seen from the distant lowlands becomes a complex mosaic of both useful and hazardous environments to the highlander. Altitude is not a major factor, inasmuch as most of those who live in the mountains live at the lower altitudes present. In all cases, these people are acclimated to the altitude(s) at which they live. Verticality, or local relief, is much more important. Relief is important locally in terms of the problems, or opportunities, it presents. Steep, unstable slopes may be the source of landslides, avalanches, debris flows or rockfalls, representing continuing hazards to the villages exposed to them. Gentle slopes, with soil and a water supply, become agricultural or village sites. There is considerable data describing the biophysical and socio-economic environments of mountains, but this information is commonly fragmented, and analyzed primarily in site- or project-specific terms. There are few general studies that will permit comparative assessments of project suitability or the probability of project sustainability either within, or among, mountain regions.

IV. Planning Mountain Development:

From the perspective of the scientist, engineer, planner or manager, the primary challenge presented by mountains is planning and implementing projects in this extremely heterogeneous environment. The properties that determine this heterogeneity are associated with:

1. Topographic properties: altitude (determining primarily air mass characteristics) and relief (determining slope and aspect).

2. Geologic Properties: primarily competence (the degree with which a rock will transmit stress, and resist erosion)

3. Meteorological properties: water and energy exchange (related to latitude, continentality, and air mass properties

Taken together, these factors determine site habitability, agriculture potential, energy and water potential, transportation possibilities, etc.

For the most part, mountain environments are described by gross aggregate means, commonly derived from data obtained from monitoring stations in the adjacent lowlands. This problem is reflected in a section of the Bishkek Platform, produced at the Bishkek Global Mountain Summit, at the conclusion of the International Year of the Mountains 2002:

“Mountain-specific data: We recognize that the lack of spatially disaggregated socio-economic and environmental data hampers the recognition and specific analysis of mountain livelihood issues. We encourage governments to produce, publish and use mountain-specific data to improve policies for sustainable mountain development, especially in relation to dominant lowland economies”.

It is probable that most governments will need considerable assistance to, “…..produce, publish and use mountain-specific data…for sustainable mountain development….”.

Inhabitants of large mountain range are generally perceived to be at risk from elements of the geophysical environment that surrounds them. A major problem at the moment involves the problem of determining how real the apparent hazards are, and how imminent. It is essential that the concept of probability be contained in all hazard assessments and the management plans based on those assessments. It is not practical to develop detailed and expensive management strategies for hazards that have a very low probability of occurrence with sufficient magnitude to produce a significant impact.

The most obvious mountain hazards are phenomena associated with geophysical processes – earthquakes, destructive downslope mass movements of geological materials, as well as hydrometorological phenomena. Mass movements are complex causally, but are associated primarily with tectonism (uplift of the mountain range, topographic slope, geologic structure and stratigraphy. Hydrometeorological processes are phenomena such as freeze-thaw cycles, the rapid advance of glaciers, or extreme precipitation events and the resulting floods.

Less obvious hazards faced by mountain inhabitants are those imposed by isolation, social, political and economic marginalization and the uncertainties of subsistence agriculture in the mountain environment.

The complex three-dimensional environmental mosaic of the high mountains complicates identification of hazards and the specific villages that may be threatened by specific hazards. A hazard may have no direct and obvious geographical association with a specific village, or villages, but will be connected along an energy gradient represented by, eg., a slope, or stream channel. A recent example is the village of Dasht, Tajikistan that was virtually completely buried by a debris flow, resulting from a glacier lake outburst flood originating over 10 kilometers from the village.

The identification of geophysical or hydrometeorological hazards by field mapping alone would be an extremely difficult and long-term undertaking in any large mountain range. These hazards are the result of dynamic processes, but this dynamism may be operating on a time scale that is not immediately perceptible. A geomorphic (landform) analysis will identify the process involved, but will provide little information on how active the process is at the present time. Hazard identification and assessment of potential magnitude should be based on 1) historical records, 2) interviews with villagers to obtain local perceptions of hazards, 3) field mapping, 4) inspection of maps and imagery, 5) literature reviews. Unless a majority of these sources combine to indicate the presence of a hazard, the existence of a credible threat to villages, roads and activities will remain questionable.

Both in identifying hazards, and in assessing strategies to deal with those identified, the range of options must be factored into the evaluation. Management and mitigation options may be active or passive. Active measures may include engineering modification of local terrain or surface conditions, e.g., control or protective structures or barriers, vegetation control, water diversion or drainage. Passive measures include planning and zoning, relocation, monitoring, training. Active engineering measures, where they may be warranted, are generally expensive, and commonly do not eliminate the underlying cause(s) of a hazard. Passive measures may involve participants ranging in scope from local villagers to the national government, and thus may require a broad social and political consensus prior to implementation.. Decisions regarding which active or passive measures should be applied and what level of risk is acceptable could be based on 1) information on recurrence and magnitude of hazard and 2) the socio-economic and political broadness of the perceived need for such measures.

V. RISK MANAGEMENT AND DEVELOPMENT PLANNING

There are at least two levels at which risk management should be considered for the mountains of Central Asia.

- Risk management should prepare necessary information and coordination for disaster response agencies in the event of a major catastrophic event (for example, a major outburst flood, an earthquake, or a major landslide). At this level, the primary need is the development and distribution of an information system that will enable the rapid and effective response to disasters to those agencies that would logically be involved in a disaster response.

- A second level of risk management would involve development of a risk management plan, or plans, to be implemented at the village level, involving the identification, organizing, training and equipping of village clusters to deal with local emergency situations or mitigation strategies. It is at this level that the integration of risk management and development planning becomes most important.

For purposes of this discussion, development planning is defined as the process by which governments produce plans to guide social, economic and spatial development over a period of time. Risk management may be defined in terms of both proactive and reactive activities.. Reactive measures – rescue, relief, rehabilitation, and reconstruction - are beyond the scope of this paper.

V.1 Proactive Measures

Proactive measures involve activities undertaken in advance of the occurrence of a hazardous event, and are broadly categorized as *preparedness, mitigation, and prevention* (PMP). The range and scope of such activities is not well defined, but may include such efforts as major or minor engineering, data collection and analysis, monitoring, training and education, stockpiling, organization of emergency response agencies, and land use planning and zoning. Information needs include:

V.1.1 Hazard Assessments

Natural hazard assessments consist of studies that provide information on the probable location and severity of natural hazards and the likelihood of their occurrence in a given area within a specified time period. These studies rely heavily on available scientific information, including topographic information, geologic information, geomorphic maps, climatic and hydrologic data, aerial photographs and satellite imagery. Historical records, either as formal reports or oral accounts from long-time residents, also help characterize potential hazardous events. Ideally, a natural hazard assessment promotes an awareness of the issue in a developing region, evaluates the threat of natural hazards, identifies the additional information necessary for a definitive evaluation, and recommends appropriate means of obtaining it.

V.1.2. Vulnerability Assessments

Vulnerability is the inverse relationship between the magnitude of the hazard and resulting damage. High vulnerability implies that extensive damage or death will result from low magnitude events. Vulnerability studies are designed to estimate the degree of loss or damage that would result from the occurrence of a natural phenomenon of a given severity. The elements analyzed include human populations, capital facilities and resources such as settlements, production facilities, public assembly facilities such as schools, and the engineering characteristics of, e.g., buildings or bridges. All other things being equal, vulnerability correlates directly with poverty, or with location relative to the zone of maximum intensity or impact of a hazardous event. .

V.1.3. Risk Assessment

Information from the analysis of an area's hazards and the vulnerability to them is integrated in an assessment of risk, which is an estimate of the probability of expected loss for a given hazardous event. Once risks are assessed, planners have the basis for incorporating mitigation measures into the design of investment projects and for comparing project versus no-project costs and benefits.

VI. DISCUSSION

For the most part, villages in the mountain ranges of Central Asia are small and widely scattered. There is no tradition of land-use planning. The economics of the region are determined largely by subsistence agriculture and herding. Except in the larger towns of the region, construction is based on the use of local materials, generally cobbles, mud and wood from trees grown at, or near, the construction site. These mountain villagers are characterized by their isolation from the major economic and political centers of the region, by a tradition of independence, and by an approach to hazards characterized primarily by fatalism, reliance upon the local family group for assistance, and a high degree of risk acceptance.

A major thrust of any discussion on the development of computer-aided techniques for facilitating risk or disaster management in the mountains of Central Asia must be a consideration of how such techniques will be used. In the U.S., the primary use of GIS in disaster management has been to direct emergency response activities and to assess potential insurance losses. It is reasonable to assume that PMP activities in these mountains will, of necessity, differ greatly from those in the U.S. Initially at least, it is assumed that the most important role of the GIS will be to facilitate spatial comparisons of attribute layers describing the relative locations of hazards and risks.

Similarly, the questions related to identification of user groups require consideration. In the U.S., the primary users of disaster-related GIS databases are government emergency response groups, local planners and managers, and the insurance industry. It is less clear who the primary user groups may be in the mountainous regions within developing countries.

Identification of hazards and the specific villages that may be threatened by specific hazards is complicated by the complex three-dimensional environmental mosaic of the high mountains. A hazard may have no direct and obvious geographical association with a specific village, or villages, but will be connected along an energy gradient represented by, for example, a slope or a stream channel. The identification of geophysical or hydrometeorological hazards by field mapping alone would be an extremely difficult and long-term undertaking in any large mountain range. Mountain hazards are the result of dynamic processes, but this dynamism may be operating on a time scale that is not immediately perceptible. In general, the recognition of conditions specific to a particular hazard requires considerable training and experience. While there are many earth scientists having this type of training and experience, it cannot be assumed that every earth scientist will have the necessary expertise to recognize incipient hazards. In the field, the most appropriate course of action will generally be the establishment of a measurement or monitoring program where a hazard is suspected. Ideally, hazard identification and assessment of potential magnitude will be based on 1) historical records, 2) local knowledge, 3) field mapping, 4) inspection of maps and imagery, and 5) literature reviews. Unless a majority of these sources combine to indicate the presence of a hazard, the existence of a credible threat to villages, roads and activities will remain questionable.

Both in identifying hazards and in assessing strategies to deal with the hazards identified, the range of options must be factored into the evaluation. Management and mitigation options may be active or passive. Mitigation may include control structures, protective structures, and forestry practices, planning and zoning, monitoring, training and risk acceptance. Engineering measures, where they may be warranted, are generally expensive and require a broad socioeconomic consensus if they are to be undertaken. Passive measures may involve participants ranging from local villagers to the national government, and thus provide more flexibility to organizations such as FOCUS, but may involve forms of “social engineering” that may run counter to the wishes of local inhabitants. Decisions regarding which active or passive measures should be applied and what level of risk is acceptable should be based on 1) information on the recurrence and magnitude of hazards, and 2) the general perception and acceptance of the need for such measures on the part of the population at risk, as well as national, provincial and local government officials

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