HAZARDSCAPES: RANKING DISASTER RISK IN PAKISTAN AT DISTRICT LEVEL

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ABSTRACT:

Pakistan is a hazard-prone country with more and more people living in high-risk areas. Increasingly, holistic approaches consider landscapes across all hazards. In extreme situations the net result of natural and man-made hazards and the risks they pose cumulatively across a given area may be called a hazardscape. The approach introduced here reflects interactions among nature, society, and technology at several spatial scales. At present, a vast majority of all disaster risk management efforts undertaken in Pakistan concentrate on the response phase, although the mitigation of hazards is crucially essential to sustainable development. Pakistan has disaster management policies at national and regional levels. Efficient spatial planning tools are very limited although it is known that the particular multi-faceted nature of spatial planning requires a multi-risk approach which analyzes all relevant hazards as well as the vulnerability of the particular area. In this study several hazards were selected based on their frequency and severity and they were analyzed by means of GIS. It results in an integrated hazard map, combining various vulnerability factors within the same area and subsequently in an integrated risk map. Based on expert opinions, suitable weights have been assigned to each hazard and to each vulnerability factor to evaluate the integrated disaster risk for each district of Pakistan. The resultant risk map is supposed to be used by end users in Pakistan to decide whether a particular level of risk is related to an area's hazard potential, its vulnerability or both. Hence, the user will be able to portray the disaster risk ranking of Pakistan at district level on a map whereby the term 'map' metaphorically encompasses printed maps and online interactive visualisations. The resulting maps shall help decision makers and end users such as local authorities, NGOs, disaster and prevention officers. They shall enable them to a) decide the level of acceptability of a risk, b) to determine which protection level is needed to be put in place and c) which predefined mitigation measure is best to be applied.

1. INTRODUCTION

Pakistan is among those developing countries which is situated in the world's hazard belt and is subject to flood, drought, cyclones, earthquakes, landslides. The human impact of natural disasters in Pakistan can be judged by the fact that 6,037 people were killed and 8,989,631 affected in the period from 1993 to 2002 (WDR, 2003). Disaster management (particularly to natural hazards) in Pakistan, mainly focus on rescue and relief processes. There is a dearth of knowledge and information about hazard identification, risk assessment and management, and linkages between livelihoods and disaster preparedness (WCDR, 2005). Disaster management policy responses are not generally influenced by methods and tools for cost-effective and sustainable interventions. According to UNDP, many countries still lack clear guidelines on how to deal with hazards and risk on a spatial planning level (UNDP, 2004). In case of Pakistan, the Kashmir Earthquake 2005, has brought changes in the realization that risk potential is increasing and it is not sufficient to restrict policies only to response phase of the disaster management cycle, although mitigation of hazard is an essential component for sustainable development, appropriate spatial planning tools have still to be developed. Even if the awareness of natural hazards and associated risk has increased but the scope of most management related activities are limited because of single hazards approach. An integrated multi hazard/risk approach is still rare. Nature of spatial planning requires multi-risk approach which analyzes all relevant hazards as well as vulnerability of the same area. Besides the versatile nature of vulnerability, this study only focuses socio-economic, environmental and physical dimensions of vulnerability for the measurement of damage potential and coping capacity. Vulnerability is an essential part of hazards and risk research and refers to the susceptibility of people, communities or regions to natural or technological hazards. Vulnerability is a condition and processes resulting from physical, social and environment factors or processes which increase the susceptibility of a community or area to the impact of a hazard (ADRC, 2005). Vulnerability also encompasses the idea of response and coping, since it is determined by the potential of a community to react and withstand a disaster. Westgate and O'Keefe (1976) suggest that vulnerability has a social character and is not only limited to potential physical damage or to demographic determinants. It is stated that a disaster only takes place when the losses exceeds the capacity of the population to support or resist them. In other words , vulnerability is the degree to which the different social classes are differentially at risk (Susman et al, 1984) From this perspectives the conditions that characterize underdevelopment (social; due to high population growth with lack of basic facilities like education, health, water scarcity, food insecurity) have made the poorest communities , more vulnerable to natural disasters.

2. DATA USED

Pakistan has 138 districts organizing five provinces (Sindh, Punjab, Baluchistan, Khyber Pakhtunkhwa, Gilgit-Baltistan), plus Federally Administrated Areas (FATA) and Azad Kashmir. Some districts are excluded from the analysis due to data unavailability. Therefore the present analysis is based on 107 districts. Various sources have been used to gather data at district level, briefly described below;

2.1 For Hazards assessment

- **Drought:** Aridity Index – WARI[1], NARC[2]/PARC[3]; 2001 FAO[4], WFP[5] - Special report; 2001
- **Flood:** Flood Hazard Distribution Map – WHO[6]; 2007 Flood damage reports: FFC[7], IUCN[8], UNDP[9], PMD[10]
- **Earthquake:** Seismic Map: Geological Survey of Pakistan, historical records of earthquake events
- **Cyclone:** Reports by PMD and NDMA[11]

2.2 For Vulnerability assessment

- Landuse/landcover data (based on Landsat satellite data),
- Census report Pakistan, 1998
- LandScan Global Population Data , 2008
- Statistics (published reports): FBS[12], WFP, IUCN, UNDP; 2003 , Pakistan Socio-Economic survey, 1999

3. METHODOLOGY

3.1 General approach

Multi-risk approach has been adopted which consider all relevant hazards that threaten the certain area as well as the vulnerability of the same area and hence to evaluate disaster risk level of districts in Pakistan by examine various vulnerability indicators within the extant of natural hazard for each district (is prone) which shows the degree of risk for each district. The resultant aggregated risk map enables to see whether the level of risk is related to an area's hazard potential, its vulnerability or both, hence to be able to portray the disaster vulnerability ranking of Pakistan at district level on a map.
The overall methodology based on following three main steps is described below

1: Water Resources Research Institute
2: National Agricultural Research Centre.
3: Pakistan Agricultural Research Council
4: Food and Agriculture Organization of the United Nations
5: World Food Program
6: World Health Organization
7: Federal Flood Commission
8: Int. Union for Conservation of Nature and Natural Resources
9: United Nations Development Program
10: Pakistan Meteorological Department
11: Pakistan National Disaster Management Authority
12: Federal Bureau of Statistics

temporal distribution of risk for specific locations and time periods by comparing, for different natural hazards, the estimated levels of particular hazards, and exposure to those hazards (WDR, 2003). Unfortunately, many factors make this difficult include lake of comparable detailed data about the spatial location and extant of hazards, their intensity and duration. Although Pakistan is prone to many natural hazards, but due to the data limitations, only four natural hazards (Flood, Drought, earthquake and Cyclone) has been selected and analyzed in this study. The hazards, which threaten the community, have been identified by the number of hazard occurrence (based on historical records of hazards of each district) along with its intensity. Since each hazard has specific characteristics with respect to intensity and frequency therefore it is impossible to come up with one classification for all hazards. Therefore in first step each hazard has been classified separately then combined according to the adopted weighting criteria (Fig: 1). The Delphi method developed by (Helmer. 1966), based on expert opinions has been utilised in this study to assign weights for each hazards and therefore an integrated hazard or multi/total hazard map was created by adding the intensities of individual hazards which was finally classified in four classes at scale 1-4, indicating very low or not effected, low, medium and high respectively.

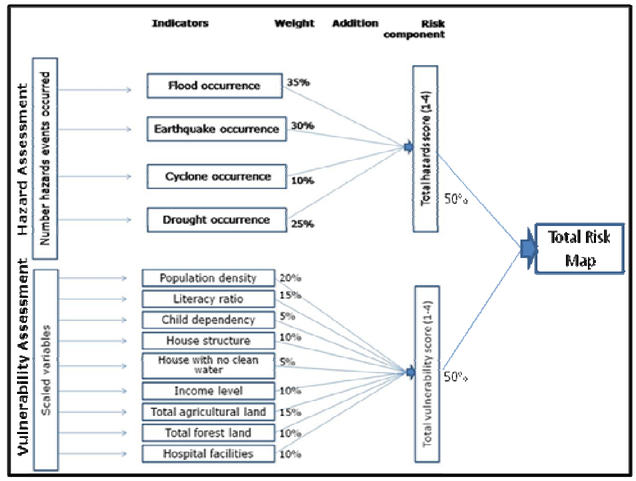

Fig. 1: Calculation of Total hazard, Total vulnerability and Hazard scores *(based on Greiving et al. 2006)*

3.3 Vulnerability Analysis and Measurement

To measure vulnerability, indicators that cover both damage potential and coping capacity, within the range of socio-economic, physical & environmental vulnerability dimensions were used. Damage potential indicators measure anything concrete that can be damaged by a hazard and measure the scale of possible damage in a particular region. Coping capacity indicators measure the ability of a community or a region to prepare or respond to a hazard (Satu Kumpulainen, 2006). The lack of vulnerability related (social-economic, environmental etc...) data sets not only constrained the approach to the evaluation of vulnerability assessment and measurement at district level but also has limited the number of indicators. However it has been possible to identify 9 indicators related to poverty, health, education and environment. Table.1. shows the indicators selected at the district level for this study

Categories of vulnerability	Description
Population density	People in danger
House structure	% of kacha house (mud house)
Income	Monthly house hold income
Education	Literacy ratio: Community's ability to understand information
Age dependency ration	% of Children
Health facilities	Hospitals bed/1,000 population
Sanitation	Houses with no improved water
Economic activities	Total agricultural land
Environment	Total forest land

Table, 1. Vulnerability Indicators

High population density may increase the potential damage of area and can be worst with limited health facilities and low income level. Generally the indicator 'house structure' present physical vulnerability of area but it can be consider as social status of community as well, therefore ratio of more mud houses (kacha houses) may decrease the coping capacity and increase the potential damage of area against flooding particularly. At local level, the most important factor concerning vulnerability is the level of income (Bishop, 1998). It is typically assumed that people with high income/wealth is less vulnerable than those with low income and wealth (Staines 2002), therefore high income levels increase the coping capacity and lower the vulnerability. The degree of dependency within household structure either children or elderly persons considered most vulnerable groups during disaster events, due to lack of information about elderly persons at district level only child dependency ratio has been used in this study. Indicator 'literacy ratio' measures community's ability to understand information. It is assumed that people with a low educational level do not find, seek or understand information concerning risks which ultimately decrease the coping capacity and hence are more vulnerable. Indicator 'hospital bed per 1000 population' determines the size of health facilities per district provided by the government which has direct impact on coping capacity of area in terms of emergency response & mitigation activities during disaster events. Research and experience have shown that forest play an important role in reducing the vulnerabilities of communities to natural disasters, both in terms of reducing their physical exposure to natural hazards and providing them with the livelihood resources to withstand and recover from crises therefore because of less forest land, the damage potential of area will increase which ultimately decrease the coping capacity of the community (IISD, 2005) Generally more agricultural land may indicate increasing agricultural productivity to raise the income of rural poor and generate rural jobs, but in case of severe flood , the damage potential of agricultural land are increased. By using indicator 'improved water facility', it is assumed that sufficient access to such facility may increase resilience and thereby reduce vulnerability to natural disasters (Cicone et el, 2003)

It must be stressed that although the above indicators are likely to be highly correlated, each indicator on its own will contribute to individual or community vulnerability and therefore can be considered separately.

Similarly as for hazard assessment, expert opinion based Delphi criteria has been adopted for assigning weights for all vulnerability indicators, figure 1 shows overall calculation used for total vulnerability assessment, in this way 4 classes were selected, ranging from the lowest to the highest vulnerabilities.

3.4 Risk Assessment

The total/integrated multi risk evaluated by combining the total hazard map and total vulnerability (Fig: 1) which make it possible to distinguish between those areas that are on high risk because of hazard, vulnerability or both

4. RESULTS AND DISCUSSIONS

Since the total hazard assessment (methodology as shown in figure 1) is heavily weighted toward floods, earthquake and droughts with cyclones receiving a meager weight, therefore the top twenty districts possessed high ranks of total hazard has been shown in figure 2, which are located in north (Chitral, Mardan, Sawat, Peshawar, Dir & Hafizabad) , southcentre (Jakobabad & Naushki), southwest (Chagai, Pashin, Awaran, Khuzdar, Bolan, Turbat, Gawadar & Panjgoor) and southeast (Thatta & Badin). Figure 2 also shows top twenty districts which acquire high ranks of possessed high and medium vulnerability ranks are with low economic activities so as with least income and education levels, and also having low health and clean water facilities, are mostly situated in southern part, few are in centre and in northern part of Pakistan.

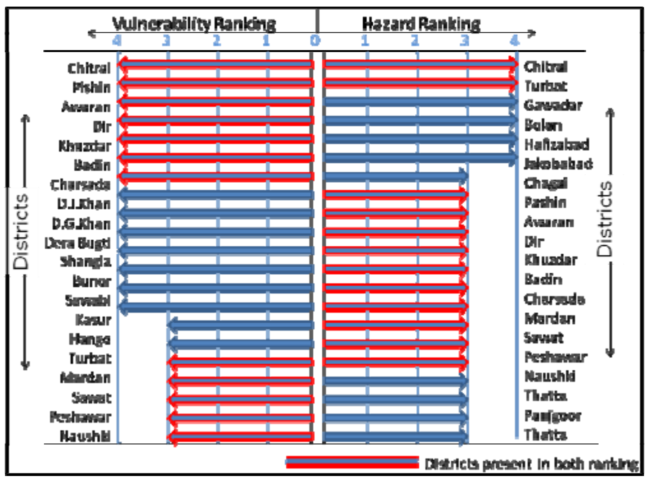

Fig. 2: Top twenty districts in Hazard and Vulnerability ranking

top twenty districts which acquire high ranks of vulnerability, are located in north (Chitral, Dir, Charsada, Peshawar, Shangla and Buner), southwest (Pashin, Khuzdar Awaran and Turbat), southeast (Badin), east (Rahimyarkhan, Kasur and Rajanpur), and in southcentre (Dera Bugti and Dera Ghazi Khan)

Figure 3 shows the overall pattern of risk for Pakistan at district level. Higher risk areas are found where both the hazard threat and vulnerability are high, while lower risk areas are found where the hazard threat and vulnerability are low; a gradation from low risk in the centrally located to extremely high and medium risk mostly located in the south while few located in north.

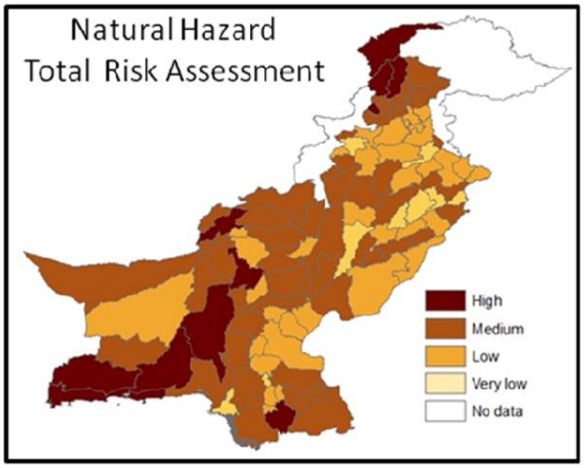

Fig. 3: Patterns of Total Risk to Natural Hazard for Pakistan at District level

Excluding some anomalies, the risk map naturally divides into four broad risk zones: very low in eastern districts, low risk in the central areas, moderate to high risk in the southern and northern areas. Districts with high risk ranking mostly located in south west, are; Gawadar, Turbat, Khuzdar, Awaran, Bolan, Pashin and few situated in north are; Chitral, Charsada and Dir respectively.

The risk map clearly demonstrates the compound problem of high frequency of multi natural hazard incidences and extremely high vulnerability in the above areas. Districts fell in very low risk ranking are well developed and are main hub of Pakistan's economic activities are located in south (Karachi), in east (Lahore, Faisalabad, Sargodha and Jhelum), although Peshawar and Rawalpindi districts ranked very low in total vulnerability assessment but due to high frequency of multi hazards (earthquake and flood) grouped both in medium risk level

5. CONCLUSIONS

Due to the unavailability of data several simplifying assumptions had to be taken which lead to some limitations of the results. The study is mainly based on information derived from secondary sources; a comprehensive survey in Pakistan was impossible due to security reasons and because of the limited scope of the research study carried out. Most of the information has been derived from the published reports of UNDP, FAO, WFP, NDMA, PMD, WMO and federal government statistics; therefore the range of available data limited the selection of indicators.

The data sets related to hazards are not sufficient for evaluating absolute risk levels and rankings posed by any specific hazard or combination of hazards; they are adequate for identifying areas that are at relatively higher single or multi hazard risks.

The weighting criteria need to be interpreted relatively. Assigning weights to factors is a normative process. The observations and judgments may differ from expert to expert. The Delphi exercise carried out in this study and the criteria used can be considered to be useful to create a common understanding about the existing risks of district or community. As it is known from literature this kind of ranking is understood even by non-experts explained to different audiences appropriately.

The multi hazard risk ranking was evaluated at a large scale i.e. at the district level. Therefore this information only allows to identifying most vulnerable districts but it does not provide sufficient spatial resolution to locate vulnerable areas within districts. The resultant aggregated risk map enables to see whether the level of risk is related to an area's hazard potential, its vulnerability or both, hence to be able to portray the disaster vulnerability ranking of Pakistan at district level on a map. The Delphi method adopted for evaluating appropriate weights of multi-hazard and total vulnerability shows common understanding about the relevance of existing hazards, vulnerabilities in districts. This common understanding can provide essential foundation for consensus of policy makers, local authorities to a) decide the level of acceptability of a risk, b) to determine which protection level is needed to be put in place and c) which predefined mitigation measure is best to be applied.

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