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MODERN APPROACHES IN FLOOD DISASTER RISK MANAGEMENT

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ABSTRACT

In all the natural hazards of world, floods are the most damaging. Pakistan has diverse geography with Northern alpines covered with glaciers and Southern Plains bordering the Arabian Sea. There are five big rivers flowing through the country from north to south namely the mighty Indus and its tributaries i.e. Jhelum, Chenab, Ravi and Sutlej. There is a well marked monsoon season from July to mid September in which most of the country receives rainfall. Riverine flooding is common in the low lying areas along the rivers during monsoon season while flash flooding is also experienced in hilly and semi hilly areas. Since its creation, Pakistan has faced several floods. These floods affected the basins of the rivers in Punjab and Sindh. Also, in Khyber Pakhtunkhwa (KP), Balochistan, FATA, G.B, AJK and in some areas of Punjab , damages are caused mainly due to flash floods in secondary and tertiary rivers including hill torrents. Flood counts for more than 80% of the natural disasters considering the scale of people affected in Pakistan. The country needs to do all it can to protect people from future catastrophic flood disasters and increase the resilience of infrastructure, economies and communities including better emergency warning and evacuation systems, better flood protection for key infrastructure and plans to help communities recover once the waters recede. There is immense need for improving flood damage mitigation potential in the country. In this paper some modern approaches have been discussed and recommendations have been made for effective flood risk management in the country.

KEY WORDS; Flood Disaster, Risk Management, Flood Damage Mitigation

1. INTRODUCTION

Inundations due to floods have the potential to cause fatalities, displacement of people, and damage to the environment and thus severely compromise economic development. Flooding accounts for 40% of all the natural hazards worldwide and half of all the deaths caused by natural disasters (e.g. Ohl and Tapsell 2000; Jonkman and Vrijling 2008).

Floods are natural phenomena which cannot be prevented; nevertheless, some human activities contribute to an increase in the likelihood and adverse impacts of flood events (European Parliament, Council 2007). First, the reduction of the natural water retention by inappropriate land use and river management (e.g. continuous embankments) increases the scale and the frequency of floods. Recent analyses investigated such effects on flood hazard (see, e.g. Fohrer et al. 2001; Wooldridge et al. 2001; Brath et al. 2003; Camorani et al. 2006). Second, there has been an increasing vulnerability of flood-prone areas because of the growing number of people and economic assets located in flood risk zones (flood-prone areas are traditional zones of special importance as they offer favourable conditions for human settlements and economic development). Finally, flood risk, that may be defined as the product of probability of flood and associated damage (i.e. the damage expectation, Merz et al. 2007), increases with economic development given that potential damage increases.

Resistance strategies of flood risk management are based on the construction of levees may be (Vis et al. 2003). The design of levees and other water-retaining structures is usually based on an acceptable probability of overtopping and the portion of risk that remains is called residual risk (van Manen and Brinkhuis 2005). Residual flood risk behind levees is largely unaccounted. Levees are usually characterised by a uniform safety level (e.g. return period equal to 200 years). It implies that streamflows above the design discharge may cause flooding anywhere and even at several locations at the same time, and therefore the evolution of the flood event is unpredictable. It is obvious that this condition is undesirable (e.g., in case of exceptional events a large area must be evacuated as all areas adjacent to the river theoretically have the same probability of flooding).

The so-called resilience strategy is a different approach to flood risk management. The concept of resilience originates from ecology (e.g. Holling 1973) and was introduced, in the context of flood risk management, by De Bruijn and Klijn (2001). The idea behind the resilience approach is living with floods instead of fighting floods. In this approach, flooding is allowed in certain areas, whereas the impact of flooding is minimised through policies of land-use planning and management (e.g. Vis et al. 2003).

2. HUMAN RESPONSE TO FLOOD HAZARD

According to Hewitt and Burton (1971), the flood hazard comprises many aspects including, structural and erosional damage, loss of life and property, contamination of food, water and other materials, disruption of socio-economic activity including transport and communications, and the spoiling of agricultural land. The principal relationships between flood hazard and response were formalized by Kates (1971). Some of ideas are incorporated into Figure-1 which shows schematically the main facets of man's response to the flood hazard.

The extreme responses to the flood hazard are, on the one hand, indiscriminate development of floodplains and flood prone coastal areas, thereby inviting considerable damage, suffering and loss of life, and on the other hand, the complete abandonment of these areas, which would clearly represent gross waste of a valuable resource (Bue, 1967). In reality an intermediate view normally prevails in which response is strongly related to perception of the hazard which, in turn, is very much dependent upon experience.

Major types of response to the perceived flood hazard are detailed in Figure 1. Basically, the choice lies between moderating human activities in flood prone areas and moderating the floods themselves, either by action taken in the catchment area of a river or by action taken along the channel. In other words, the choice is between adjustment, abatement or protection. For a number of reasons the most frequent choice until comparatively recent was that of protection by means of the physical 'control' of the river. Gradually, as general awareness of the socio-economic aspects of flooding hightened, adjustment became a more widely canvassed and more imaginative alternative to the engineering approach. A third possibility, long applied in the field of erosion control, is that of abatement by means of improved catchment management techniques. The continuing development of our understanding of flood producing processes has opened up the possibility of replacing the previous ad hoc attempts at catchment manipulation by scientifically based approach to flood abatement.

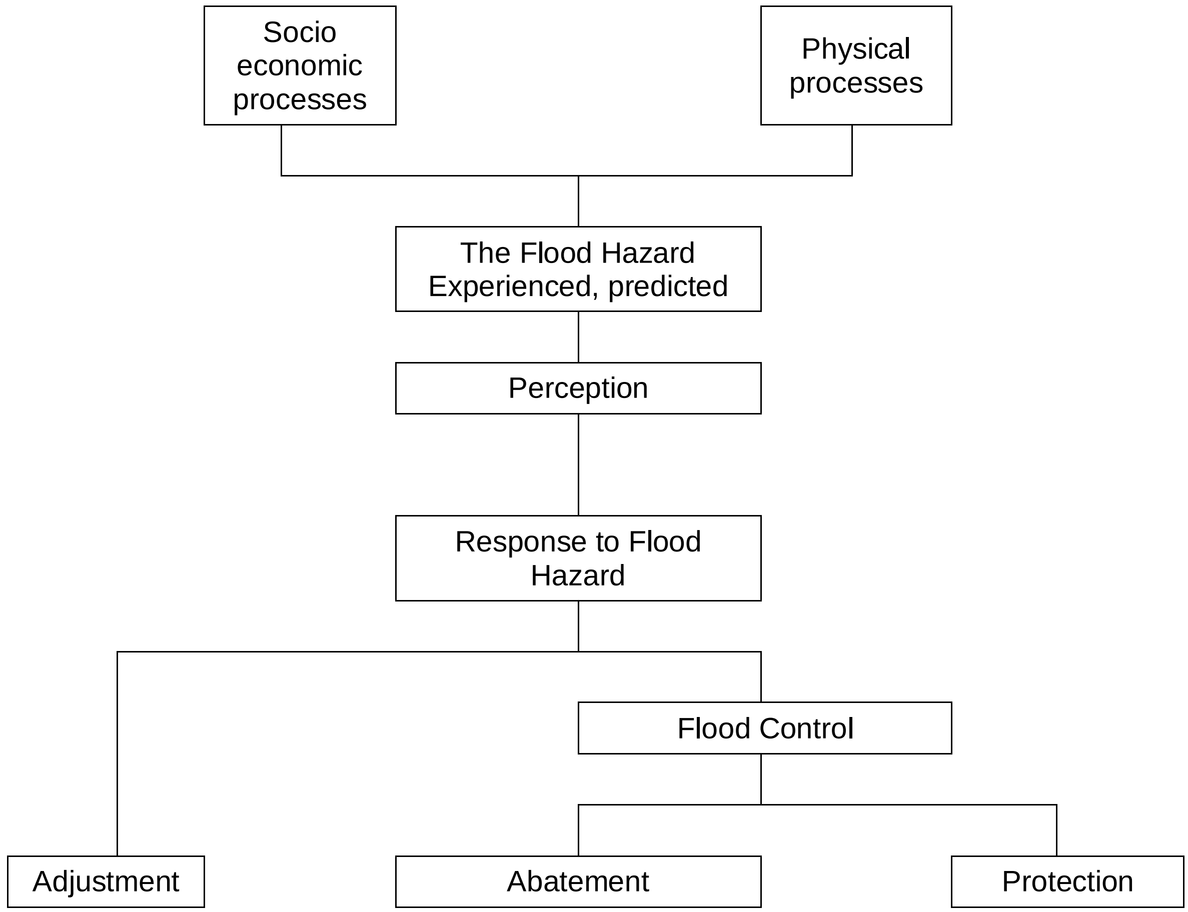

Figure 1: The Main Elements of Man's Response to Flood Hazard

3. POSSIBLE ADJUSTMENT TO FLOOD HAZARD

It is evident that human beings adjust in a number of ways to the flood hazard and that their adjustment may represent a viable complement to, and in some cases substitute for, the control of water in river channels or the wholesale removal of intensive land-use from flood-prone areas. The changes in land use could be made selectively and in effective combination with emergency action, structural changes and other measures that imply accepting a degree of coexistence of man and water on the same land. Some of the possibilities are briefly discussed.

3.1 NO ADJUSTMENT

The most common adjustment to the flood hazard is simply to suffer and bear the losses when they occur. This is certainly the response in countries where the people are too poor to do any thing else or where there is ignorance either of the flood hazard or of any alternative response. The growing emphasis on assessing all types of response to the flood hazard in benefit cost terms implies that in many cases bearing the loss may be the cheapest of the range of possible adjustments, certainly as far as the expenditure of public monies is concerned. In most developed countries, however, the experience of being flooded usually results in some conscious adjustment intended to offset future losses.

3.2 EMERGENCY ACTION

Emergency action constitutes a more or less unpremeditated response to a flood warning and involves varying degrees of prior preparation by private individuals, but often a high degree of prior organization by responsible public services. Emergency action usually encompasses the removal of persons and property from the flood hazard area, the protection of immovable property and the rescheduling of certain operations. The success of such measures will depend largely on the amount of advance warning that can be given and partly on the type of evacuation, protection and rescheduling which has to be carried out.

3.3 FLOOD PROOFING

There are a number of ways in which a combination of emergency action with structural changes or the adoption of appropriate structural design standards can be used to reduce the vulnerability of individual buildings and units to the flood hazard. Hoyt and Langbein (1955) outlined some of the possible courses of action, such as the installation of submersible electrical circuits, the anchorage of ‘floatable’ buildings, proper bridge and culvert design to avoid damage by floodwaters, the bulkheading of buildings, the sealing of non-essential openings in buildings below flood level, and so on. Later Sheafter (1960) coined the term ‘floodproofing’ to designate this particular adjustment to the flood hazard.

3.4 LAND-USE REGULATION

Land-use regulation is employed to obtain the beneficial use of floodplains with a minimum of flood damage and a minimum expenditure on flood protection. In other words, it aims to promote such land usage that the benefits derived from using the land exceed the flood damage plus the cost of providing a specified degree of protection (Bue, 1967). Land-use regulation aims to the policy which combines the abandonment of limited parts of the flood prone areas with a careful regulation of land-use in the reminder of such areas. In the flood-plain situation, Murphy (1958) distinguished between the floodway- the channel and those adjacent parts of the floodplain necessary for the conveyance of a selected flood discharge, for example the 100-year flood- and the remainder of the floodplain, sometimes referred to as the floodway fringe. He suggested that the aims of land-use regulation are to prevent encroachment on the floodway cross section.

3.5 FINANCIAL ADJUSTMENT

A number of financial procedures may be used to modify human response to the flood hazard. Some, like certain other types of adjustment and control, in the long term often exacerbate the flood problem rather than alleviate it. It is important to recognize that assured social / governmental assistance does nothing to reduce the flood hazard; indeed, by encouraging rebuilding and modernization of damaged property, it may substantially increase the potential flood damage. Moreover, the expectation that financial help will be available in any emergency may encourage new development in flood prone areas, further adding to the problem.

3.6 CHOICE OF ADJUSTMENT

Although each of the adjustments discussed here may be theoretically available, it may not in practice, represent a realistic choice. For example, insurance will have little effect unless there are strong incentives to purchase it. Again certain solutions may be politically unacceptable and others ruled out by physical conditions, as in those desert and other areas where the flashiness of flooding makes emergency evacuation almost impossible. It is equally important to reiterate that these possible adjustments are by no means mutually exclusive; indeed, a combination of alternatives will often provide the most economically attractive solution.

4. FLOOD ABATEMENT

It is sometimes referred to as watershed (or catchment) management and constitutes an attractive scientific procedure in which the flood problem is approached from first principles and action is taken at the point upstream where the flood is generated rather than waiting to take action downstream at locations where that flood would represent a potential threat. Flood abatement thus subscribes to the basic maxim that 'prevention is better than cure'. It would, of course, be ideal if, through proper management of catchment areas, flood could be avoided. It will be seen, however, that this is not always possible and that, even where it is, the flood abatement approach is often hampered by a number of problems.

Lack of understanding of the physical processes involved in flooding has been a major problem in the past. A related problem is that much that has been achieved so far in this field is of a piecemeal and empirical nature. Outside of experimental and research programmes, there has been very little organized catchment treatment of flood control. The situation is more positive in some countries, such as the United States, where there is a legislative framework for watershed treatment and a fairly substantial annual expenditure, commonly amounting to about 10 per cent of the total expenditure on flood control. Because of the scarcity of land treatment programmes for flood control, together with the large number of watershed experiments aiming at increased water yields from river catchment areas, much of the evidence concerning the effects of upstream land use manipulation is of a negative kind in regard to flood prevention. For example, the effects of deforestation is increasing stream flow are well documented, but comparatively few experiments have investigated the effects of afforestation in decreasing stream flow.

5. FLOOD PROTECTION

Flood protection refers to attempts to minimize or mitigate flood damages by means of structural measures in a way which is economically feasible. Sometimes, the population resident behind the protective works may be lulled into a false sense of security and not evacuate in time when a large flood threatens. In such a situation, loss of life and property can actually be greater than if no protective works had existed. Engineers, extremely conscious of this paradox, realize they must clearly explain to the public the degree of protection afforded by each structure (Linsley and Franzini, 1972).

With experience over the centuries, a variety of structures have been evolved to mitigate the flood hazard. Their aim was to achieve at least one of the following objectives: a reduction in the area flooded a reduction in the depth of floodwaters or a reduction in flood discharge. Specifically, the four main approaches involve:

(1) The construction of embankments (sometimes referred to as dikes or levees) and floodwalls to confine the floodwaters.

(2) The improvement of river channels to enlarge their discharge capacity, for example, by straightening, widening or deepening.

(3) The construction of bypass and diversion channels to carry some of the excess floodwater away from the area to be protected.

(4) The construction of reservoirs for the temporary storage of floodwater.

In most circumstances a combination of two or more of these approaches is used to develop an optimum solution to the flood problem. Since, however, even within one region non two rivers have an identical regime, and even a single river rarely has two floods with the same characteristics, methods of flood protection vary from place to place and it is difficult to assess whether a method which has been successful at one location will be equally so at another

(United Nations, 1951). In any case, to a large extent the method of flood protection used shows a fairly close relationship with the progress of economic development. It is not so much the lack of technical skill in under developed countries, but the absence of financial and economic justification that prevents the employment of more advanced and usually more expensive methods (United Nations, 1951).

6. FLOOD DAMAGE ASSESSMENT

It is usual to differentiate tangible and intangible damages according to whether or not they can be expressed in monetary terms. Intangible damages include fear, anxiety, annoyance, distress, insecurity, ill-health and ultimately loss of life (Parker and Penning-Rowsell, 1972). It will be emphasized later that a number of the major problems in flood damage estimation concern the quantification of intangibles, some of which are extremely suspect. An even more basic problem is the failure to agree on which intangibles it is possible or even desirable to attempt to quantify

A schematic breakdown of flood damages is shown in Figure 2.Tangible damages can be further subdivided into direct and indirect categories. Direct damages result from the direct physical contact of damageable property with floodwater and the extent of the damage is assumed to be the cost of restoration of that property to pre-flood condition, or to its current market value if restoration impracticable. Direct damages thus include physical damage to buildings and their contents, bridges, roads and railways, physical damage to agricultural land, particularly in the case of coastal flooding by salt water which can result in long term deterioration of soil structure and fertility and finally the loss of agricultural crops. Direct damages are controlled by the physical characteristics of the floodplain or coastal land use system and by its susceptibility to flooding (Middlesex Polytechnic, 1974). Indirect damages are losses resulting from the breakdown of certain physical or economic linkages in the economy. Examples include loss of production, loss of income and business, and delays in transportation of goods and people involving the valuation of time.

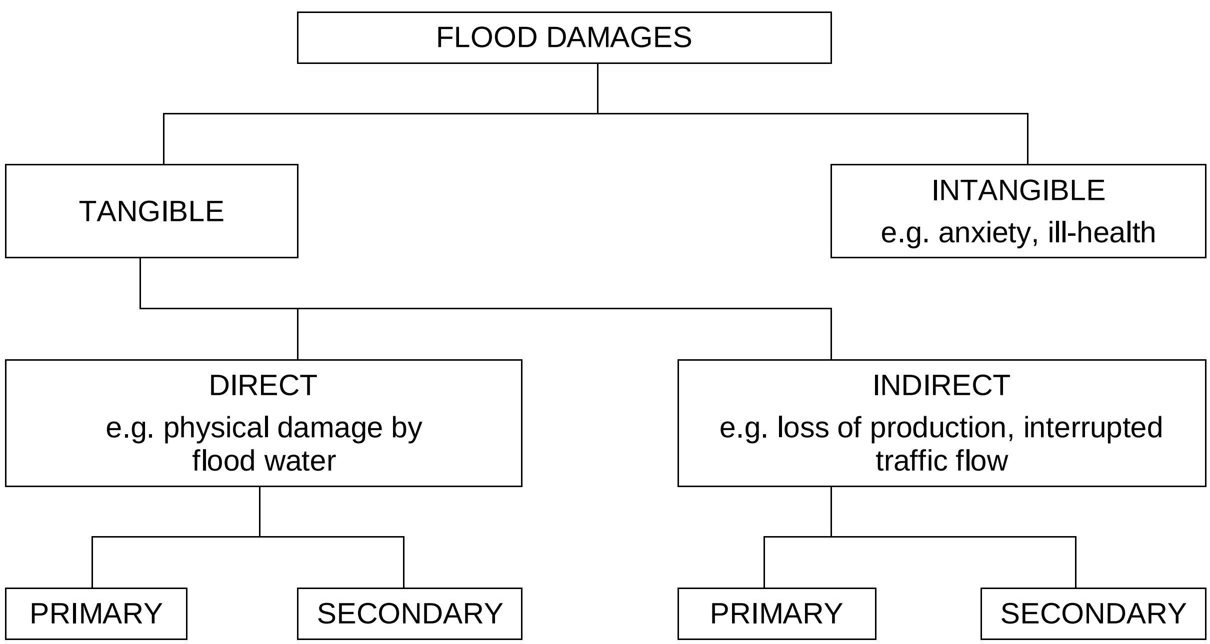

Figure 2: Schematic Breakdown of Flood Damages

The flood damages can be alternatively classified according to the categories of land use affected, in each of which flooding causes markedly different types of damage, for example agricultural, residential, retail/ commercial/ offices, public utilities, public buildings, industrial, transportational, recreational. Again, Kuiper (1965) referred to a simple fourfold classification as follows: (1) Physical damage to buildings and their contents, bridges, roads, railways, etc. (2) Agricultural crops losses, (3) Loss of income due to interruption of business, and (4) Cost of flood fighting, and the evacuation, care and rehabilitation of flood victims.

7. FUTURE PROSPECTS IN FLOOD DISASTER RISK MANAGEMENT

Floods have been presented as a global phenomenon affecting both rich and poor, the prepared and unprepared. They are a complex, interdisciplinary problem-for some aspects satisfactory solutions have already been advanced, but for others no likely answers are as yet forthcoming (Ward, 1978). Man's attempts to control rivers have often had little or no success. In fact, many times his efforts have aggravated the situation (Marie Morisawa, 1968). The greatest natural disasters come as a result of ignorance or, even worse, half-knowledge.

One hopes for an improvement in this situation as new understanding and improved techniques of accumulating and processing data reflect the current "knowledge explosion'. In terms of the global flood problem, though, it seems unlikely that dramatic advances will develop in our understanding of the basic physical processes which cause flooding, or the emergence of new techniques of flood prediction or even the discovery of new responses to the flood hazard. In each of these fields substantial advances have been made during the past two or three decades and our present level of comprehension is high. In other areas, however, advances are long overdue which could do much to alleviate flood problems at the local, national and international scale.

Although in some areas limited categories of flood data have been collected for very long periods, there are other areas in which programmes of data collection have only recently been initiated. Both long and short data runs tend to be characterized by the variable quality of the data and in many cases analysis and interpretation are impeded by the form in which the data have been collected. Also, there has been an inexcusable concentration on the collection of hydro-meteorological data and a corresponding neglect of socio-economic data even in recently initiated data collection programmes.The variable quality of both hydro-meteorological and socio-economic data is likely to be a continuing problem, although some improvement will undoubtedly come with the introduction of better data collection techniques and instrumentation. There is, however, considerable scope for improving the form in which data are collected and presented.

There is need for the compilation of clear and useful information on floods and flood hazards; the encouragement of optimum use of valley-bottom lands; the dissemination of flood hazard information to the general public; and the reduction of future expenditure on flood alleviation resulting from improper use of floodplains.Also, there is undoubtedly scope for improving flood forecasts. The main potential improvements seem likely to be brought about not by more rapid processing of data in larger and faster computers, but by reducing the time taken to input hydro-meteorological data to the computers. In this respect improved precipitation or tidal-level forecasts based on satellite observations, together with improved techniques of areal precipitation assessment, for example through the use of radar, may play an important part. However, as has been frequently observed, in the case of river floods it is not only the precipitation input which matters but also the hydrological responsiveness of the catchment on which it falls. Clearly then, procedures which permit an accurate continuous accounting of catchment wetness, expressed perhaps in terms of soil moisture deficit or by direct satellite observations of soil moisture status , are likely to play a major role in improved forecasting. Flood forecasting will undoubtedly also benefit from direct satellite observations of the areal extent of upstream flooding and its change with time.One of the most pressing tasks in flood management is to sharpen the perception of the flood hazard and the range of possible responses among those most at risk. From repeated experience it is obvious that more than the mere presentation of facts is required.

While floods may be natural occurrences, the flood hazard is largely man-made and as long as man chooses to live in flood-prone areas disasters are inevitable. Certainly, much progress has been made already and further progress will undoubtedly come about as a wide range of skills is brought to bear on this complex and far reaching problem-skills which include a knowledge of flood-forming processes, an understanding of probability theory, an acquaintance with economic analysis, an insight into the social behaviour of man and an awareness of the realities and constraints of the political process (Penning-Rowsell and Underwood, 1972). However, it must be borne in mind that the protection from floods is only a relative matter, and that eventually nature demands its toll from those who occupy flood plains.

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