INTEGRATED FLOOD MANAGEMENT IN THE CONTEXT OF DEVELOPMENT PLANNING

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Abstract: Sustainability and effectiveness of urban and rural development depend on how to manage potential risks there. Flood risks need to be well considered in development planning take risk-aware decisions. Integrated Flood Management (IFM) is a development policy concept that integrates land and water resources development in a river basin, with a view to maximizing the efficient use of flood plains and minimizing loss of life. As such floodplains are viewed not only as areas of risk but also as areas of opportunity. Flood risks result from a combination of components, comprising hazard, exposure and vulnerability. The recognition of these components facilitates the understanding of flood risks because it underlines that only the combination of natural and human factors create flood risks. Apart from the damage potential the degree of vulnerability of various human activities to flooding plays a crucial role in determining overall flood risk. Ensuring livelihood security and poverty alleviation thereby reducing vulnerability is one of the IFM objectives. Vulnerability can be defined as degree to which a socio-economic system is susceptible or resilient to the impact of flood hazards. In the context of land use-planning and regulation, for instance, one way of approaching flood vulnerability is to classify different types of developments and uses. Each class of developments can be regulated differently under the principle that the higher the vulnerability of the development or use the more elaborate the regulatory framework governing development permits and emergency preparedness measures. A prerequisite for taking such risk-conscious decisions in development planning is the availability of sufficiently reliable flood maps at adequate scales and level of detail.

Keywords: Capability assessment, disaster preparedness, local government, emergency management, Japan

1. INTRODUCTION

Ongoing developments such as population growth and connected issues of food security and urbanization put land and water resources under considerable pressure. Looking at the development history of societies it becomes evident that floodplain areas have been preferred for human settlement. Some of the reasons for this development in the past have been the readily available natural resources such as fertile soils and abundance of water resources, readily available livelihood opportunities in agriculture and fisheries, transport links and access to markets for economic goods. The human response to the prevailing flood hazard on those lands has in most cases been based on the construction of flood defenses. Modern flood management approaches employ, however, a much wider array of flood management measures, both structural and non-structural. While the contribution of those flood-liable lands and the flood protection infrastructure to socio-economic development need to be recognized, the growing risks to the development process have become evident over the past decades in numerous examples of large scale flooding with serious economic consequences. Flood risk is described as a function of the flood hazard (probability of occurrence of a particular flood

event), the exposure of human activity to the flood (flood damage potential) and the specific vulnerability of the community affected by the flood. Integrated Flood Management (IFM) as a development policy concept calls for a balance between the development needs of society and the flood risks oriented towards the maximization of net-benefits derived from the flood plains to ensure sustainable development.[1] This paper is to bring the different aspects of flood risks together under the umbrella of a risk management approach that aims to explain flood risks as well as to show possibilities of how they can be managed successfully under IFM concept.

2. CAUSES AND IMPACTS OF FLOOD RISK

In order to fully understand flood risks it is crucial to be familiar with the different components that construct risks. Often risk is understood only superficially by equating it with the occurrence of an extreme event or hazard (flood, drought, earthquake, storm, landslide etc.) caused by natural forces or by a combination of natural forces and human influences. Although the occurrence of such a hazard is obviously the primary precondition, it is only one component in the creation of risk. The second component in the creation of risk is the fact that somebody or something has to be *at risk*; that is vulnerable to a hazard. This widespread definition makes the basic structure of risks very clear. However with reference to the term vulnerability a further distinction is necessary in order to enhance the understanding of the creation of flood risks. The notion of vulnerability in this definition does not distinguish between the mere physical exposure to hazards on one hand and the susceptibility of persons or things to hazards on the other hand. At first glance this might be considered to be a distinction without difference but when it comes to the analysis of flood risk and to the question of which measures are most effective in reducing such risk this distinction does make a difference. Hence the following chapters are based on this extended definition of risk:

> *"Risk is the probability of a loss, and this depends on three elements: hazard, vulnerability, and exposure. If any of these three elements in risk increases or decreases, then the risk increases or decreases respectively."*[2]

Risk = function (Hazard x Exposure x Vulnerability)

While exposure refers only to the question whether people or assets are physically in the path of flood waters or not, vulnerability may be defined as "The conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards"[3].

2.1 Understanding flood hazards

Floods result from a combination of meteorological and hydrological extremes as indicated in the Table 1. In most cases floods are additionally influenced by human factors. Although these influences are very diverse, they generally tend to aggravate flood hazards by accentuating flood peaks. Thus flood hazards in built environments have to be seen as the consequence of natural and man-made factors.

Table 1. Factors contributing to flooding

Meteorological Factors	Hydrological factors	Human factors aggravating natural flood hazards
- Rainfall - Cyclonic storms - Small-scale storms - Temperature - Snowfall and snowmelt	- Soil moisture level - Groundwater level prior to storm - Natural surface infiltration rate - Presence of impervious cover - Channel cross-sectional shape and roughness - Presence or absence of over bank flow, channel network - Synchronization of run-offs from various parts of watershed - High tide impeding drainage	- Land-use changes (for example, surface sealing due to urbanization, deforestation) increase run-off and may be sedimentation - Occupation of the flood plain obstructing flows - Inefficiency or non-maintenance of infrastructure - Too efficient drainage of upstream areas increases flood peaks - Climate change affects magnitude and frequency of precipitations and floods - Urban microclimate may enforce precipitation events

2.2 Impacts of Floods

Floods have large impacts particularly in terms of economic losses both direct and indirect. Flood risks are a function of exposure of the people and the economic activities along with the vulnerability of social and economic fabric. As such the impact of such floods on the lives and livelihoods of people, a function of their vulnerability, needs to be understood. Especially, a number of urban areas particularly in low and middle income countries that have relevance to the increased flood risks are:

- Concentrated population due to concentrated income earning opportunities;
- Large impermeable surfaces and construction of buildings;
- Concentration of solid and liquid waste without any formal disposal systems;
- Obstructed drainage systems;
- Intensive economic activities;
- High value of infrastructure and properties;
- Forcing out of poor from official land markets giving rise to informal settlements;
- Housing without any health and hygiene standards; and
- Changes in regions around cities.

2.3 Exposure

Exposure refers here exclusively to the question of whether or not people or values are in range of flood waters. One of the major factors for the rise, especially in urban flood damages, is simply the increasing number of people and assets that are physically exposed to floods in cities. The fast and unplanned growth of cities results in a larger number of people living in areas potentially liable to flooding. Around 2006 the global population living in cities exceeded for the first time in history the global rural population, thus introducing "the urban millennium".[4] The number of people living within 1 meter of high tide level exceeds 150 millions[5]. Cities in many developing countries are growing rapidly. Unprecedented migration from rural areas to cities has led to uncontrolled urban sprawl with increasing human settlements, industrial growth and infrastructure development in hazard areas such as riversides, wetlands, land below the river, sea or reservoir level or even inside dried up river beds - areas where floods will occur sooner or later. Often, urban growth that expands over some of the floodways, reducing the area into which floods can naturally overflow. In small islands sea level rise is expected to increase the exposure to inundation due to storm surge and erosion thereby threatening infrastructure and livelihood of people. Due to economic development, assets are growing even faster than population[6]. With the progress of the societies therein, the value of the assets that are now concentrated in such areas has gone unchecked and unabated. The human settlements and infrastructure behind such embankments assume the area to be free from flood risks grossly ignoring the residual risks that are associated with any flood protection scheme. The infrastructure such as underground transportation systems, multi layered basements used for storage and the telecommunication networks that have indirect impacts on the economies have spiralled over the past few decades. The cities and urban population protected from floods with structural measures have over the years intensified their economic activities in such areas. However, urban growth need not necessarily lead to the intensification of risks if it takes into account the flood risks in the land use planning processes. The decisive factor is whether urban growth factors flood risks in the development process or not. Many a times the commitment to flood risk sensitive urban planning depends strongly on the flood frequency. After years or decades without major flood events it becomes more and more difficult to maintain the flood awareness of both people and authorities. This is particularly the case with urban settlements allowed to develop behind the flood levees. Unfortunately, many urbanization processes take place either without any planning or with plans that ignore or underestimate flood risks. Often the construction and land use regulations, the underlying legal basis, as well as a set of concrete plans do exist but are not enforced. In short, the increase of the exposure component of risk in terms of number of people at risk constitutes mainly a challenge for the developing world, whereas the increased exposure of assets is a challenge for all countries, particularly to the developed countries.

2.4 Vulnerability

Vulnerability is the most crucial component of risk in that it determines whether or not exposure to a hazard constitutes a risk that may actually result in a disaster. If the potential exposure to floods becomes reality, that is when flood waters physically encroach on people and infrastructure, then the vulnerability of people and infrastructure is decisive for the degree of harm and damage. Vulnerability can be defined as degree to which a socio-economic system is susceptible or resilient to the impact of flood hazards. While this definition can also include flood damage, resilience includes the aspect of how well the system is coping and is as such influenced by community's combination of prevailing social conditions and factors such as poverty and livelihoods[4,7]. For instance, if an emergency shelter or an essential access road is flooded, the structural damage may be negligible compared to the problems this creates for the emergency

response, in finding adequate alternatives and in consequence the safety and well-being of the affected population and the speedy recovery process. In cases where means of local income generation are disrupted or destroyed by flooding, such closure of as local factories, the recovery process may be much more problematic, far beyond the direct damage to the facility.

Physical vulnerability of people and infrastructure

Development inherently creates larger risks, but those in higher income groups are able to avoid or bear such risks while those with low incomes cope with them to their detriment. There is a clear socio-spatial segregation with reference to the hazard exposure of settlement locations. For instance, since urbanization is essentially the increase of population density, space gets rare and expensive. Consequently those who cannot afford to purchase or to rent space in secure environments are forced to move to cheaper places. Such locations may be found at the outskirts of town or in areas inside town where the wealthier do not want to live, for example, because these areas are prone to floods or other hazards. Given the fact that the livelihood of the urban poor often depends on the proximity to informal economies in the central areas of big cities, many prefer to inhabit hazard areas inside town. Two more factors aggravate this spatial marginalization. First, hazard prone areas are often not privately owned, and thus informal dwellers are less likely to get displaced. Second, however, many urban poor are migrants from rural areas who are not familiar with the respective hazards and therefore tend to underestimate the risk of living in such exposed areas. The physical vulnerability of urban populations tends to increase as a result of the dense concentration of potentially dangerous infrastructure and substances in urban areas (solid and liquid waste, chemicals etc.). Existence of health threatening infrastructure such as sewage treatment plants (usually located at very low spots), waste dumps or dangerous industries at such locations, increases additionally the risk of secondary hazards and damages. Special attention in the context of human settlement locations has to be paid to socio-economic factors. Obviously healthy and young people are more likely to resist physical stresses than sick and old people. In addition, those who are familiar with a given stress situation might have developed certain adaptation techniques that allow them to cope with floods despite of their disadvantaged physical condition. Similar explanations apply to infrastructure. Although concrete houses are less likely to get destroyed by floods other more simple houses might be less vulnerable provided that they are well-adapted to floods, for example, stilt houses.

Unfavourable organizational and economic conditions

Informal settlement dwellers are unable to act effectively together. As such they face difficulties in getting support from government and make use of institutional mechanism to the betterment of their conditions. The lack of organizational structures may lead to chaotic circumstances in times of stress whereas the existence of formal or informal organizations or institutions may constitute a stabilizing factor. In any case mutual support among community members is crucial for coping with stress situations. Such informal social networks are often the only “insurance” of the poor and are particularly important if official support is weak. Unfortunately it belongs to the characteristics of urban poverty that social networks tend to be weaker in cities than in villages. Livelihoods of people living in informal settlements, is dependent on their daily earning capacities, which is severely effected by flooding. On the other hand, those who have regular source of livelihood, their income are not disrupted by floods. Economic vulnerability prevails obviously among those households who lack financial resources and those who cannot afford or are reluctant to purchase flood insurances.

Attitudes and motivations

Reluctance towards flood preparedness and mitigation measures may be the result of lacking hazard knowledge or of fatalistic attitudes. Moreover, dependence on too much external support can reduce the individual responsibility to deal with problems in a proactive manner. Like exposure, vulnerabilities should not be considered merely as given unsafe conditions but as the result of different processes, which finally make people and their belongings more or less susceptible to the impact of hazards. Among the root causes of these processes, socio-economic factors are the driving forces, including access to or exclusion from education, medical facilities, economic opportunities, political participation and the use of natural resources. Those entitlements usually depend on the socio-cultural background of people in terms of class, ethnic origin, gender and religion. In the case of a hazardous event, access to such entitlements enable “… a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard”.[8] Such capacities are also referred to as resilience, the opposite of vulnerability.

2.5 Flood Damages

The impacts of urban floods can be physical, economic and environmental. In addition to the exposure and vulnerability, the magnitude of the damage depends on the flood type (especially in terms of depth, flow velocity, water quality, duration and sediment load). Figure 1 provides an overview of typical flood losses and distinguishes moreover between

primary, secondary and tertiary loss categories. Although the impacts of urban floods are almost exclusively adverse, it should be kept in mind that riverine floods in rural areas often have positive ecological effects.

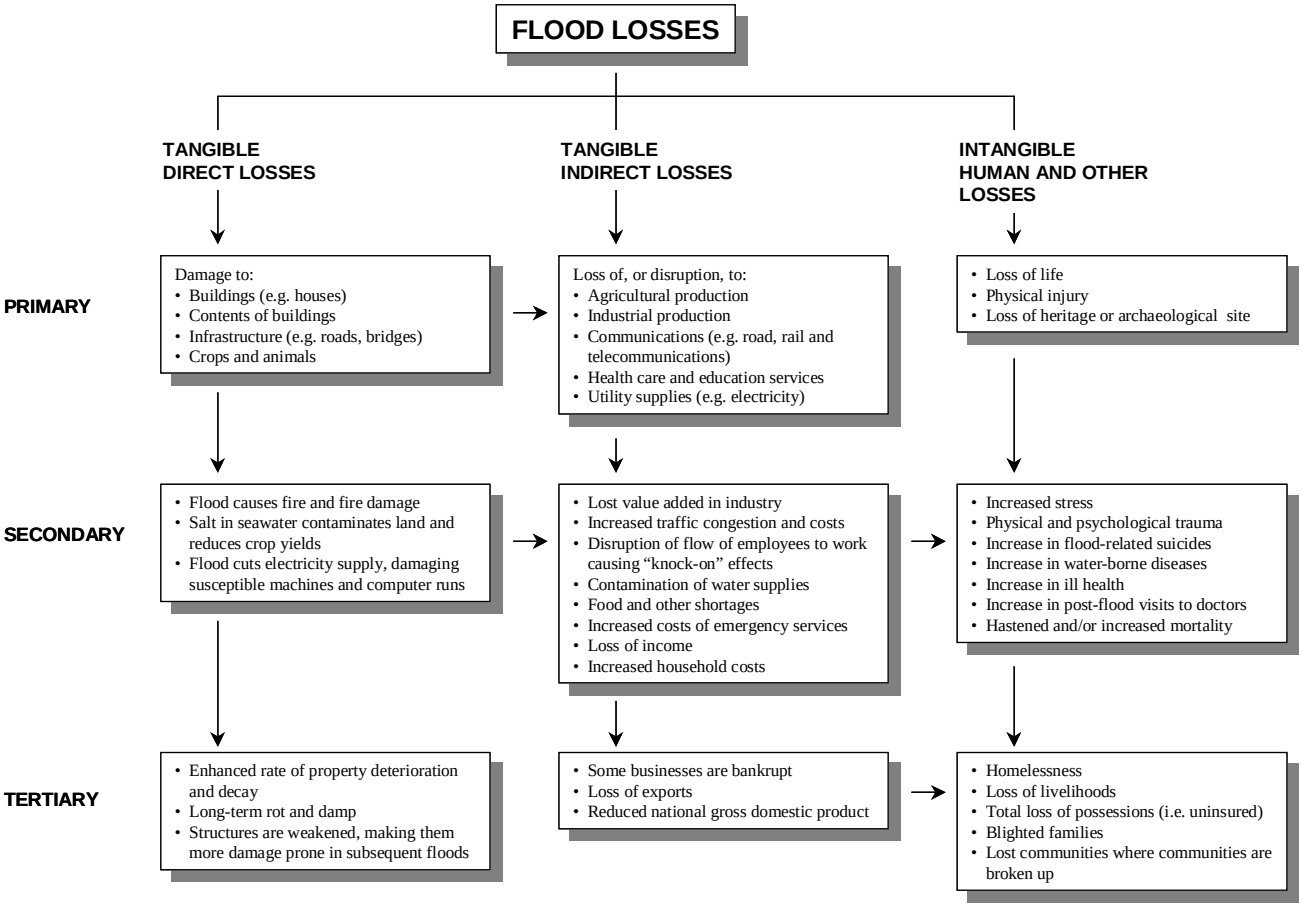
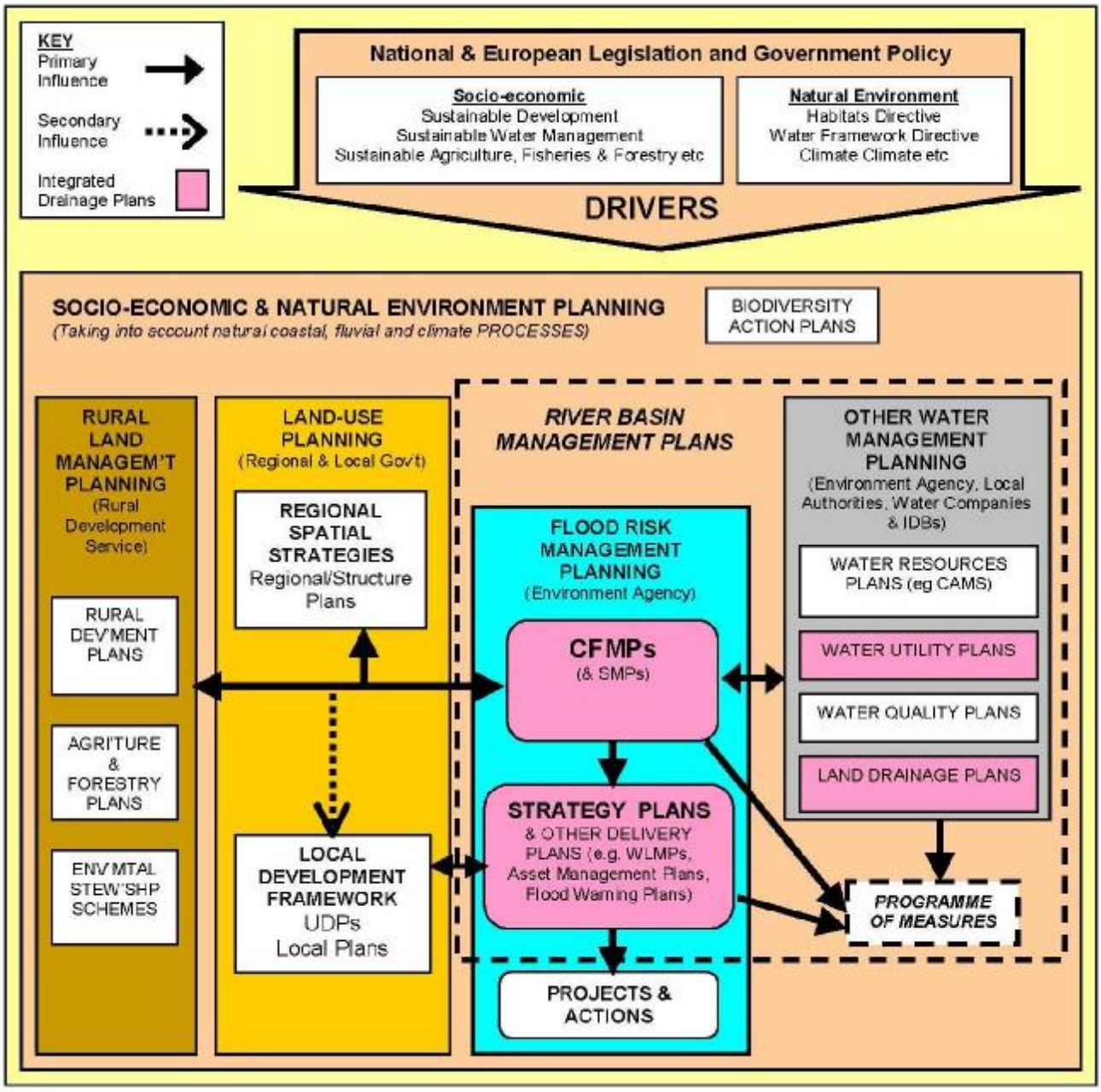


Figure 1. Categorization of Flood Losses [9]

3. INTEGRATED FLOOD MANAGEMENT IN DEVELOPMENT PLANNING

The ultimate aim of integrated flood risk management is to minimize human loss and economic damages, while making use of the natural resources for the benefit and well being of the people. However it is realized that absolute flood security is in most cases utopian. Flood risks cannot be entirely avoided, thus they have to be managed. Consequently, flood management does not strive to eliminate flood risks but to mitigate them. This may be achieved either by reducing flood risks to an acceptable level or by retaining, sharing or transferring flood risks through respective measures. The complex inter-relation between various development processes and flood management is illustrated by an example from England in Figure 2.

A feature apparent from this example is the obvious disparity between plans prepared for certain jurisdictions such as the municipal or national level and those developed for catchments and river basins. One way of approaching this is through flood vulnerability classifications of different types of developments and uses. Each class of developments can be regulated differently under the principle that the higher the vulnerability of the development or use, and the consequential impact on socio-economic activities of the society, the lower should be the flood hazard in the area where it is placed. If this is not possible, measures should be taken to reduce the damage potential (through flood proofing or local flood defenses) or the vulnerability of the affected population. The latter would for example relate to mandatory provision of evacuation plans or emergency response plans to such developments. Some elements may be classified differently in different socio-economic conditions, for example, in an area based on subsistence agriculture, where destroyed crops would present a major blow to food security.



(Note) CFMP=Catchment Flood Management Plans

Figure 2. Links between flood risk management plans and wider planning framework in England [10]

It needs to be stressed that only a best mix of the strategies presented in Table 2 adjusted to the particular circumstances of each river basin can serve the aims of IFM. This becomes apparent when thinking of a flood management strategy that would only focus on reducing the susceptibility to damage as this would lead in its most consequent form to largely ignoring the development potential of the floodplains.

Table 2. Strategies and Options for Flood Management [1]

Strategy	*Options*
Reducing Flooding	Dams and reservoirs
	Dikes, levees, and flood embankments
	High flow diversions
	Catchment management
	Channel improvements
Reducing Susceptibility to Damage	Flood plain regulation
	Development and redevelopment policies
	Design and location of facilities
	Housing and building codes
	Flood-proofing
	Flood forecasting and warning
Mitigating the Impacts of Flooding	Information and education
	Disaster preparedness
	Post flood recovery
	Flood insurance
Preserving the Natural Resources of Flood Plains	Flood plain zoning and regulation

3.1 Floodplain zoning and risk sensitive approach

It is of crucial importance to adopt a risk-sensitive approach that would increase regulative intervention with increasing levels of risk, based on different hazard zones and the projected or existing types of development within each zone. Compared to the simplicity of that statement in theory, the successful practical application is highly complex. Floodplain zoning ordinances constitute an important tool to operationalize a risk-sensitive approach. Floodplain zoning can be undertaken on the basis of floods of different average annual exceedance probabilities, such as the 1% ("100-year flood"), 0.5% ("200-year flood") or 0,1% ("1000-year flood") exceedance probability. The most commonly used for land-use planning purposes is the 1% average annual exceedance probability. In the United States, for instance, a further distinction in floodplain zoning ordinances is made between the 'floodway' and the 'floodfringe' based on floods of a 1% exceedance probability. The level of risk to determine floodway areas can be based on factors such as the depth and velocity of flood water, duration of flooding, available flood storage capacity, or the rate of rise of flood water. While in some countries land-use plans have legal authority in their own right, floodplain zoning ordinances or similar legally binding instruments are used elsewhere to enforce land-use planning. Illustrated in Figure 3, another distinction applied in zoning is made based on the "Probable Maximum Flood (PMF)", which is the largest flood that could conceivably occur in a particular location. This can be based on historical records and specific flood studies. While it is neither practical nor economically viable to provide defences up to that level or to regulate the use on all flood prone land associated with the PMF, it is essential to consider the PMF in locating strategic installations, or for emergency response and evacuation planning.

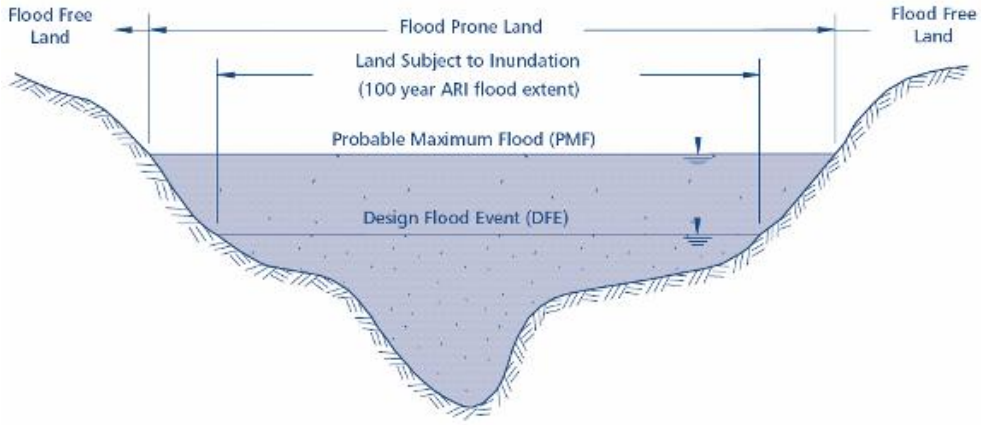


Figure 3. Defining Flood Prone Land [11]

Different zones can also be identified based on the type of flooding, such as riverine (or fluvial) flooding, coastal flooding, flash flooding or storm water flooding, and groundwater flooding. While the riverine and flash flooding are relevant for rural and urban areas, storm water flooding is particularly associated to urban areas where overland flow develops from heavy precipitation when the discharge capacity of the storm water drainage system is exceeded.

Based on those zones specific regulatory mechanisms can be introduced. High risk areas can be put under strict provisions that regulate land-use and/or developments (buildings, infrastructure, etc). Rules relating to "no development" or even removal of existing developments can be introduced, especially after flood damage has occurred and the cost and sustainability of reconstruction in the particular area is considered undesirable. The latter is usually politically viewed as controversial as the social and legal repercussions of such intervention are difficult to gage in advance.

While the development of more restrictive land use regulations can be regularly observed after the occurrence of large flood events, it should not be assumed that regulations must always become tighter. If development options are evaluated in conjunction with flood risk, floodplain regulations may also allow more flexible approaches[12].

3.2 Planning permits

The process of issuing development or planning permits is applied to ensure compliance of planned developments or changes of land use with the regulatory regime, that is in relation to flood management to limit or minimize the flood risk to the development and the effects of new developments on flood risk elsewhere. Various activities on the floodplain or activities that have an influence on flood risk can be subject to permission, such as:

- Changes of land-use type or intensification of land use
- Buildings and structural works: dwellings, commercial and industrial buildings, levees, fences, roads, embankments, etc
- Earthworks, resulting in: land forming, lanes, tracks, aqueducts, laser grading, surface and subsurface drains, etc
- Subdivision: the splitting of an existing land parcel into several pieces owned by different owners

Depending on the type of activity the use of low risk areas such as the 'flood fringe' may be acceptable under certain conditions and enforced during the application process for a planning permit. Certain developments may be permitted under certain conditions, relating for example to the:

- Location and extent of building and works;
- Incorporation of various flood proofing measures into the design of the development;
- Restriction on storage and goods and materials that may create pollution or become a floating hazard during floods;
- Land drainage and effluent disposal requirements;
- Requirements for access roads or tracks;
- Maximum height and extent of landfill and earthworks, including levees;
- Availability of emergency preparedness plans (for example, for tourist sites, camping places, hotels etc.); and
- Provision of adequate water retention or drainage facilities.

In England, flood zones have been defined and through a planning policy document next to general policy principles and objectives, several tools are provided for regional planning bodies and local planning authorities to steer development towards zones with lower probability of flooding. Those tools include a 'sequential test' to determine the suitability of land for development in areas liable to flooding, and an 'exception test' which provides a method of managing flood risk while still allowing necessary development to occur. The latter may only be applied under specific conditions outlined in the policy document. Interestingly, the zoning does not take into account flood defences with the argument that those may be breached, overtopped or that the lifetime of developments on the floodplain may longer than the one of the flood defense[13].

- In developed areas protected by levees a strip behind the levee must be kept free of development. This is necessary to allow access in case of flood fighting or maintenance, but also in light of future levee heightening such strip will be required. The question arising in practice is of course how much of the protected area can be kept free of use without harming the economic viability of the protection project.

- Zones where land-use changes can significantly increase flood risk downstream can also be regulated to strengthen retention. This in turn requires an elaborate assessment of flood risk, not only of the areas at risk of being flooded but also of those areas that generate higher peak flows through land use changes.

3.3 Building standards and codes

Building standards and codes can play a strategic role in reduction of potential flood damages. They must, however, be coordinated with floodplain regulations. Building standards can address various structural features of a development to take into account prevailing flood hazards, such as

- Freeboards above base flood elevation for buildings and essential infrastructure (access roads etc.)
- Protection against foundation erosion
- Limit enclosure for parts of the building below the regulatory flood level (for example, put houses on stilts)
- Orientation of the building to least obstruct flood flows
- Various measures of wet and dry flood proofing (backflow valves, waterproofing measures to opening, elevated electricity features, water proof storage of oil and other hazardous materials etc.)
- Compensation for storage losses due to land fill

Building standards and codes tend to be under a stronger local inspection regime than floodplain regulations. Therefore compliance is more likely to be enforced. Therefore, it is advisable to consider building codes as crucial elements of flood damage reduction strategies when reforming the flood management system. Examples exist where reform to building codes has been undertaken through dedicated flood management legislation[14]. Coordination of such legislation must be undertaken at a higher administrative scale, that is national or state level.

3.4 Multifunctional land use

In view of the dilemma faced by land use planners in dealing with flood hazards multi-functional land-uses play an important role. In countries that face the scarcity of land already for decades and for urban planners this concept is already widely applied. It can, however, be observed that the concept is gaining importance even in countries that previously were not using this approach. Examples of widely applied multi-functional land uses include the use of water storage areas for recreational (non-residential) purposes, such as outdoor sports facilities, parks and nature reserves. Flood adapted housing is also used increasingly, such as floating structures or elevated structures on stilts. In Southeast Asia such approach is common place for long, yet in the countries that had adopted a strict flood defence policy which worked on the premise that flooding could be prevented, such practices had not been prevalent. Similarly, recession agriculture is commonplace in various flood prone developing countries, using the floodplain for agriculture in the flood-free months.

4. CONCLUSIONS AND RECOMMENDATIONS

Complexity of flood risk evolution process requires a clear understanding of the construct of the typology of various components of flood risks and the factors that mitigate or abate them. Many sectoral development processes have profound influence on their management. The complex interaction between development processes and flood risk genesis requires a clear conceptual framework which is supported by appropriate organisational and institutional mechanisms to develop and implement surface water management plans. Following issues need to be addressed while developing and implementing such plans.

- Flood risks are more than flood waters; risks result from a combination of components, comprising hazard, exposure and vulnerability. The recognition of these components facilitates the understanding of flood risks because it underlines that only the combination of natural and human factors create flood risks.
- Flood management measures have to be planned across administrative and sectoral boundaries. Institutionalized links between concerned authorities facilitate cooperative planning.
- Successful flood risk management is only possible if different measures, comprising structural and non-structural, spatial and organizational, are combined.
- The implementation of multiple purpose measures enables municipalities to achieve multiple goals (flood mitigation, water supply, space for recreational activities, groundwater recharge, improvement of urban aesthetics etc.).
- Recognizing sustainable, flood aware planning as the most promising strategy for successful flood risk management in the long run. Flood aspects have to form an integral part of development planning.

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