Technical Note

on the

Classification of Measures and Instruments For Flood Risk Reduction

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The need for a new classification

The past has seen manifold approaches dealing with the systematisation of approaches of what today we refer to as flood risk reduction. The most often used classification of measures and instruments is based on the general distinction of 'structural and non-structural measures' (Smith & Tobin 1979, Penning-Rowsell & Peerbolte 1994, Marsalek et al. 2000, Kreibich et al. 2005).

Many different classifications for flood risk reduction measures have been proposed in the past decades. A few examples are e.g. the classifications by point of time including pre-flood, flood event and post-flood intervention, by character differentiating technical measures and regulatory, financial and communicative instruments (Hooijer et al. 2002) or by aim differentiating flood abatement, flood defence and flood impact mitigation (De Bruijn et al. 2003).

One of the most recent and most comprehensive of these was developed in the Foresight project differentiating "26 functional response groups" describing basic services, which they provide. Within these response groups "80 possible response measures, policies and interventions" are distinguished, which can contribute to the response groups (Evans et al. 2004, pp. 25ff). However, also this classification does not provide a homologues classification describing the functioning of the interventions with the flood risk system.

Therefore, a new classification is proposed which tries to serve a number of requirements in order to be both consistent in itself and a basis for the methodology. This classification seeks to cope with following premises:

- The classification represents the full array of approaches to the reduction of flood risk before, during or after a flood event. In this scope the balanced consideration of traditional as well as more recent approaches is a main challenge.
- The classification is based on the functional characteristics of interaction between intervention and the flood risk system.
- The classification considers that effects of interventions often go beyond the intended. Therefore, it avoids explicit and implicit reference to single effects in order to avoid prejudices regarding the full range of expectable impacts, which are issue of evaluation.
- The classification is applicable to different contexts within Europe and allows as far as possible an unambiguous attribution of measures and instruments to a category or sub-category by scientists and practitioners.
- The classification primarily addresses interventions at project level (clear temporal and spatial boundaries, +/- clearly assignable costs and outcomes).

The new classification is organised in three levels:

1. Differentiation of direct interventions (physical measures) and indirect interventions (policy instruments)
2. Description of the functional character of measures and instruments in their interaction with the flood risk system
3. Description of types of measures and instruments differentiating the manner of intervention with the flood risk system within the functional groups.

Due to the chosen approach of classification which is different from most previous typologies, only little of existing terminology is taken recourse to. Explicitly, the traditional differentiation of structural and non-structural measures is not followed. Instead, the terms 'physical measures' and 'policy instruments' mark the basic differentiation of interventions.

Level 1: Physical measures and policy instruments

At its first and most general level, the proposed classification is based on the differentiation of two general principles of intervention: direct interventions resp. physical measures and indirect interventions resp. policy instruments.

Physical measures are direct interventions into the physical flood risk system, which generate physically tangible changes as their direct output. Examples are civil engineering works, flood proofing of buildings or cultivation techniques. The basic understanding of this group is widely consistent with the understanding shared by Marsalek (2000) and Petry (2002). Traditionally, physical measures primarily influence elements of the hydrological system (Amoros & Petts 1993, Pottier 1998) and are thus most prevalent in the field of hazard control addressing sources and pathways of flooding. However, physical measures are also applicable to the receptor (by evacuation of exposed population or flood proofing of buildings) and have certain importance for the mitigation of consequences (e.g. in course of post flood mitigation). Thus, physical measures can be applied at any point of the SPRC chain discussed above.

> ***Physical measures*** *are direct physical interventions into the physical flood risk system, which become manifest in the emerging or changing of technical and natural structures respectively of their patterns and properties as well as in the direct exposure of health and life to the flood hazard.*

Complimentary to the widely accepted term of physical measures, the term 'instruments' is applied to describe the indirect approaches of flood risk reduction. The term is not consistent with the often used term of non-structural measures. The term signals the principally different functioning of the concerned measures. Their essence is not the direct and tangible impact on the flood risk system, but the triggering of activities (incl. behavioural change) connected with flood risk. These interventions are thus rather tools that are used to achieve a certain goal that cannot be reasonably implemented directly. As synonym for 'tool' the term 'instrument' is widely used in European languages for policy action (policy instruments) based on economic options ('economic instruments', cf. OECD 1994, Tyagi & Saalmüller 2004), legal regulations (legal instruments, Pottier 1998 uses 'tools') and particularly in the field of spatial planning (Handmer 1996, ARL 1998, Morrison 2002, Hooijer et al. 2004). Also the EC communication (CEC 2004, p. 6) calls for "appropriate prevention instruments" to contribute to flood mitigation and the on proposed Floods Directive (CEC 2006) takes recourse to "financial instruments" as options of flood risk management.

Policy instruments are interventions, which influence the perception and behaviour of individuals and institutions, which in effect can also lead to the development of intended physical structures through inducing physical measures. Thus, the direct effect of policy instruments is the triggering of activities. The latter can be nearly obligatory (e.g. in case of binding land use regulations) or of a rather soft nature (in case of information instruments). Other instruments function by shaping vulnerability which does not necessarily materialise in

physical changes (preparedness, risk perception etc.). While various types of vulnerability are being distinguished (Parker et al. 1997, Messner & Meyer 2006), most relevant for current flood risk management appear the social and partly the economic vulnerability.

> ***Policy instruments*** *are interventions into the socio-cultural flood risk system, deploying influence on human perception and behaviour thus triggering mechanisms which can (indirectly) lead to intended results incl. the development of physical structures, patterns and properties.*

The latter has a special importance for the evaluation of such instruments. In cases, where an instrument mainly influences the realisation of physical measures, the ex-post evaluation needs to take into account also its physical manifestation.

Level 2: Functional character of measures and instruments

Measures and instruments can be characterised by manifold aspects. However, many of them are do not necessarily allow an unambiguous allocation of interventions. For example, certain measures and instruments can be applied in different phases of flood risk management (e.g. pre-flood or flood-event) and by different stakeholders (public authorities, private). Other aspects, such as the permanence of intervention, offer rather general distinctions which are not sufficient for the set up of a classification. Therefore, the functional character of the intervention is used in order to provide an unambiguous classification. It describes at a general level the interaction of the intervention with either the physical or the socio-cultural flood risk system. The functional groups consider the fundamental functional differences between physical measures and policy instruments (Figure 1).

As functional groups for the description of interaction with the *physical flood risk system* three categories are defined:

- *Adaptation* of existing non-built physical conditions by special management techniques
- *Control* of physical conditions in the flood risk system by introduction and adaptation of built structures
- *Retreat* of uses by temporal evacuation or permanent relocation of elements at risk

The three functional groups represent the three principles of interaction with the physical flood risk system. The first physical option is the *adaptation of existing natural conditions*, mainly those of the source and along pathways - e.g. by periodical application or adaptation of specific treatment techniques. The second is the structural *control by man made conditions* through the introduction and adaptation of built structures mainly with regard to the source, pathway and receptor - e.g. by controlling processes of runoff or reducing exposure and susceptibility of receptors. Finally, a third option is the *retreat of elements* reducing the exposure of the receptor by temporary evacuation or permanent retreat of uses.

Policy instruments, in contrast, have no possibility to directly influence the physical flood risk system. Their functioning is based on the triggering of mechanisms in the socio-cultural flood risk system, by influencing the action of stakeholders which can lead to changes also in the physical flood risk system. However, the effect of policy instruments can also be restricted to social factors such as perception, awareness or preparedness, which need not find manifestation in physical changes.

Four functional groups are identified describing the interaction of policy instruments with the socio-cultural flood risk system:

- *Regulation* of (mainly spatial) development based on legal backing
- *Stimulation* of development and behaviour by positive and negative incentives
- *Information* of stakeholders for the benefit of perception, awareness, preparedness and behaviour
- *Compensation* of consequences through distribution of flood risk and losses

The four functional groups are organised according to their rigidity of influence on the flood risk system. The only binding option, is represented by the *regulation of development* backed by various legal constellations. The latter provide more or less restrictive frameworks of regulations allowing public administrations their enforcement. A next possibility of influence is the *stimulation* of development and behaviour through positive or negative financial incentives in order to achieve changes by appealing to economical interests of stakeholders. The third option is even less intervening and is represented by *information of stakeholders* providing information about different issues of flood risk management such as about the exposure of receptors, possibilities for action or flood warning, thus apealing to the individual interests and responsibility. Finally, accepting that often losses cannot be fully avoided *compensation of losses* induced by flooding is an option to mitigate occurred harm and to foster recovery by distributing the costs over the wider community.

Regulation, *Stimulation* and *Information* instruments are applicable with the source, along pathways and with receptors and can often also impact the development of physical conditions. Furthermore, the provision of information can influence social factors like preparedness and perception, which are important for the implementation of other interventions as well as for the acceptability of risk. The application of compensation instruments is restricted to the Consequence-part of the SPRC-chain.

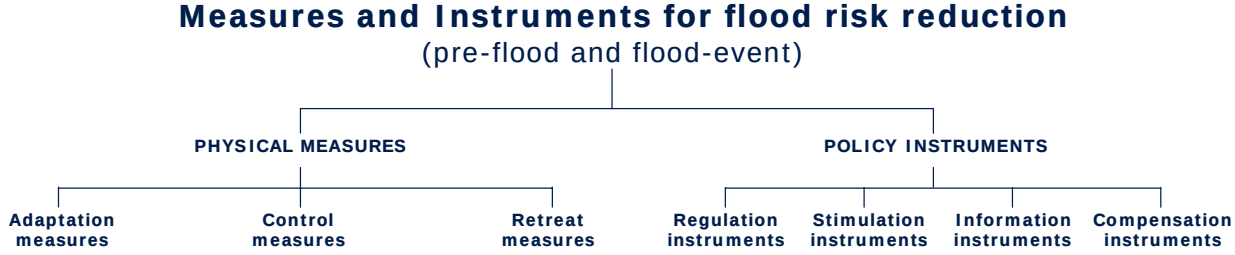

Figure 1: Categories of measures and instruments

PHYSICAL MEASURES

Adaptation measures

Adaptation measures are direct physical interventions into natural structures, the effect of which emanates from the application of specialised treatment techniques on land surfaces as well as in and along river channels (**SP**RC).

Control measures

Control measures are direct physical interventions, the effect of which emanates from introduction, alteration or removal of built structures (**SPR**C).

Retreat measures

Retreat measures are direct physical interventions, the effect of which emanates from temporal evacuation or permanent retreat of elements at risk from the flooded or flood prone area (SP**R**C).

POLICY INSTRUMENTS

Regulation instruments

Regulation instruments are policy interventions, the effect of which emanates from prescriptive regulations and the legally backed enforcement power of administrations, mainly restricting the type and quality of land uses. Regulations are mainly tools of sectoral policies (**SPR**C).

Stimulation instruments

Stimulation instruments are policy interventions, the effect of which emanates from financial incentives and disincentives offered to private or institutional stakeholders in response to certain behaviour or action (**SPR**C).

Information instruments

Communication instruments are policy interventions, the effect of which emanates from the provision of information to private or institutional stakeholders such as exposure of receptors, possibilities for action or flood warnings (**SPR**C).

Compensation instruments

Compensation instruments are policy interventions, the effect of which emanates from mechanisms distributing the risk respectively occurred losses over a wider community (SPR**C**).

Level 3: Types of measures and instruments

Types of measures and instruments further differentiate functional groups defined above (Figure 1). Types of measures and instruments are based on the manner in which the intervention interacts with the flood risk system. The driving question behind the categories is: “What is being done?” (Figure 2).

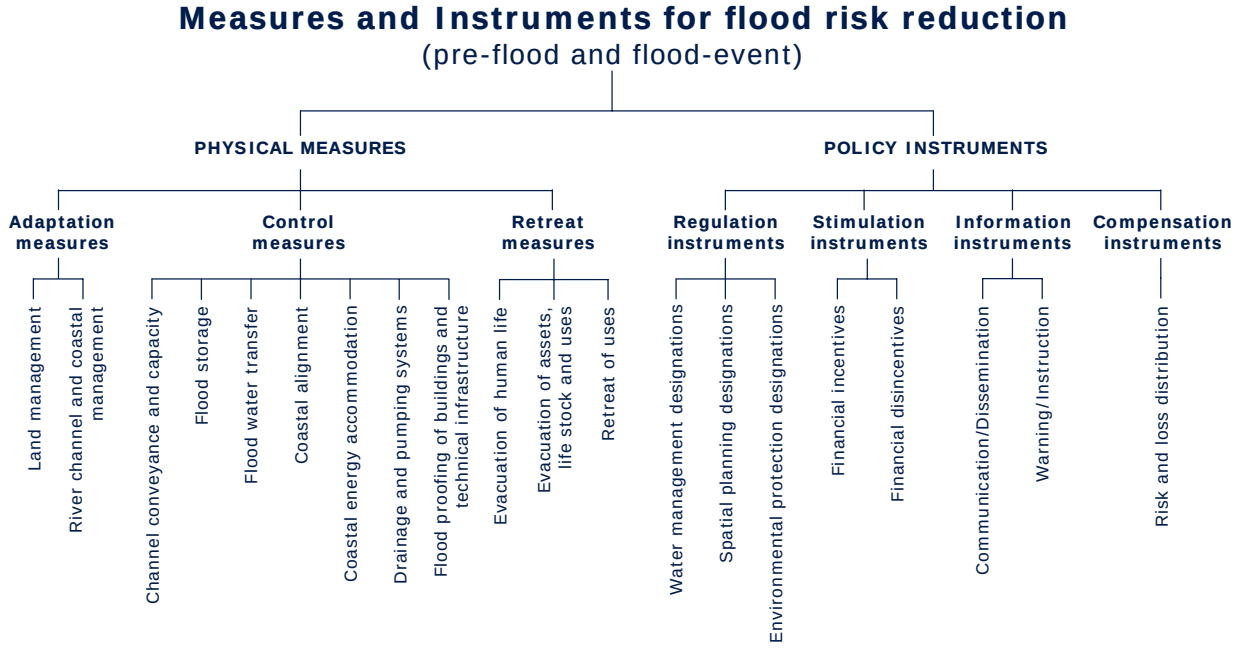

Figure 2: Types of measures and instruments

In the following, types of measures and instruments are defined. **Fehler! Verweisquelle konnte nicht gefunden werden.** classifies all identified measures and instruments following the presented system.

PHYSICAL MEASURES

Adaptation measures

Land management (**S**PRC)

Physical changes of patterns and properties of soil or vegetative cover by means of cultivation techniques and the choice of crop.

Examples Conservation tillage, Transformation of forests

Channel and coastal management (S**P**RC)
Removal, displacement, introduction of physical features incl. bed sediments, vegetation etc. in rivers, along river banks, in estuaries and along coasts.

Example Dredging

Control measures

Flood storage (S**P**RC)
Hydraulic engineering structures in river channels, valleys and floodplains retaining surface discharge.

Examples Reservoir, Pond, Detention basin

Flood water transfer (S**P**RC)
Hydraulic engineering structures conveying parts of the discharge into other catchments.

Example Flood water diversions

Channel conveyance (S**P**RC)
Hydraulic engineering structures in river channels, valleys, floodplains and estuaries influencing the shape and capacity of the river channel.

Examples Channelisation, Dikes, Channel restoration

Coastal alignment (S**P**RC)
Physical barriers to coastal floods along the coastline.

Examples Dike, Flood Wall, Managed or unmanaged retreat

Coastal energy accommodation (S**P**RC)
Physical elements introduced along the coastline to control the energy of currents or waves.

Examples Offshore barriers, Beach nourishment

Drainage and pumping systems (S**P**RC)
Drainage and pumping systems conveying waste, ground and flood water from vulnerable areas or pumping excess water into storage areas or into the river.

Examples Central pumping devices (in urban areas), Local ground water lowering

Flood proofing of buildings and infrastructure (SP**R**C)
Additions, changes and adjustments at buildings and technical infrastructure following two main approaches:
Dry flood proofing by protection against the ingress of water
Wet flood proofing by provisions in structure and installations against damage by water

Examples(dry) Shielding with mobile/temporary barriers, Elevated construction
Examples(wet) Waterproof construction material, elevation of installations

Retreat measures

Evacuation of human life (SP**R**C)
Temporary or permanent relocation of human life or life stock from of flood-prone or flooded areas.

Examples Evacuation of especially vulnerable population

Evacuation of assets, life stock (SP**R**C)
Temporary evacuation of assets (incl. life stock) from flood-prone or flooded areas.

Examples Relocation of physical inventory at risk
Change of interior uses in lower levels of frequently flooded buildings

Retreat of uses (SP**R**C)

Permanent relocation or give up of sensitive uses from flood-prone areas.

Examples Relocation of sensitive uses (offices, production facilities) from flood-prone areas or to upper levels, Give up of sensitive uses (e.g. sauna in basement)

POLICY INSTRUMENTS

Regulation instruments

Water management designations (**SPR**C)

Land use regulations backed by the enforcement power of water management related legislature.

Examples Flood zones
Prohibition to store harmful substances (e.g. chemicals) in floodplains
Regulations for 'Flood source areas' (D, Saxony)

Spatial planning designations (S**PR**C)

Land use regulations backed by the enforcement power of spatial planning legislature.

Example Priority areas for certain uses

Environmental protection designations (**SPR**C)

Land use relevant regulations backed by the enforcement power of environmental protection related legislature. Here, flood risk reduction is rather a side-effect of regulations addressing nature conservation.

Examples Landscape Protection Area, Nature reserve, Nature 2000 area

Stimulation instruments

Financial incentives (**SPR**C)

Financial incentives encouraging activities which lead to the development of intended physical patterns/properties or behaviour.

Example Subsidies and/or allowances for flood-proof construction of buildings

Financial disincentives (**SPR**C)

Financial disincentives discouraging activities which lead to the development of unwanted physical patterns/properties or behaviour.

Examples Levies/ imposts, Fines, Taxes

Information instruments

Information/Dissemination (SP**R**C)

Transfer of knowledge to and/or between stakeholders of flood risk management and the public using various communication media.

Examples Information events, Brochures, Guidelines

Warning/Instruction (SP**R**C)

Operational information of stakeholders and public about an upcoming/ongoing flood event incl. directives for action and behaviour.

Example Official flood warning

Compensation instruments

Risk and loss distribution (SPR**C**)

Risk and loss distribution is realised by allocation of risk or the burden of losses on a larger community by public policy or private-sector initiative.

Examples Flood insurance payments, Public relief (compensation payments) after flood event

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