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Decentralised water retention along the river channels in a mesoscale catchment in south-eastern Germany

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ABSTRACT

Throughout the Ore Mountains, a low mountain area located in the German–Czech border region, storm runoff frequently causes severe damage in headwater areas as well as in lower reaches. Settlements along smaller tributaries and towns at the receiving water are affected simultaneously, so measures distributed throughout the entire drainage area (decentralised measures) have to be considered for flood protection planning in such areas. The concept of decentralised flood protection, which is well established in the German literature, offers a large number of potential flood control schemes including measures along the river channels, in agriculture and forestry as well as in settlements. The investigations presented here focus on the group of measures along the river channels, including small, distributed retarding basins, river renaturation and afforestation of floodplains. Based on rainfall-runoff models, its aim is to show how such measures influence flood hydrographs in low mountain areas with a 100-year recurrence interval, using the example of the Upper Flöha watershed in the Central Ore Mountains.

The results indicate that along the tributaries of the Flöha very high local peak reductions can be achieved with small retarding basins. The efficiency of the basins is related to the available storage capacity in the valleys upstream of the settlements. On a supralocal level, i.e. at the Flöha River, an additional reduction of the peak discharge occurs in the model. Other significant supralocal effects can be observed for the scenarios with an increased floodplain roughness (afforestation). In a combination of both scenarios the supralocal effects increase further, whereas the local effects are as high as in the retarding basin scenario. By contrast, the river renaturation scenario does not show a significant impact on the flood hydrographs. However, the limited effect is a result of the local characteristics of the study area, where the number of suitable river sections is limited and the slope gradients are high.

On the whole, it can be concluded that decentralised measures along the rivers can be efficient elements in the framework of flood protection strategies. The reduction of flood peaks includes not only the receiving water, but also the tributaries, so that an improvement of flood protection extending across the entire watershed can be achieved.

1. Introduction

During extreme rainfall events serious floods with massive economic losses occur in low mountain regions in Central Europe as a result of the steep terrain and the limited infiltration capacities of the shallow soils and the underlying periglacial cover beds. A remarkable example of such events was the August 2002 flood, which has directed much attention to flood generation in the mountain areas of south-eastern Germany such as the Ore Mountains at the border between the German Free State of Saxony and the Czech Republic. As part of the Elbe basin, this region generated a significant amount of the discharge observed downstream. Along the Elbe tributaries in the Eastern Ore Mountains such as the Weisseritz and Müglitz, losses of 1.176 billion Euro (LfUG, 2004) occurred, and similar values were reached in the Central Ore Mountains at the source areas of another large Elbe tributary, the Mulde river. Even at small and short brooks without any tributaries and a length of a few kilometres, losses of up to two million Euros and more were recorded.

Like in other German federal states, the flood management strategy in Saxony is based on a combination of (1) technical flood protection using dykes and dams, retention basins, reservoirs, etc. and (2) area-wide water retention by a restoration and improvement of soil infiltration capacities. A third pillar is related to the field of precaution and spatial planning, including early warning systems, education, public relations as well as identification of flood-generating areas and inundation areas. The backbone of technical flood protection consists of 47 flood protection concepts with more than 1600 individual measures for the Elbe and the major

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rivers of Saxony which were developed after the August 2002 flood (Socher et al., 2006). On the federal state level, major rivers are classified as first order river, whereas tributaries are considered to be of second or lower order. According to the Water Act of Saxony municipalities are responsible for flood protection along the latter class of rivers and in their catchments, but protection concepts are still lacking in many cases, so further research is required.

However, the problem of flash flood-like events in headwater areas and the special demands on flood protection is not a local problem that occurs in Saxony only, but is frequent in many other mountain areas in Europe and worldwide. Owing to the distributed character of flood losses, central technical measures along large rivers are not sufficient to reduce the flood hazard across a watershed, especially because settlements located at smaller brooks in the headwater areas cannot benefit from the protection. In such cases decentralised measures are required, which allow an improvement of flood protection on different scales, i.e. along first as well as lower order rivers.

Decentralised flood protection (DFP) is based on the idea that protection measures can be distributed throughout a drainage area instead of – or in addition to – the development of large technical constructions downstream (Fig. 1). However, technical measures are not excluded but remain small and are used in combination with natural water retention and other ecological measures. The term decentralised flood protection (or decentralised water retention) and its principle is well established in the German literature (e.g. Assmann et al., 1998; DWA, 2006; Bölscher and Schulte, 2007; Marenbach and Koehler, 2003; Rieger and Disse, 2008; Röttcher et al., 2006; Röttcher and Tönsmann, 2001). In international publications some similar ideas occur in the context of water harvesting (Brooks et al., 1997; Lancaster, 2008) or integrated watershed management (e.g. Brooks et al., 1997). However watershed management covers a much wider range of water management tasks including water quality and quantity (Lee et al., 2008), e.g. erosion and degradation protection, control of nutrient fluxes, land and forest management, etc., whereas flood protection is only one optional element in the integrated watershed management concepts.

In general three different groups of measures are frequently used for DFP. Some of the measures are also applied separately in order to solve local water management problems, but in the context of DFP they are understood as elements of an integrative flood protection approach.

1.1. Point or linear measures along river channels

Measures in this group mainly influence the flood discharge after runoff has already concentrated in the channel, e.g. in retention basins or by an improvement of retention in channels and floodplains. A frequent idea is to use the retention volume behind existing obstacles like cross-valley road or railway embankments by reducing the culvert's diameter, but in practice problems are quite likely because these embankments are not designed as dams and hence do not conform to the technical requirements of headworks. In many cases the required adaptations are more expensive than the construction of a new dam (DWA, 2006). An alternative would be newly constructed small retarding basins (synonymous with retention basins) with a maximum water level of 5 m and a storage capacity of less than 50,000–100,000 m^3, which conform to technical regulations. Further retention capacity can be provided by lowering the water level of existing artificial ponds.

Besides such basins, retention potentials along the rivers can be activated by river renaturation including restoration of the natural channel roughness and the originally meandering river course. Another option is a floodplain management (e.g. Castellarin et al., 2010; Di Baldassarre et al., 2009; DWA, 2006) including minor dykes, dyke relocation and other measures. In addition the increase of floodplain roughness by afforestation and the restoration of riparian forests is an interesting approach that reduces the flow velocity on inundated areas (cf. Bölscher et al., 2010; Glenz et al., 2006).

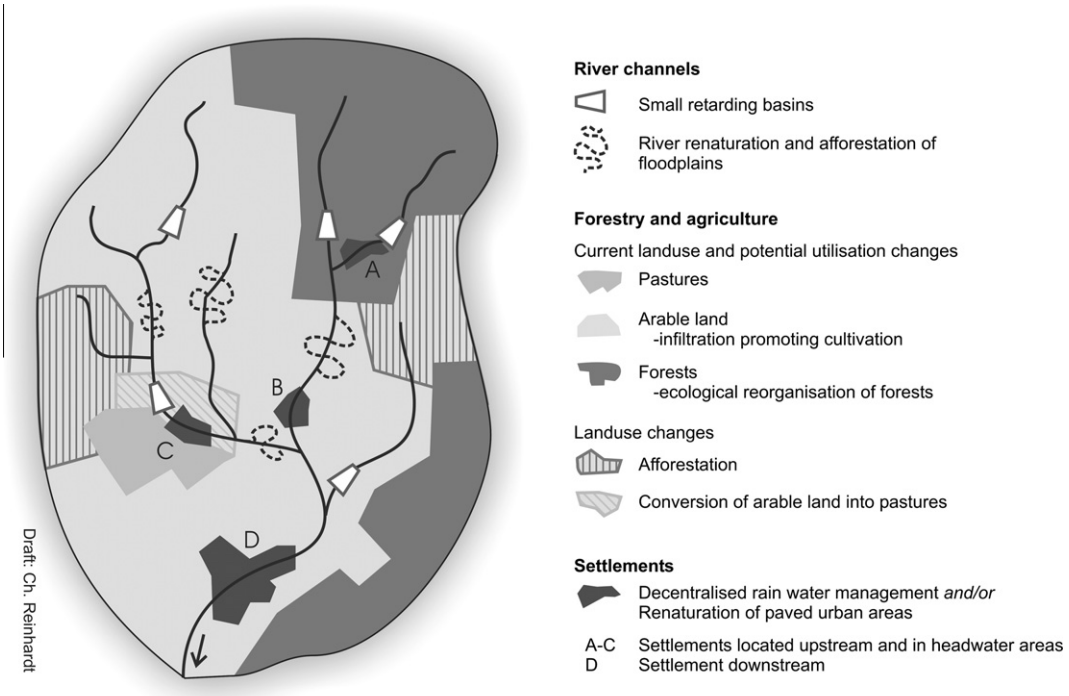

Fig. 1. Illustration of the basic principle of decentralised flood protection. The modular concept includes a large number of different measures, which can be adapted and combined to develop individual protection concepts depending on the natural characteristics and the socioeconomic requirements of the watershed under investigation.