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Introduction

Precautionary Land-Use - Sufficient for Flood (Damage) Mitigation?

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Already in 1995 the environment ministers of France, Belgium, Luxembourg and Germany pointed out in their declaration of Arles, that not only technical flood protection, but also precautionary spatial planning and adapted land-use are necessary to mitigate flood disasters. Hence it is necessary to reduce and to delay discharge peaks. Within the European INTERREG III B NWE-project “WaReLa” (Water Retention by Land-Use) all spatial management disciplines – forestry and agriculture, settlement management and road network planning – contribute to a precautionary flood protection (www.warela.eu). Eleven partner organisations from France, Luxembourg, Germany and Switzerland are cooperating within these objectives.

Effective decentralised land-use measures to retain water, wherever it is possible, were explored and implemented in WaReLa-test-sites. With the help of a geographic information system (GIS)-based tool flood generating areas can be visualized as “hot spots” for run-off mitigating and – and by this, where to implement run-off delaying measures. Also the spatial flood and retention potential within the low-mountain range landscapes can be seen in GIS-maps. For this the very different land use options as well as the various landscape features were analysed by remote sensing methods. The efficiency of precautionary land-use measures to mitigate flood damages was evaluated exemplarily on a process-controlled basis at plot scale and at river basin scale, taking pedological and geological factors as well as landscape features into account. Building on this a digital tool was developed to evaluate the eco-efficiency, the economical consequences and the sustainable benefit of precautionary flood mitigating land-use measures to support the decision process. The methods and results of the WaReLa-project will be integrated in an expert spatial planning system. Spatial planning is an important instrument to reconcile the various interests in a catchment area. Hence the WaReLa-project elaborates a range of transnationally applicable decision-making instruments for the spatial planning and the future land-use. Considering the different national administrations and the different national planning instruments recommendations will be made by WaReLa to harmonize land-use regarding flood mitigation within a transnational river basin management for the purpose of the European Water Framework and Flood Directive.

At river basin level, the WaReLa-concept has transnational significance by the reduced and delayed discharge from tributaries into higher order rivers. In addition to flood disasters along major rivers, damage caused by the flooding of smaller tributaries is also of considerable significance.

Flash floods of smaller rivers in the low-mountain ranges of Europe cause at least as huge damages as the large floods along major streams. Flash floods often occur unexpectedly after torrential rains in small delimited areas. Hence the warning times are short. In these regions technical flood protection is less optimised and the safety awareness of the riparian is lower than that at the watersides of large rivers. In addition the land-use management in the Mid-European low-mountain ranges does not consider sufficiently its protection functions within the landscapes. The increase of the economic benefit mostly has still the top priority. Each day new additional settlement areas and roads as well as new agricultural technologies decrease the spatial water retention capacity. As a result of this the amount of water discharge increases and the water discharge itself accelerates. Even in forests the management using heavy machines for wood harvesting and logging supports a fast run-off.

The efficiency of precautionary decentralised water retention measures must be discussed in the context of the particular level of observation. Land-use has only limited effects in winter time, when the landscape is saturated with water and additionally burdened by torrential rain during a longer period. Then large scale climatic situations in a sensitive time period are responsible for the generation of infrequent, damaging floods. Those big flood events at the meso- and macroscale will happen repeatedly, even if the land-use will consider the possibilities of water retention. Flood events are natural events with a sure repetition.

But at the microscale each additional flood precautionary measure reduces the flood-causing run-off and there the flood frequency will happen at a higher flood return period. If all small catchments in a larger watershed are managed with a view to water retention, the occurrence of damaging floods can be reduced. Above a certain threshold of flood return period only technical flood-protection measures (e.g. dams) are effective. This threshold

depends strongly on the magnitude of the climatic event, and on the site, soil, geology, land-use and landscape characteristics. It should be the objective of spatial flood-protection planning to predict the particular threshold of danger, depending on the damage potential in catchment areas.

Flood precautions require the cooperation of water management, forestry, agriculture and viticulture sectors as well as land and infrastructural planning management in residential area and traffic systems, combined with spatial planning and domestic policy, all to be integrated into a truly eco-hydrological approach. All precautionary measures that effectively enhance water retention in small watersheds are suitable.

A digital tool is under development within the European WaReLa-project to determine the efficiencies of the various precautionary measures. Measures must be validated on the basis of ecology, cost and benefit impacts. This eco-efficiency tool will allow the evaluation of land-use measures relative to the specific site and landscape characteristics.

Regarding the probable future development of climate with extreme local torrential rain within drought periods decentralized water retention measures and the natural retention potential of the landscape features will get more and more important and they have to be consequently implemented and used to take precautions against the terrible consequences of flash floods.

Session 1

Tools and methods in hydrological catchment typification

Up-scaling of soil hydrological processes with respect to distributed rainfall-runoff modelling

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Key words: dominating runoff generation processes, processes mapping, classification of discharge, conceptual modelling, distributed modelling

The MESO scale often lacks detailed information on basic dominant runoff generation processes. In this respect, a methodology that simplifies these processes solely based on the permeability of the substratum and slope can help to compensate at least potentially this lack of information and will help to generate a GIS-based map of dominant runoff generation processes, which will function as a basis for the modelling of rainfall runoff relationships in MESO scale basins. The permeability of the substratum, which is used in this study, is based on a study of Zumstein et al. [5], who classified the infiltration permeability of the substratum with respect to its lithology and geohydrological characteristics such as fractures and porosity obtaining eight different permeability classes. This classification was adapted and simplified into only three classes: permeable, semi-permeable and impermeable. Scherrer and Naef [4] developed an approach to determine dominant runoff generation processes at the plot scale. It uses soil data, geology, topography and vegetation for the process identification. They conducted sprinkling experiments on 18 grassland hill slopes with varying slopes, geology and soils throughout Switzerland and also recorded the soil-water levels, soil-water content and soil-water tension in each plot. Since several runoff processes can occur at the same site, the one process that contributes most is called the dominating runoff generation process.

The methodology uses an existing micro-scale dominating runoff generation processes map of the 14 km² sized Zemmer catchment (Germany) that is obtained by field measurement campaigns. The spatial analysis tools of a GIS then produce a processes map of the Zemmer catchment based on the permeability of both its substratum and slope. For this purpose the raster based slope values are classified and the geological formations are classified with regard to substrate permeability. The comparison of the results thus obtained with existing maps of dominating runoff generation processes in the Zemmer catchment give an agreement of 80%, which can be judged fairly good. This approach is applied to three sub-basins of the meso-scale 250 km² sized Attert basin (Luxembourg), by generating also a dominating runoff generation GIS-based processes map, that uses the geological formations and slope values of the Attert basin.

For modelling the rainfall runoff relationships, a conceptual distributed model particularly developed for this task is applied. The model concept classifies the seven dominating runoff production processes into five types, depending on their storage potential (table 1). Firstly, storage constants for each dominating runoff generation process are defined. Storage 1 reflects the storage capacity of the processes below field capacity and has a high reservoir coefficient (k-value). Storage 2 reflects the storage capacity above field capacity and has a low reservoir coefficient. In the model concept, two superposed storages and depletion functions are constructed to serve as reservoirs (figure 1). A transfer routine is introduced to provide a time lag to the transport of the discharge from the reservoirs to the outlet of the basin. The transfer routine is based on Nash-cascades. Since only temperature data is available, the Hamon equation [2] is used for the calculation of the potential evaporation. This algorithm was proven to deliver the most consistent results in similar modelling exercises [3], when only temperature data was available.

Table 1. Storage capacities for the two reservoirs of each process type

	Storage 1 [mm] (Below field capacity)	Storage 2 [mm] (Above field capacity)
Type 1 (HOF, SOF1)	0-100	0-20
Type 2 (SOF2, SSF1)	0-200	0-40
Type 3 (SSF2)	0-300	0-60
Type 4 (SOF3, SSF3)	0-400	0-80
Type 5 (DP)	0-400+	0-100

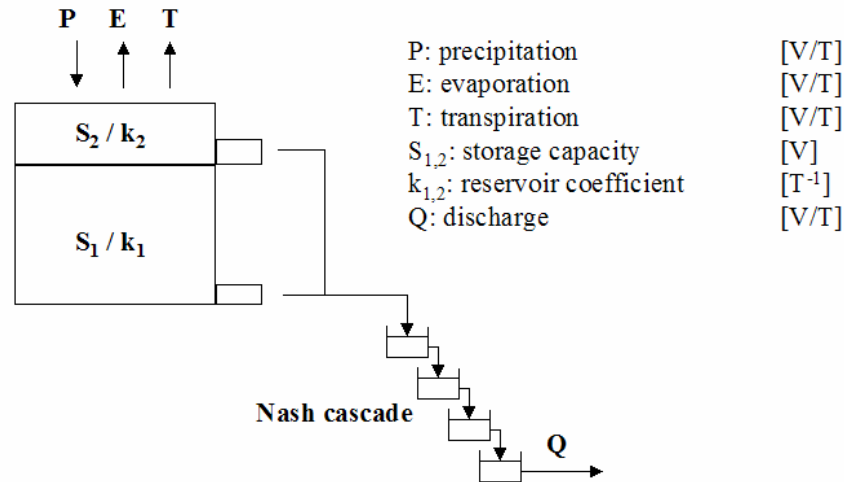


Figure 1. The conceptual linear reservoir for the five process types (each type has its own linear reservoir) and the Nash cascade transfer function

The parameters that are used in the model are given in table 2.

Table 2. Parameters that are used in the model with their unit and estimation method

Parameter	Symbol	Unit	Estimation method
Precipitation	P	V/T	Measured
Evaporation	E	V/T	Calculated from measured data
Transpiration	T	V/T	Calculated from measured data
Storage 1	S_1	V	Estimated from soft data
Storage 2	S_2	V	Estimated from soft data
Reservoir coefficient 1	k_1	T ⁻¹	Calibrated
Reservoir coefficient 2	k_2	T ⁻¹	Calibrated
Discharge	Q	V/T	Measured/modelled

As a first step in the modelling exercise, for three sub basins of the Attert, namely the Colpach, Schwebich and Roudbach (figure 2), as well as for the Zemmer basin (figure 3), the discharge was modelled. By calibrating the model, typically the k-values of each process type were determined. As next steps in the procedure, the Attert basin was modelled, using the results of the sub-basins as a reference. Furthermore, a raster grid is foreseen, which is projected over the study area. For each raster cell the percentage of the various types of the dominating runoff producing processes are calculated. The model will use the above-introduced linear reservoirs of the five classes to transfer the rainfall into discharge. The grid cell size can be varied in order to assess the influence of up-scaling on the modelled discharge. Furthermore, the influence of model complexity on model performance will be assessed by gradually introducing more complexity into the model. For this purpose all 30 possible combinations of the types will be used starting with only one type (1, 2, 3, 4 or 5) as model parameter and ending with all 5 types as model parameters, hence providing 30 models with increasing complexity. Performance of the 30 models will be assessed using a Pareto front, which is a good method to compare merits of different models and to track changes of model performance as model structures are modified [1].

With the model it is possible as well to calculate changes in discharge when land use measures are implemented in the study area, for example changing D_{SOF3} and D_{SSF3} into D_{DP} , or changing D_{SOF2} into D_{SSF3} .

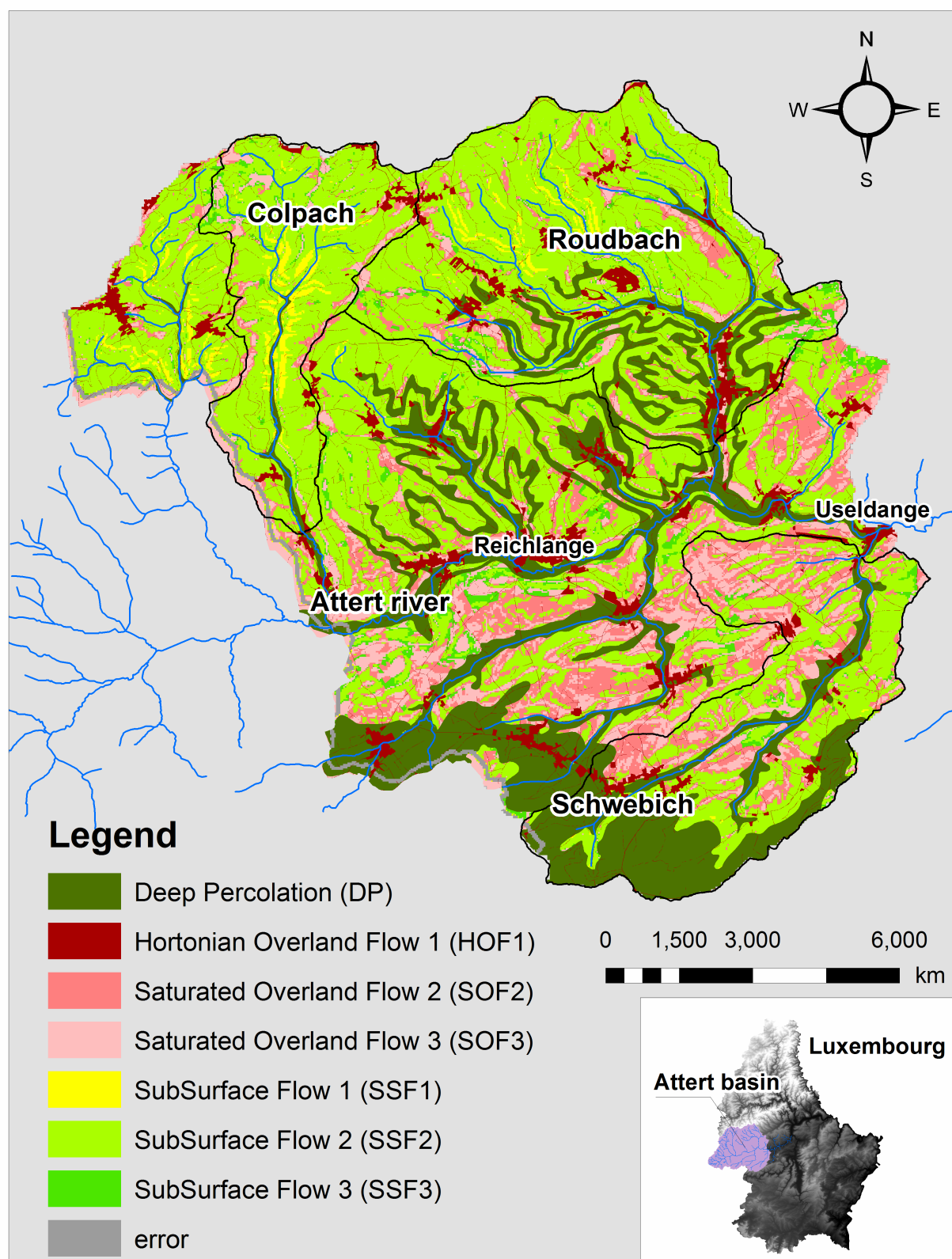


Figure 2. The sub basins of the Atttert river: Colpach, Roudbach and Schwebich with their dominating runoff generation processes

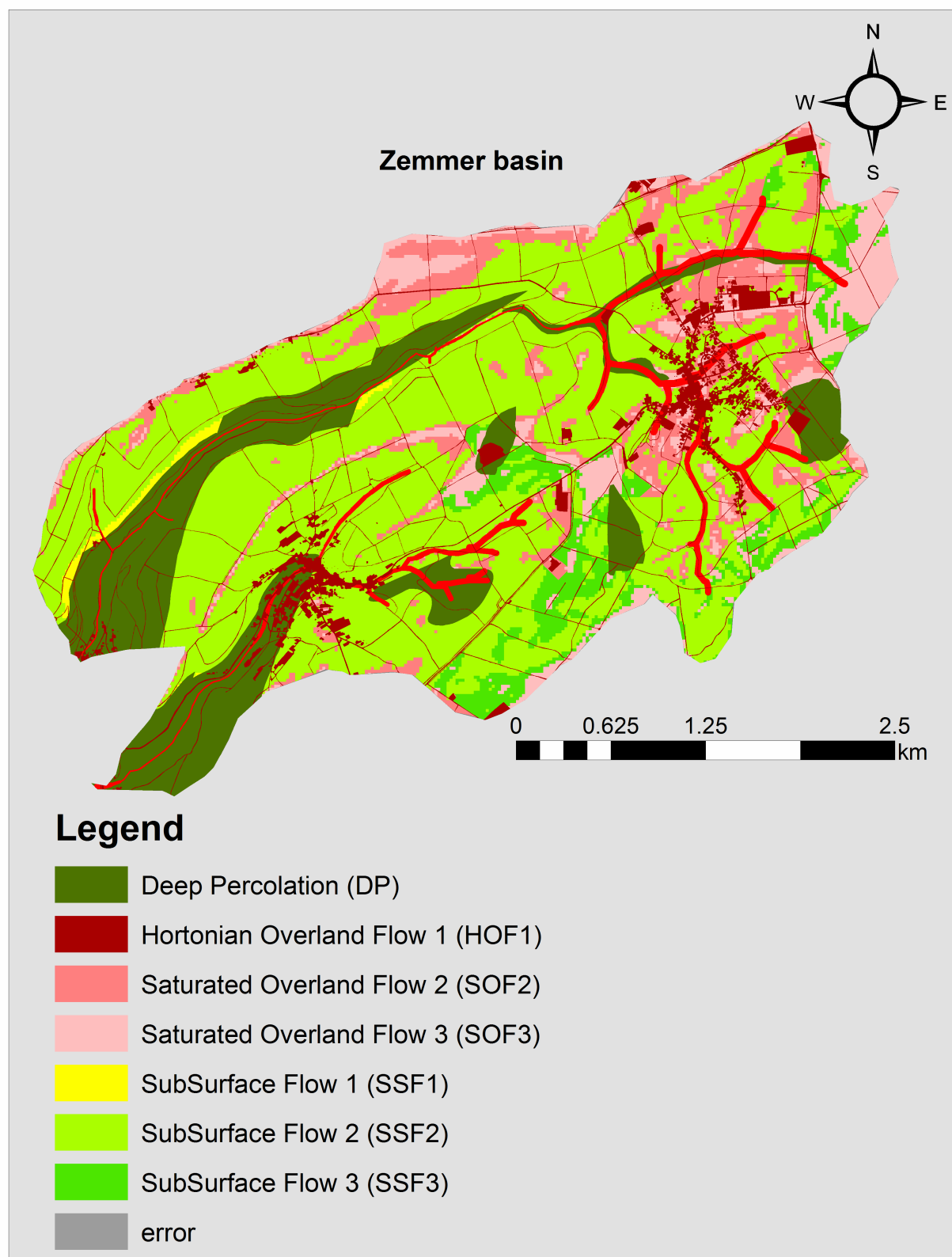


Figure 3. The Zemmer basin with its runoff generation processes

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Lidar-derived DEMs for catchment management

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Abstract

To model the water fluxes in small catchments a good digital elevation model (DEM) with a high spatial resolution is necessary. Airborne laser scanning (ALS, Lidar) is a modern and cost effective way to produce such DEMs. Modern laser scanners have high measurement frequencies of up to 100 kHz which results in typical point densities of more than 1 m⁻² with height accuracies of a few cm. Even in forested areas enough laser points reach the ground so that after a classification of the points a detailed DEM is obtained.

This DEM is used to model the way water flows through a catchment. In our study, the Frankelbach stream is investigated. The influence of spatial resolution and accuracy of the DEM on the hydrological modelling has been analyzed. Retention areas and channels that accelerate the runoff have been identified in the catchment and their influence on the total runoff has been estimated. The influence of the data degradation on the retention and runoff acceleration areas was another point of investigation.

Keywords: Airborne Laser Scanning, Lidar, Catchment, DEM.

1 Introduction

In September 2005, an Airborne Laser Scanning campaign using a Riedl Litemapper 5600 Laser Scanner [1] aboard a Helicopter was flown. Airborne Laser Scanning (ALS) is an active remote sensing technique. The scanner sends tens of thousands short laser impulses per second toward the ground. As a pulse is reflected back to the sensor, the elapsed time and the intensity is recorded. Given that the speed of light is known and constant the distance between sensor and hit ground object can easily be computed [2]. If the position and the attitude of the sensor are known, the location of each ground point can be derived. The position is measured using differential GPS, the attitude, expressed as the angles for pitch, roll and yaw, is recorded by an Inertial Measurement Unit (IMU) [3]. To scan the area below the aircraft a rotating four-sided polygon mirror deflects the laser beam across the flight track [4]. With an IFOV of 0.5 mrad, the laser beam of the small-footprint laser diverges to a diameter of about 30 cm. In vegetated areas, several targets, e.g. leaves, twigs and the ground, can be hit by a single laser pulse, and each target reflects part of the laser energy back to the sensor. Three datasets are recorded: The First Pulse dataset contains the uppermost echoes, the Last Pulse dataset the lowest echoes. If only one echo is recorded, its position is recorded in the Only Pulse dataset. Additionally, each echo's intensity is recorded.

The combined First and Only Pulse dataset comprises a model of the surface. The Last and Only datasets are filtered so that only ground points are left. These form a model of the ground, a digital elevation model (DEM) [5]. If vegetation is to be analyzed the difference between the surface model and the DEM showing the tree heights is the most interesting product, but in a hydrological study the DEM is the desired dataset (fig. 1). Our dataset has an average point density of about 4 points per square meter.

The preprocessing of the data consists of the steps filtering, tiling, interpolation, and mosaicking [6]. The filtering step was done by the data provider. Ground points were filtered from the Last and Only Pulse datasets forming the Ground dataset. The Ground ASCII data was then tiled into partial datasets, each containing a maximum of 2 million points. These partial datasets could be interpolated into a 1 m x 1 m raster. The raster tiles were then mosaicked to form a DEM of the whole area of investigation.

In this study the Frankelbach catchment, situated in south-western Germany near the City of Kaiserslautern, was investigated. It is a small catchment of about 6km² in a low mountain range area at about 49° 32' N and 7° 38' E.

The aim of this study was to find out the necessary resolution for the identification of hot spots and locations for measures targeted at reducing the risk of floods in small catchments. This preliminary study is based mostly on

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simple hydraulic modelling and visual interpretation. It is planned to add a hydrologic study containing the process allocation and taking into account the land cover.

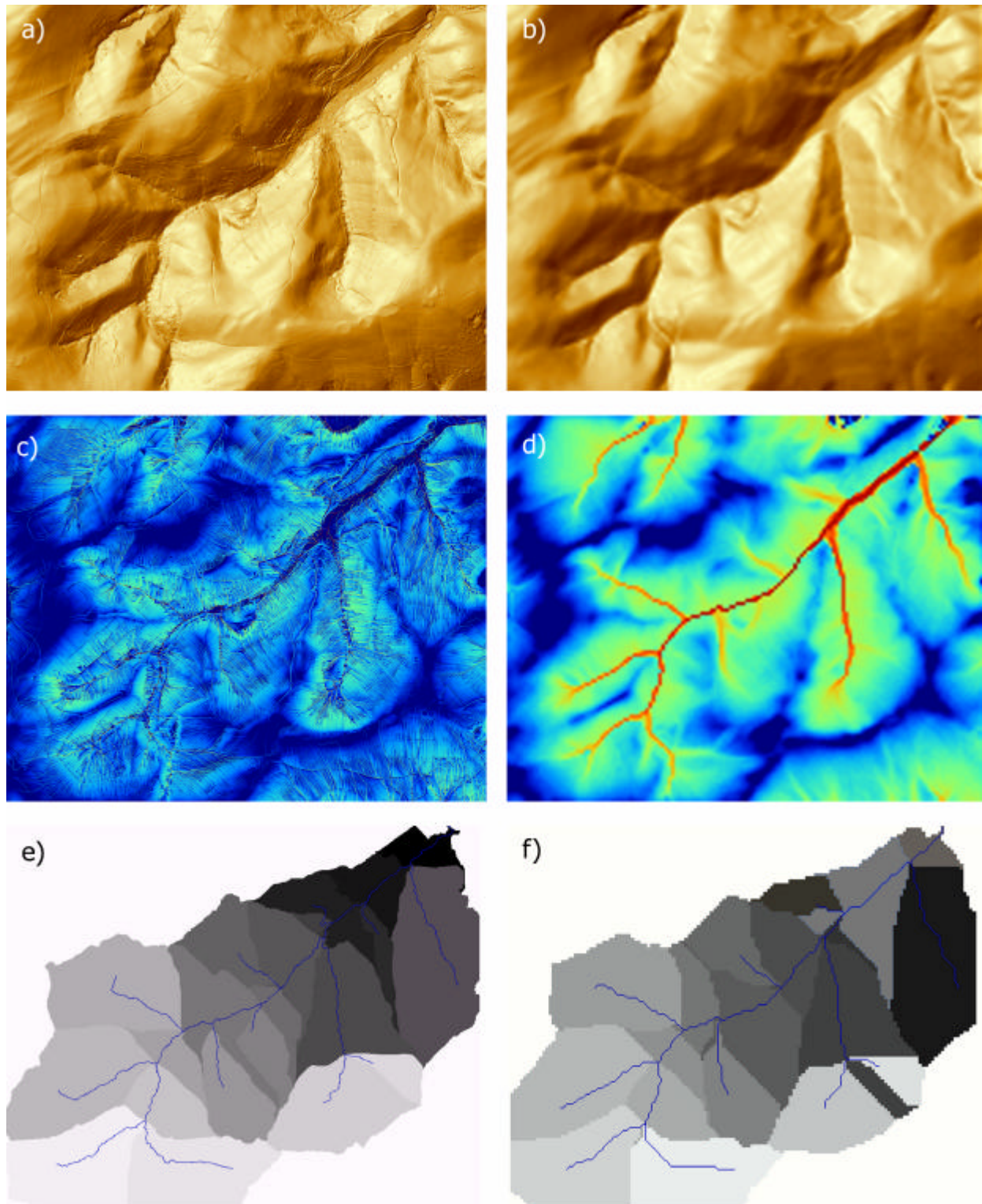


Figure 1. a), b) Hill shade image of DEM, c), d) LS factor, e), f) channels basins and network. Left: 2 m DEM, right: 20 m DEM

2 Methods

For this study hydrological products derived from a DEM with a spatial resolution of 2 m x 2 m and from a DEM with a spatial resolution of 20 m x 20 m were compared. Both were subjected to hydraulic analysis using the open source GIS software SAGA Version 1.2.

In a first step, the sinks in the DEMs, i.e. cells that are surrounded by cells with a higher elevation, were identified and filled. This step is done before further hydrological analysis because many flow routing algorithms behave badly in these cells [7]. The next step was calculating the catchment area. Using the default method “Deterministic 8”, the number of cells sending water into each cell is calculated. With this method, every cell’s runoff is sent to one of the eight neighbouring cells, restricting the flow directions to multiples of 45°. The channel network and the basins to every subchannel are another step in the hydraulic terrain analysis. With these results some further hydrological indices were calculated. The LS factor reflects the effects of slope length and slope steepness on erosion.

3 First results from visual interpretation

Fig. 1 shows, from top to bottom, an illuminated image of the DEM section, the calculated LS factor and the channels basins and network image. The images on the left are derived from the 2 m DEM, the right images from the 20 m DEM. As can clearly be seen, the results from the fine DEM are much more complex than those from the coarse DEM, although the hill shade images a) and b) do not look too different. The 2 m products show a lot more detail. This amount of detail can be confusing to the operator, and it displays some artefacts in the data that cannot be seen in the coarser scale, so only when a very detailed study of a very small catchment is planned, a DEM of such a high spatial resolution is needed in hydrology. A closer look at the images reveals some important differences. In the coarse LS factor image (d) the whole main Frankelbach channel is displayed in red, suggesting a high susceptibility to erosion. The fine LS image (c) shows that the meadow at both sides of the channel is rather flat and hardly in danger of erosion, which results in blue colouring. It can also clearly be seen that each slope behaves differently and not uniformly, while the right image shows them very alike each other and without internal structure. The channels basins and network images e) and f) look quite similar, but especially at the middle reaches of the stream some differences are obvious.

Fig. 2 illustrates an example where the very high spatial resolution available from small-footprint airborne laser scanning data is beneficial in catchment management. The left part of the image shows a section of Frankelbach’s northern slope where a road cuts into the slope and clearly redirects the runoff. The centre of the figure is an intensity image of the Lidar data, comparable to an aerial image, with a spatial resolution of 1 m x 1 m. The same section as seen in a 20 m hill shade image is shown on the right. No micro-topographic influence on the runoff can be discerned at this level of detail.

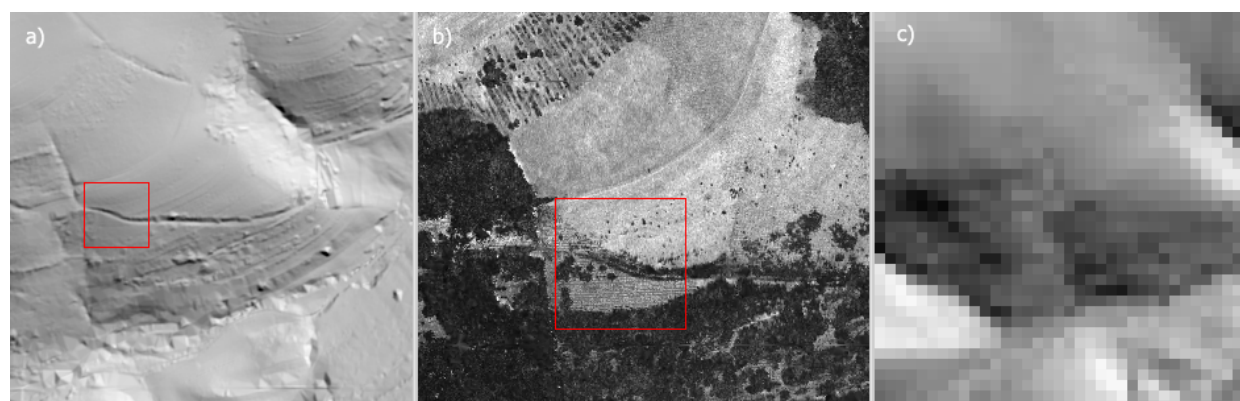


Figure 2. a) Hill shade image of a section of the catchment at 2 m resolution, b) intensity image, c) hill shade at 20 m resolution

4 Conclusions

DEM's are crucial in hydraulic modelling. The finer the DEM's spatial resolution, the more detailed studies are possible. In some cases, especially when a complete catchment is considered, however, a DEM with a spatial resolution of 20 m is sufficient. DEM's like this are available for many areas from the local administration. Only when micro-topographical effects are to be investigated, the fine resolution provided by laser scanning DEM's is necessary. In cases where the effect of single roads or trenches is of interest or when the internal structure of slopes

is to be investigated, Lidar offers the best possibility to obtain DEMs in the resolution needed. Doing hydrological modeling on larger high resolution DEMs lead to long processing times without offering much excess value.

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Efficiency of distributed flood mitigation measures at watershed scale

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Abstract

Protection of dispersed zones of interest against flooding inside a watershed needs careful consideration. Uncoordinated flood defence strategies render certain areas vulnerable while assuring protection to a given zone. Hence decentralised flood mitigation measures are solicited. By definition dry dams are ideal structures which attenuate flood peaks without rupturing the normal river flow regime and are activated only in case of high flows. Our study analyses the impact of dispersed retention measures along the drainage network on the watershed dynamics.

To test the above approach, a chain of models reproducing physical processes at watershed scale was developed. The chain is composed of a rainfall generator (stochastic), a hydrological model (GIS) and a hydraulic model (1 D). The rainfall generator (TBM) feeds spatially distributed rainfall fields into the distributed hydrological model (MARINE), which in turn simulates lateral surface run-offs. The surface run-offs are then injected into a hydraulic model (MAGE), which routes the flow and can also simulate scenarios with the presence of hydraulic structures. The chain of models was then calibrated and tested on a existing watershed. The spatial aspect is of importance, since the response of a watershed is found to be sensitive to this parameter.

For a chosen set of intense events input into the chain of models, a flood frequency distribution is calculated with the simulated outputs. The statistical data calculated gives the likelihood of various discharges as a function of recurrence interval or exceedance probability. In the next step, hydraulic structures are introduced and their influence on the dynamics of the watershed is then simulated and analysed at different locations. To quantify the efficiency of mitigation measures, the frequency distribution obtained with hydraulic structures is compared with frequency distribution without any mitigation measures. The attenuation achieved with different mitigation configurations are noted and their respective efficiency is compared. The developed chain of models serves as a means to test the influence of rainfall distribution, mitigation measures and strategies. Thus the proposed approach can support decision-support systems and help identify potentially applicable solutions and efficiency indicators at watershed scale.

Keywords : Flood mitigation strategies, watershed scale, dispersed retentions, spatially distributed rainfall, distributed modelling, dry dams

1 Introduction

Recent floods have incited the need of new strategies for better management of floods. Present flood management paradigm promotes risk handling and living with floods instead of defensive tactics against hazards. The changing land use practices creates dispersed zones of interest and thus uncoordinated flood defence strategies while protecting one area could aggravate the situation elsewhere. Hence one needs to look at a decentralised strategy to protect the entire watershed area and promote coordinated development and management actions. The impact of dispersed retention measures on the hydrological regime of watershed is analysed. The mitigation measure proposed in this study is aimed to encompass the entire watershed and is achieved via dry dams.

2 Approach

To identify efficient flood mitigation strategies, a thorough management and risk analysis of various possible scenarios should be formulated and tested. For this, a correct hydrological regime of the study area is to be established and then various mitigation strategies are to be tested. After which the most adaptable strategy for the study area can be chosen. Dry dams were chosen for their peak attenuation during highflows and respecting normal flow regimes otherwise.

To execute the above explained approach MARINE [1] a distributed rainfall-runoff model is run with spatially distributed rainfall fields furnished by a rainfall generator [2]. The runoff so generated is in turn injected into MAGE [3], a 1 D hydraulic model to route the outflow. Thus dominant physical processes involved in the production of runoffs are simulated to the best via these models. Once this chain of models is put in place, dry dams are introduced in the hydraulic model, to simulate flows under the influence of dispersed retentions.

3 Application

The above enumerated approach was tested on an existing watershed of about 150 km² (Figure 3a). The first step was to calibrate the chain of rainfall-runoff and routing models to simulate observed discharge at Taffignon. The calibration was carried out under a uniform rainfall scenario. In the next step, a set of 45 intense stochastically distributed rainfall fields simulated by the stochastic rainfall generator capable of producing high flows were chosen (an example in figure 3b). These events were routed through MARINE and MAGE to obtain flood hydrograms at various points. With the resulting simulations, a discharge – frequency curve was constructed at Taffignon. The aim was to reproduce a instant discharge - frequency curve resembling to that observed at the discharge station Taffignon. This newly generated discharge – frequency curve will henceforth serve as the reference to quantify the mitigation achieved through dry dams. To evaluate the efficiency of dispersed dry dams three strategic control points (Figure 3c) were chosen in the watershed; Charbonnières amont (upstream), Craponne (intermediate) and Taffignon (downstream). Likewise discharge-frequency curves were constituted at Charbonnières amont and Craponne. The consideration of spatially distributed rainfall fields is important since homogenous rainfall scenarios tend to underestimate runoff volumes [4]. A correct estimation of flood volume is an important criteria to model the functioning of any hydraulic structure.



Figure 3a. Study area with discharge stations (circle) and rain gauges (triangle)

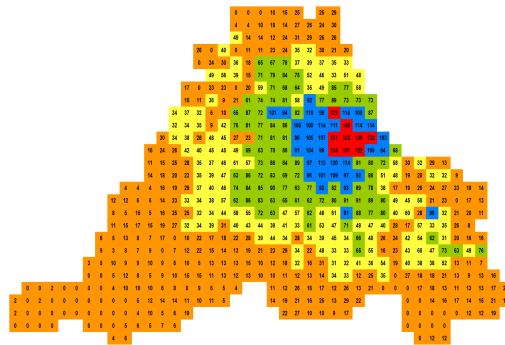


Figure 3b. Example of a cumulated 12 h spatially distributed rainfall field simulated by the rainfall generator for the study area. Variation of intensities is represented through colour code degradation; beginning from red (intense) to blue, green, yellow and orange (low)

Dry dams assure normal free flow through the bottom outlet and mitigate only high flood flow volumes. 11 dispersed dry dams were chosen for flood mitigation (Figure 3c) i.e 6 upstream (1 to 6), 3 intermediate (7 to 9) and 2 downstream (10 to 11). Outlets were dimensioned to constrain the discharge outflow to a 2 year (Q_2) and 10 year (Q_{10}) discharge values when the dam is full (Table 3a). The total storage volume of dry dams was maintained approximately to 2.0E+06 m³ for each placement i.e $S_1^6 v_i = S_1^3 v_i = S_1^2 v_i$ where v_i = storage of individual dry dams (Table 3b). The sensitivity of volume, placement and outlet dimension of dry dams on flood mitigation is analysed presently.

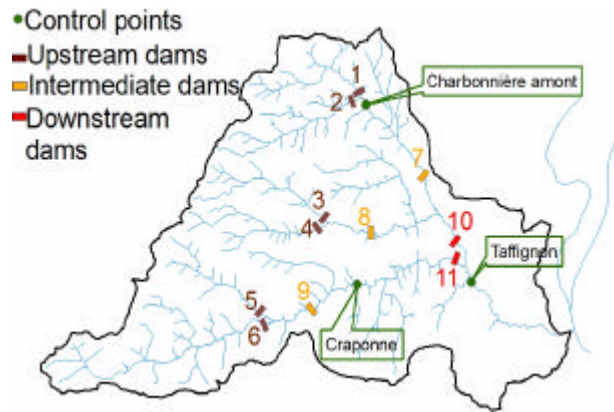


Figure 3c. Dry dam placements and control points

Table 3a: Discharge values of 2-yr, 10-yr and 100-yr return period

Control points	Q_2 (m^3/s)	Q_{10} (m^3/s)	Q_{100} (m^3/s)
Charbonnières amont	6.44	11.75	19.87
Craponne	6.60	13.00	23.00
Taffignon	39.0	72.00	117.00

Table 3b. Approximate storage volumes of the 11 dry dams

Dry dam n°	1	2	3	4	5	6	7	8	9	10	11
Storage volume (m^3)	3.E+05	3.E+05	4.E+05	3.E+05	4.E+05	3.E+05	7.E+05	7.E+05	6.E+05	8.E+05	1.E+06

4 Results and discussion

It is obvious that the storage volume of hydraulic structures has a significant effect on the extent of mitigation. Mitigations achieved at the three control points is calculated by noting the flood peak reduction for different dam configurations. The effect of increased storage volume can be observed at Craponne and Taffignon (Figure 4 b & c). The influence of placement on the mitigation can be ascertained at Taffignon, where a higher efficiency is assured by the two downstream dams compared to intermediate and upstream dams initially (Figure 4c).

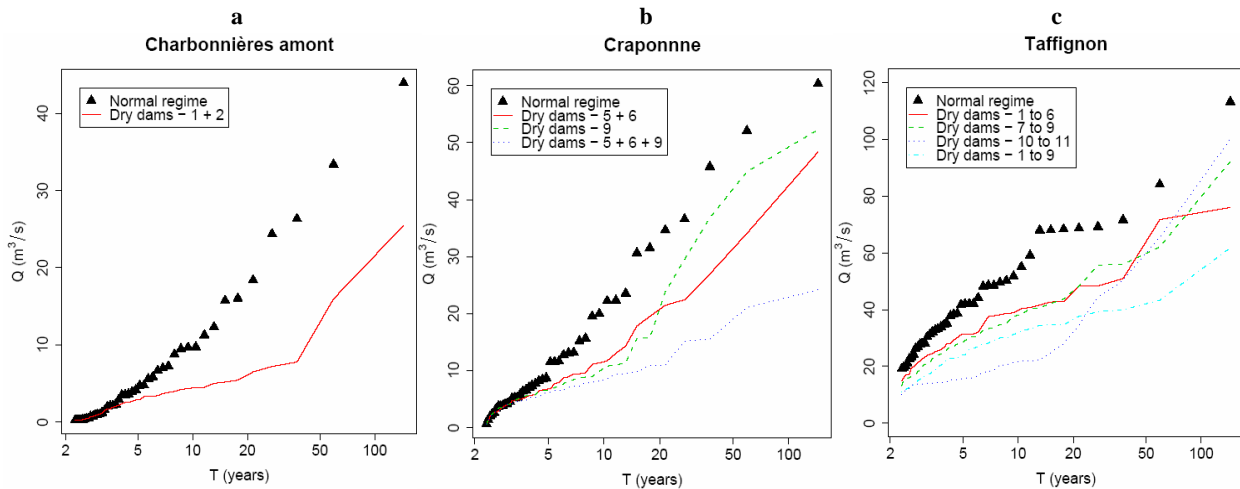


Figure 4a. Mitigation via upstream (1 and 2) dry dams, b. Comparison of mitigation through upstream and intermediate dry dams, c: Comparison of mitigation attained with upstream, downstream and intermediate dry dams for Q_2

In the present case the influence of two outlet dimensions, which limit the outflow discharge to 2-yr and 10-yr return periods are tested. The mitigation achieved from the two outlet dimensions at Charbonnières amont is shown in figure 4d. The percentage of mitigation achieved for the two outlets at the three control points is recapitulated in table 4a. We see that the average flood peak attenuation through the outlet limiting the outflow discharge to a 2-yr return period (Q_2) is relatively higher for return periods up to 40 years at the three control points. In comparison, the outlet limiting the outflow discharge to a 10-yr return period (Q_{10}) has a higher mitigation from 40 to 100 year return periods at Charbonnières amont and Craponne except at Taffignon. Since at Taffignon the incoming volume of a 100-yr return period is around $5.8E+06 m^3$, while the available storage volume is only $2.0E+06 m^3$ (Figure 4c). Thus smaller outlet dimensions are efficient for frequent floods of small amplitude, while the larger outlet

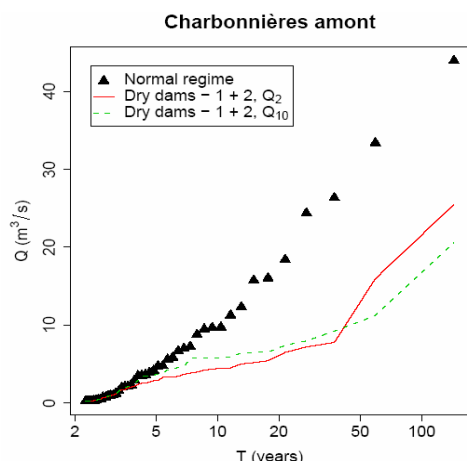


Table 4a: Comparison of average flood peak attenuation for 2 year and the 10 year design floods in percentage

Flood return period (years)	Charbonnières amont (1+2)		Craponne (5+6+9)		Taffignon (10+11)	
	Q ₂ (%)	Q ₁₀ (%)	Q ₂ (%)	Q ₁₀ (%)	Q ₂ (%)	Q ₁₀ (%)
2 to 40	7.52	5.93	14.79	12.60	55.35	46.16
40 to 100	18.20	23.09	34.03	37.02	16.09	14.41

Figure d. Mitigation due to outlet dimensions at Charbonnière amont

dimensions are found to be transparent for the same. But the larger outlets prove to be efficient for rare events and mitigate only high peak flows (Table 4a). The outlet dimension thus impose an efficiency range and beyond this range of design floods any mitigation is difficult to achieve (Figure 4c). By activating only the upstream and intermediate dry dams an average 50% peak attenuation can be achieved at the three control points. This dam configuration though protecting zones at stake (Charbonnières amont, Craponne and Taffignon) might not be the best solution when individual zones are considered (Taffignon).

5 Conclusion

The aim of the study is to identify potential mitigation strategies for the entire watershed. The efficiency of dispersed retention measures on flood mitigation at zones of interest is tested here. To test potential strategies a chain of rainfall, hydrological and hydraulic models is developed. One of the main reason for adopting a spatially distributed rainfall repartition is to account correctly the working of the hydraulic structures, which is highly dependent on the flow volume. Peak flow attenuation was the efficiency indicator used to analyse the change in flow regime. First results of the defined approach are presented here.

The influence of storage volume, placement and outlet dimension on flood mitigation at different points of watershed is analysed. The mitigation achieved is logically dependent on the storage volume, which is conditioned by the local topography and is also the decisive factor for dam placements. Outlets designed for small amplitude floods while mitigating low peak flows become relatively inefficient for large flood return periods because of early storage saturation. On the other hand, if the dry dams are designed for rare and high amplitude floods, they do not mitigate frequent low flows and affect only high flows until storage depletion. The outlet dimensions of dry dams thus impose an efficient mitigation range. Hence when a design flood for flood management is chosen, mitigation objectives need to be well defined to ensure that the resulting range of efficiency is meeting the demands of the study area. With the resulting simulations, different efficiency indicators can be developed by accounting flooded surfaces, land use practices, etc. The indicators so obtained can then be fed into economical models to help choose the most appropriate solution for the study area and strengthen decision support systems.

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Hydrograph Analysis for the WaReLa Research Basin Frankelbach

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Abstract

At the WaReLa test site Frankelbach hydro-meteorological data has been captured continuously for the last three years. The hydrographs of four gauges have been analyzed focusing on the antecedent conditions that lead to a certain runoff response. Therefore runoff coefficients as well as antecedent precipitation indices have been calculated for 21 floods. The results clearly demonstrate the big importance of the antecedent moisture state. If the basin is very dry in summer no runoff response at all was observed for extreme rainfall. In contrast, in spring when the soil moisture is high due to melting snow only little rainfall leads to high floods.

In the Frankelbach basin several measures to retain and delay fast runoff have been realized. Thus it have been analyzed if the effect of those measures is identifiable within the still short data set. But, up to now the impact of the retention measures is not clearly detectable in the observations.

Keywords: Floods, hydrograph analysis, retention measures, Frankelbach.

1 Research Area and instrumentation

The 5 km² Frankelbach basin, located in the Rotliegend sediments near Kaiserslautern is one of the WaReLa test areas. Here various measures such as reforestation, the construction of small retention reservoirs and the transformation of forest roads have been realized recently. Since 2004 a hydro-meteorological measurement network has been set up. Besides gathering the hydrological behavior of the basin in general the aim is to get further knowledge on flood generation during high rainfall as well as to assess the effects of precautionary measures for water retention.

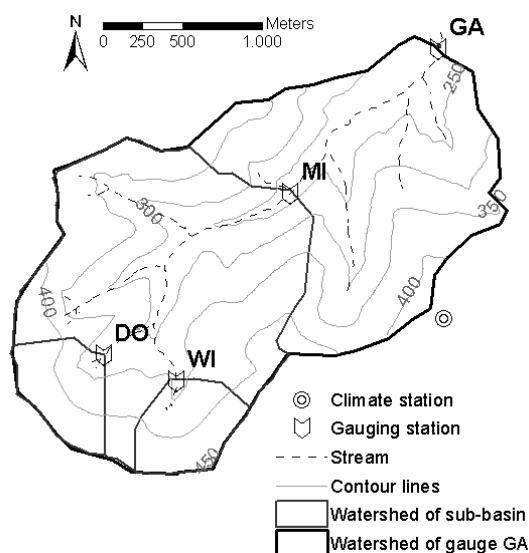


Figure 1. The measurement network in the Frankelbach basin

About 52 % of the basin is forested, 23 % is cropland, 20 % is pasture land, and 5 % is sealed. The two sub-basins DO and WI are almost of the same size (see Table 1). About two thirds of the sub-basin DO is cropland

while two thirds of the sub-basin WI is pasture land that is mainly afforested in the last years. The percentage of old forest is higher in the sub-basin DO. Furthermore the geomorphology of those sub-basins is different. The sub-basin WI is more like a bowl with steep slopes and the gauging station as outlet while the upper slopes in the basin DO are shallower and more or less exposed to the same direction.

Since Dec 2004 at four flumes GA, MI, DO and WI the water level is recorded with pressure sensors and one ultrasonic velocity sensor (gauge MI). One climate station captures meteorological data since summer 2004. All data is stored in 10-min time steps.

2 Hydrograph analysis

To describe the hydrological behaviour of the basin the statistics and runoff coefficients have been calculated for the whole discharge data set (Dec 2004 to July 2007). The maximum runoff of sub-basin WI is clearly higher than of the sub-basin DO (Table 1). The mean specific discharge at the sub-basins gauges is higher than at the gauge GA. All gauges ran dry in hot summers except for sub-basin DO. The gauge MI was installed later than the other gauges and it was out of order several times. Therefore the number of missing values is much higher.

Table 1. Statistics for the discharge measurements at the four gauges for the measurement period Dec 2004 to July 2007

	<i>GA</i>	<i>MI</i>	<i>DO</i>	WI
Missing values [%]	3.3	28.1	9.0	3.8
Mean [l/s]	33.4	19.0	2.8	3.0
Mean [l/s/km ²]	6.6	6.6	9.1	9.5
Max [l/s]	660	565	33	88
Min [l/s]	0.0	0.0	0.1	0.0
Basin Area [km ²]	5.05	7.88	0.306	0.315

The runoff coefficient has been calculated for each flood between Dec 2004 and July 2006. In doing so the base flow has been subtracted manually and the remaining cumulated discharge has been given as percentage of the precipitation. As seen in Table 2 the two highest rainfall events with maximal intensities of 50.3 mm/h (Sept 2005) and 80.9 mm/h (July 2006) do not cause any increase in discharge since the antecedent conditions were very dry. In contrast, at times when the soil is saturated and snow cover is melting the floods are high even if rainfall is low (see event no. 13). Consequently, the two highest floods were observed in March (2006 and 2007) with a high percentage of melt water. The system moisture state as crucial factor triggering high floods is demonstrated in the event series in May 2006 too. Here the runoff coefficient clearly increases with every following event (see also Figure 2). Generally, in winter the runoff coefficients for WI and DO are much higher than for GA, in summer it is the opposite way around (see Table 2).

The runoff response of the sub-basin WI is much stronger than of the sub-basin DO. As seen in Figure 2 the peak flow of WI increases enormously with a higher saturation of the soils. After a very short and sharp increase that is observed for all gauges and origins probably from sealed areas the runoff of DO decreases continuously even if some rainfall is added. But for the gauge WI at high moisture state the discharge increases for some hours and a second peak occurs (see time step 800 in Figure 2). Thereafter the discharge decreases quickly almost to the antecedent level. This different behavior of the headwaters might be due to the geomorphology of the sub-basins or to the different land use (see chapter 1). Compared to the whole basin (gauge GA) the sub-basins show a different behavior at different moisture states. The runoff response at gauge GA seems to be a mean of the responses of the both sub-basins. But since the gauge MI shows a similar signal as gauge WI, at least at time step 800 it may be that the valley Tiefertal, a tributary downstream of gauge MI reacts more like sub-basin DO.

Table 2. Event characteristics for the captured floods between Dec 2004 and July 2006. The grey rows marks the two biggest storms. Events no. 17 to 20 are shown in Figure 2

No.	Date of peak	Runoff coefficient				Precipitation		Antecedent Precipitation	
		GA [%]	MI [%]	DO [%]	WI [%]	Sum [mm]	Max [mm]	Sum of 7 days [mm]	Sum of 21 days [mm]
1	21.01.05 18:00	51.2		67.0	95.7	22	4.8	2.0	15.1
2	12.02.05 22:00	15.2		15.2	27.5	54	4.3	1.7	22.9
3	12.03.05 21:00	53.1		44.9	101.3	20	6.2	5.3	58.9
4	07.04.05 19:00	31.9		15.2	37.2	17	2.9	4.6	27.0
5	21.04.05 02:00	13.6			17.0	57	4.4	3.7	43.0
6	29.06.05 21:00	1.4	0.5	0.8	0.4	12	10.2	1.1	6.4
7	10.09.05 18:00	0.0	0.0	0.0	0.0	57	50.3	0.3	11.8
8	16.09.05 16:00	1.5	0.6	0.2	0.2	13	3.1	99.3	107.1
9	05.12.05 02:00	10.3	19.6	16.0	29.5	33	2.6	52.4	69.9
10	02.01.06 01:00	24.1		30.4	59.0	19	6.3	17.1	41.5
11	18.01.06 22:00	0.7		0.4	1.1	10	1.2	3.5	39.3
12	21.01.06 13:00	40.5	2.9	1.6	4.1	53	3.3	10.4	35.6
13	19.02.06 09:00	43.4	35.5	40.7	79.7	3	1.1	5.5	15.0
14	09.03.06 20:00	92.8		102.1	162.3	35	3.3	66.1	107.4
15	31.03.06 10:00	43.1		33.1	62.7	25	2.9	18.8	49.6
16	26.04.06 08:00	0.9		0.1	0.0	21	6.6	3.7	15.1
17	17.05.06 00:00	0.9	0.3		0.0	22	6.2	1.9	25.9
18	20.05.06 18:00	4.2	3.7	1.0	1.0	19	10.4	27.7	40.0
19	23.05.06 02:00	7.7	8.5	1.6	3.2	13	3.0	46.4	59.2
20	28.05.06 06:00	13.5	16.7	5.5	15.9	46	11.3	38.5	65.1
21	22.07.06 16:00	0.0	0.0	0.0	0.0	91	80.9	0.0	0.6

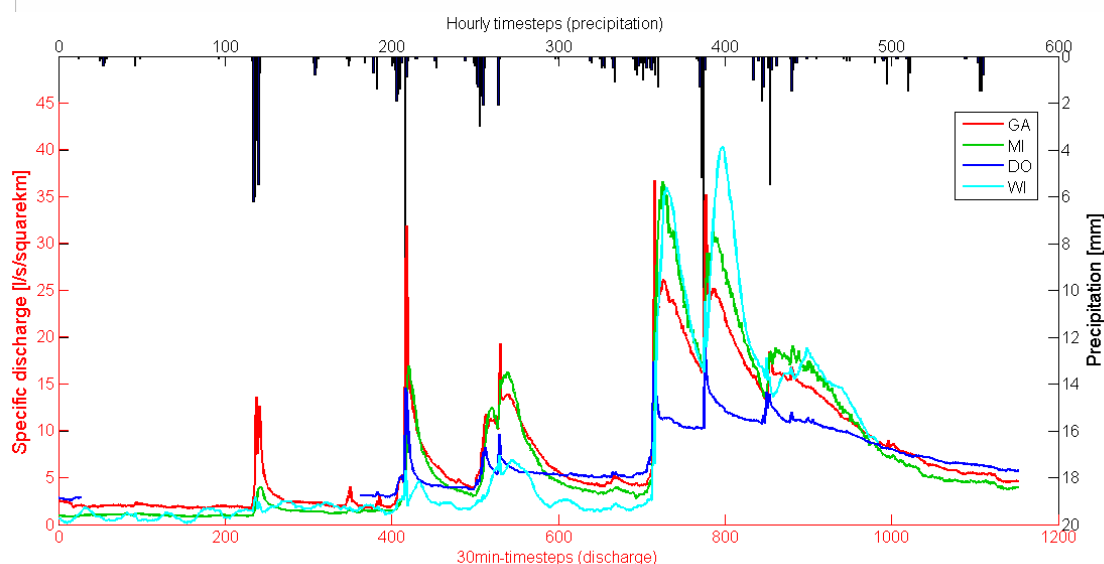


Figure 2. Specific discharge at the gauges GA, MI, DO and WI as well as precipitation for a sequence of storms between May 14th and June 8th 2006

3 Impact of retention measures

During the last years several retention measures have been realized in the Frankelbach basin. In autumn 2005 about two thirds of the sub-basin WI has been afforested. On a former sheep-grazing land alders have been planted in rows parallel to the contour lines. In autumn 2006 a small retention reservoir have been built upstream of sub-basin DO by reducing the discharge capacity of a pipe beneath a forest road.

To asses the impact of these measures one should compare at least two storm events of nearly the same intensity and during similar antecedent conditions. However such storms could not be found in the present data set. Instead the cumulated runoff of both sub-basins has been plot against each other (Figure 3). The runoff of sub-basin WI is continuously slightly higher than of sub-basin DO. The bulges of the curve towards the y-axes are due to sharper and higher response of sub-basin WI to higher rainfall. If there would be a continuous change in the runoff behaviour of one basin one would see a changing trend in the curve.

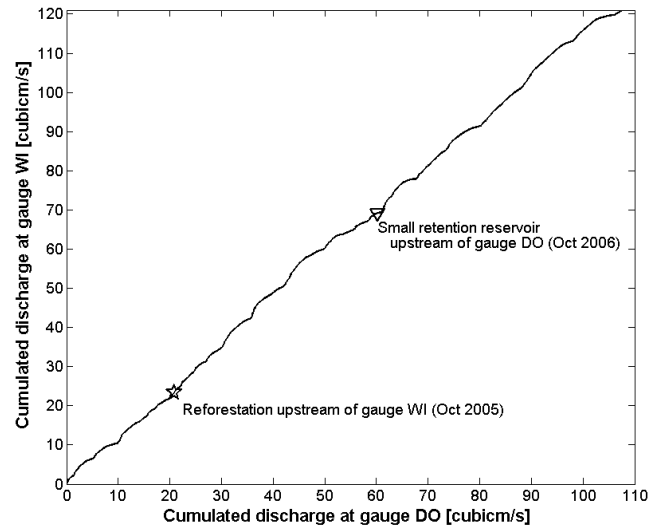


Figure 3. Comparison of cumulated discharge of the two headwaters from Dec 2004 to July 2007

4 Conclusion

Data analysis demonstrates that the soil moisture state is a very important steering factor concerning the mechanisms of flood generation. The two highest floods occurred in spring without antecedent high precipitation. But, extreme rainfall in summer did not lead to any runoff response since the basin was very dry. This very different behavior of runoff response is even more evident for the headwater WI. Here a high subsequent flood wave was observed when the soils were saturated but no increase in runoff occurred during dry conditions.

The impact of the retention measures is not yet detectable in the measurements. But of course the time series are still too short and too little floods could be compared. Furthermore, the pedogenesis of water retaining forest soil will take decades.

ACKNOWLEDGMENTS

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Retrieval of biomass and physical attributes by spaceborne SAR data in middle European low mountain ranges – opportunities and persistent constraints after launching PALSAR

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Abstract

For a the forested low mountain ridge region of the Idarwald, Rheinland-Palatinate, western Germany, we investigated in the opportunities of recent available space-borne microwave data for the distributed retrieval of standing biomass and other physical forest attributes. During the study most of the obstacles reported in literature and attributed to saturation effects in forests with high biomass were also observed for the Idarwald data sets. Additional the crossover of different physical properties in the target region influencing the backscatter signal in combination with use of data not yet radiometric corrected hindered the analysis. However it was possible to ascertain a weak correlation between C-band backscatter and average age of young deciduous forest stands and a more significant correlation between L-band JERS data and average age of deciduous forest. Based on this results opportunities offered by full polarised L-band PALSAR data are assessed as promising.

Keywords: forest biomass, remote sensing, microwave, PALSAR.

1 Introduction

Spatial distribution of standing biomass and physical forest attributes are important information layers in landscape assesment, modeling or silviculture planning. But their survey by traditional field methods is costly and feasible only for smaller regions. Hence numerous studies have investigated in the opportunities offered by different remote sensing sensors and techniques [1].

Due to the interaction of the microwave signal not only with the target's surface, the wide range of available sensors and the ability to operate even under poor weather conditions and during the night, SAR seems to be an enticing data source [1]. Additional space-borne active microwave sensors now provide satisfying spatial resolution and time series with a high repetition sequence. The practicability of the method was proved by several studies especially in boreal regions [7] or at the transition zone between tropical forests and savanna [2] with low to medium biomass. However, due to disturbing effects caused by varying canopy roughness and moisture content or topography the application is subject to limitations. One of the biggest obstruction is the early saturation of C-band signal in the retrieval of biomass. So it is recommended to employ L-band. But until the successful launch of the Japanese satellite ALOS in June 2006, only archived scenes from JERS provide satisfactory spatial and temporal coverage for L-band microwave data.

The ALOS satellite now provides a fully polarized SAR sensor in the L-band domain and a multispectral sensor. This makes us to resume the results so far achieved in a case study site, situated at the "Idarwald", a part of the Hunsrück, a low mountain range region in the central part of Rhineland-Palatinate. Additional to a recapitulating literature study and substantial experiences with multi- and hyperspectral sensors the applicability of SAR sensors was tested there by using ERS2, ASAR and JERS data.

2 Testregion, data and methods

Main aim of the presented study was to deliver a state of the art regarding the retrieval of forest biomass and structural forest attributes from so far available microwave sensors with special focus on European low mountain ridge regions. First step to be performed was a literature study on derivation of forest attributes by space born microwave instruments. Additional to this and substantial experiences with multi- and hyperspectral sensors the applicability of SAR sensors was tested by using ERS2, ASAR and JERS data.

2.1 Regions of interest

The area of study (49°40'N, 7°10'E) is the Idarwald forest in south-western Germany on the north-western slope of the Hunsrück mountain ridge. The dominant tree species are Norway spruce, beech, oak and Douglas fir. Available information covering the test site includes HyMap, Quickbird, LIDAR, GIS and field data sets. Additionally, a temporal alignment of high-resolution CORONA and Quickbird imagery was performed to investigate the possibility to elaborate "a priori information" for areas with a lack of field data, similar to that available for this study. Parameters measured at the field included tree height, crown height, crown radius, stem diameter at breast height, LAI, number of trees and canopy closure.

2.2 Datasets

For the study only commercial SAR products taken under standard conditions were employed. Data set of four ENVISAT-ASAR images reaching from January to June 2005 (VV-polarisation), one double-polarised image (VV-HH) and one cross-polarised ASAR image from April 2006 were employed to investigate opportunities to derivation of forest attributes. Additionally a pair of JERS L-Band images (July, August) for summer 1998 was incorporated in this study.

All ENVISAT scenes had been calibrated with ESA standard tool BEST and after geometric correction with ERDAS Imagine software co referenced to each other.

2.3 Methods

All forested attributes derivate from microwave imagery were visually compared to aerial photographs and available Quickbird imagery. Further investigations are based on ground reference data derived from official state forest inventories. For extra investigations in the relations between backscatter and three high resolution LIDAR-datasets of the Idarwald region were used.

3 Results

In this study preliminary results, based on the literature study and experiences with C-band ENVISAT and L-band JERS data were reported. With the available datasets opportunities offered by repeat pass coherence or InSAR techniques could not be considered.

3.1. Main approaches documented in literature

Within the last decades reasonable outcomes have been achieved in derivation of forest properties from microwave data. A comprehensive overview is given by [7]; some additional remarks on the history of SAR biophysical retrievals are given by [4]. Unfortunately, two main constrains still remain. In dependence to physical properties of the used microwave system (wavelength, polarization), the tree species observed, weather conditions and forest management practices the linear correlation between forest biomass and backscatter tends to saturate between 70 m³/h and 150m³/h e.g. for Lband JERS data [7]. Additionally the backscatter signal has to be interpreted as a combination of effects caused by the properties of the targets surface and internal stand composition. Mostly the parameter under investigation is only one among several. To overcome these limitations, advanced sensor types [6], repeat pass interferometry [8], sophisticated classification schemes [5] or the combination of different sensor types (even optical)[9] was taken in account. Therefore within recent study for the retrieval of above ground standing biomass and backscatter correlations coefficients seldom below $r = 0.7$ are achieved [7], [1]. Nevertheless studies in hilly terrain with dense vegetation cover or for operative proposes are still seldom.

3.2. Results from C-Band ENVISAT data

First results affirm the saturation of C-Band even at low biomass levels. For juvenile deciduous forest stands a weak correlation of $r^2 = 0.47$ with the backscatter signal was observed for a January scene but points within the scattergram can easily be allocated to two well defined linear groups. Further investigations are focused on the rationales behind this phenomenon. In the June scene of canopy roughness caused by foliation covers the biomass information and distinguish the correlation to $r^2 = 0.02$ (Fig. 1a, b). The possibilities to discriminate different tree species e.g. spruce and beach on base of the C-band backscatter seem to be very limited. The signal for different polarizations and during the year is very similar for both species (Fig. 1c). Only before developed foliation at the deciduous trees a very slight deviation can be observed.

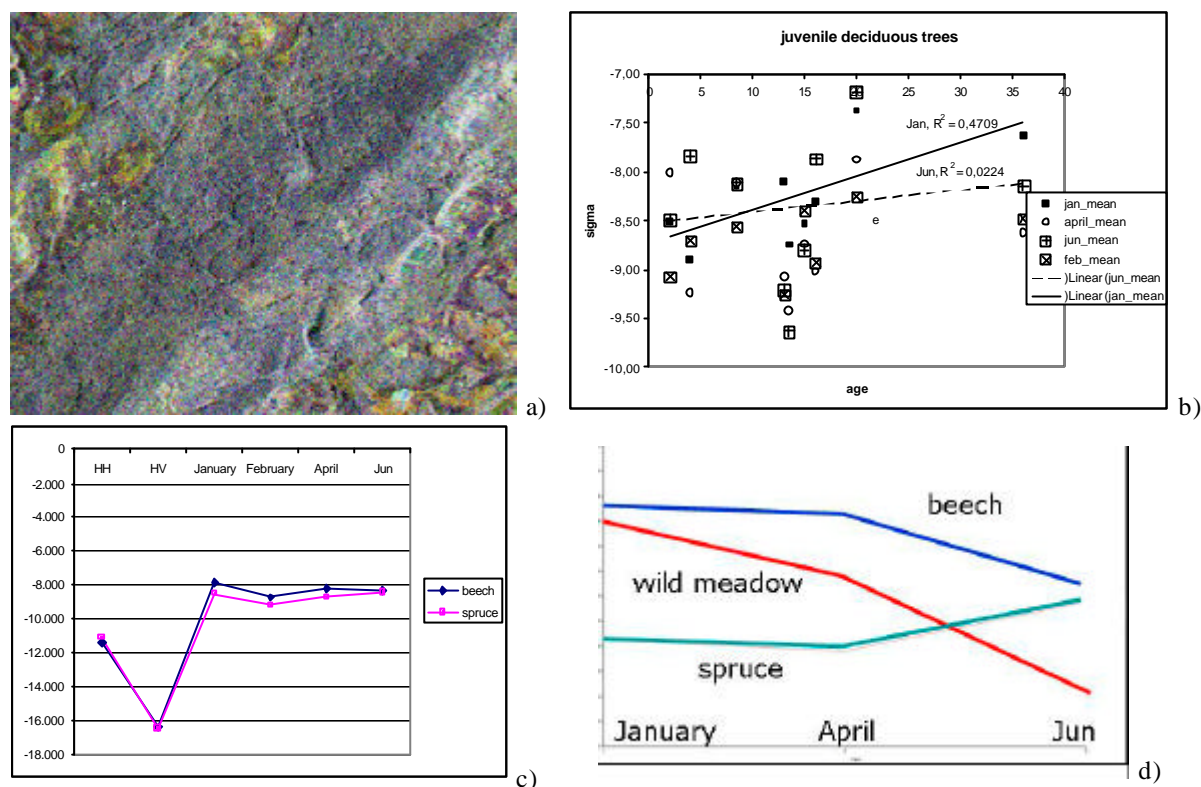


Figure 1. Results derived from a 5 images layer stack (ENVISAT, 2005) for the Idarwald region. **a)** Tree images layer stack (Jan., April, Jun), **b)** Relation between backscatter of c-band ENVISAT images and age of juvenile deciduous stands, **c)** Average backscatter in six ENVISAT scenes of different polarization or time of imagine for beach and spruce stands. **d)** Development of average backscatter for tree types of “forest canopies”.

3.3. JERS L-Band data

Due to known early saturation effects using C-band radar, it is recommended to employ L-band. But actually, only archived scenes from JERS (1992-1998), with fixed polarisation (HH) and incidence angle, provide satisfying spatial and temporal coverage. Until now a pair of JERS images from summer of 1998 was employed for first studies.

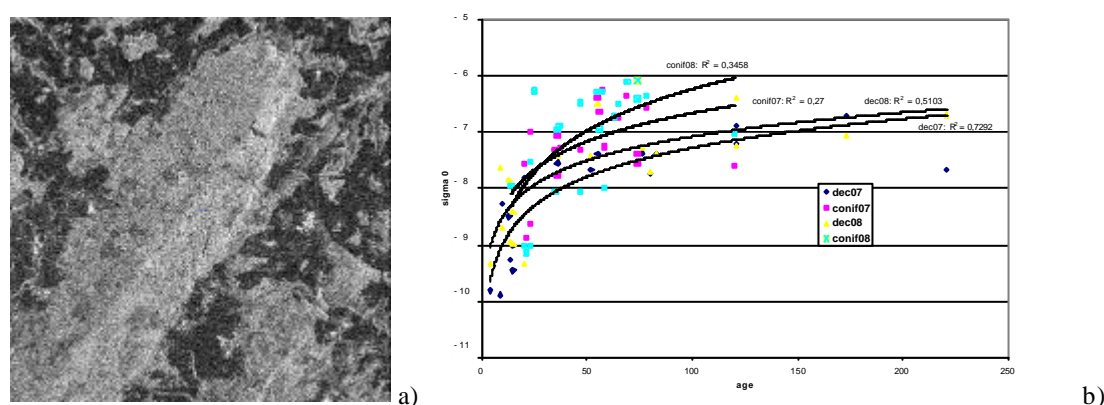


Figure 2. **a)** Section of the August 1998 JERS image for the Idarwald region. **b)** Correlation between backscatter in July and August scenes and average age of deciduous respective coniferous forest stands.

For JERS data, with known technically limited radiometric quality, a strong correlation between backscatter and forest biomass is documented in literature [1][7] up to saturation of the signal. For the test area of the Idarwald no data was available for stand wise forest biomass, so tree age and height had been used as reference data because of their high correlation with biomass. Regarding stand-wise tree age of the Idarwald forest, considerable logarithmic

correlations between and backscattering was observed for the deciduous stands ($r^2 = 0.51, 0.72$) and a weak correlation for the coniferous stands ($r^2 < 0.35$). Backscatter values have been calculated following the procedure given by [3] and using a preliminary calibration factor K of -53. Because until now only JERS data without sophisticated radiometric calibration and terrain compensation has been used better results are expected for the near future. Reference data for average stand was taken from an airborne laser scanning campaign performed in summer 2005. By scaling both data sets to a 15 to 15m raster no correlation was ascertained, but rescaled to 30 meter raster a raise of the correlation coefficient to $r^2 = 0.55$.

4 Conclusion and outlook

Using comprehensive field data for pre-calibration, it seems to be feasible to tag the type of canopy. Reducing and assessing interferences will assure reliable and transferable results. As expected C-band SAR data, neither multitemporal nor multipolarised, was found to be sensitive to forest attributes. Advanced methods like classification, C-band interferometry or wavelet analyses will possibly lead to onward results.

Concerning L-band microwave data, further results are expected from the analysis of repeat pass interferometric data (JERS) and multi-polarized and multi-angle PALSAR data. The latter is expected to provide useful information for monitoring of forest growth in young stands and rapid mapping of windthrow damage even in low mountain ranges. Based on the known saturation effects it seems to be very promising to transfer adapted and effectual methods on regions with sparse vegetation. Hence, next step to be performed will be to transfer these concepts to degraded Mediterranean mountain test sites with incomplete calibration datasets. Further tests are planned in semi-arid areas with changing land uses and vegetation cover.

ACKNOWLEDGMENTS

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Session 2

Water retention by land-use - application and evaluation

Hydrological modelling of decentralised flood protection measures in transnational headwater areas of the Natzschung catchment / Mittleres Erzgebirge

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Abstract

The headwater areas in midrange mountain systems like the "Mittleres Erzgebirge" are often one agent triggering floods in downstream valleys since the precipitation is distributed over large areas of the upper subcatchments before the water concentrates in the "high speed" receiving water courses. Next to many other places all over the Erzgebirge / Ore mountains, this happened the last time at the Natzschung river in August 2002. Due to the fact that standard flood protection management mostly focuses on the downstream catchment areas the question arises whether there are any opportunities to reduce floods by implementing small scale river engineering works along the streams, slopes and topographical depressions at the headwater areas. To localize the relevant subcatchment areas for flood evolution and flood protection and to analyse the hydrological effect of the flood protection measures the run off model NASIM was applied. The necessary input parameters were generated by GIS applications, field and lab surveys. The results of this case study will show the opportunities and limitations of this concept.

Keywords: Erzgebirge, transnational flood prevention, head water areas, retention basins, hydrological modelling

1 Introduction

In August 2002 the basin of the Elbe river was affected by heavy rainfalls, which induced an extraordinary flood all along the river system and its subcatchments [1]. One tributary of the Elbe-Mulde-Flöha catchment is the Natzschung, which is located along the borderline between Germany and the Czech Republic at the Mittleres Erzgebirge. Between the 12th and 14th of August the discharge at the gauging station Rothenthal / Natzschung river increased from 3m³/s up to 89m³/s. This led to heavy inundations and damages, in particular at the city of Olbernhau / Flöha river [2]. This discharge has corresponded to a recurrence interval of 237 years. Against that background, it arose following question. Does any potential exist to reduce the peak of discharge of that exceptional flood event by implementing decentralised small-scale flood protection measures in the transnational headwater areas? Based on this idea the hydrological effect of selected well-placed small retention basins with a low dam height and an optimal relationship between storage volume and flood retention area was analysed [3,4,5].

2 Investigation Area and Methods

The catchment of the Natzschung - illustrated in Fig.1 - is located southwest of the city of Olbernhau (50°39'42"N 13°20'01"E). Several smaller communities are located upstream. The basin encompasses an area of 75 km², about 70 % is located on the territory of the Czech Republic. 80 % of the basin is covered by mixed forests (28 %), coniferous woodlands (23 %), and mixed reforestation areas (29 %). 15% of the region is dominated by pastures and meadows, only 1% is used as agricultural crop land. 3% is covered by peat bogs and 1% is used for settlements. The Natzschung spring is located in the southwest at an elevation of 825 m NN and after 11 km, the gauging station Rothenthal is passed by at 538 m NN. The mean elevation is about 755 m NN. With a peak of 921 m, a ridge marks the southern catchment border. The relief can mainly be subdivided in upper lying low inclined regions with a slope between 25° and very steep areas at the downstream part of the Natzschung and Telcsky potok with gradients more than 40° [Fig.1]. The total river length is about 102 km with mean slopes between 2-6 % and a river density of 1,36 km/km². The mean discharge at the gauging station is about 1,4 m³/s.

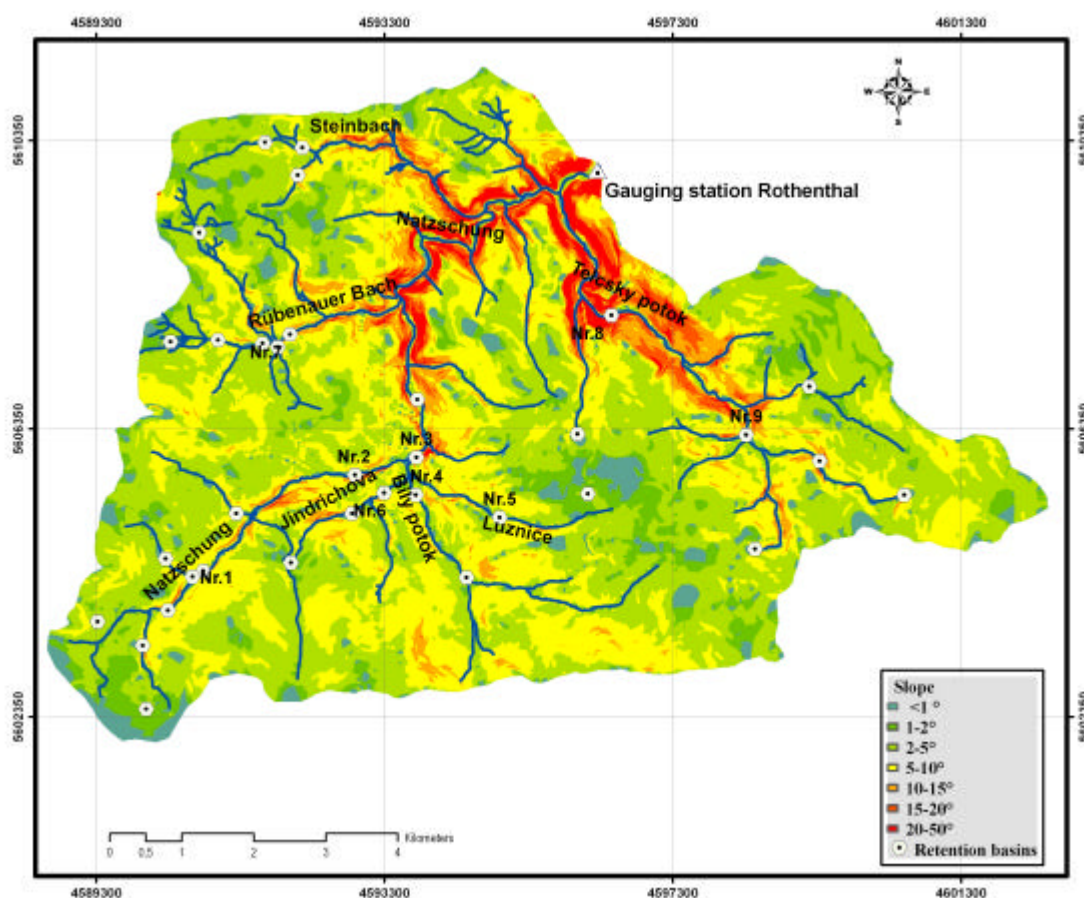


Figure 1. The Natzschung catchment upstream the gauging station Rothenthal with its main tributaries and the located 34 flood retention basins along the territories of Germany and the Czech Republic; the numbered retention basins were implemented into the hydrological model. The city of Olbernhau is located 3km north of the gauging station

Based on topographical maps with a scale of 1:10.000 a digital ground model was generated and analysed for natural depressions and low inclined areas [Fig.1]. Several ground checks and geodetic surveys delivered distinct information of precise position, area and volume of the preselected flood retention sites. To localize the relevant subcatchment areas for flood evolution and flood protection and to analyse the hydrological effect of the flood protection measures the run off model NASIM (Fa. Hydrotec) was used. The necessary input parameters were generated by field and lab surveys and the application of the Geographical Information System ARC GIS. The sites for flood protection measures were chosen according to following criteria:

1. Use for uncontrolled small-scale retention basins
2. Renaturation of drainage systems and peat bogs
3. Change or adaptation of land use systems concerning the soil water conditions

3 Results

All over the catchment area, 34 different positions for flood protection measures, especially for uncontrolled retention basins could be detected [Fig.1]. They include small lakes and already existing reservoirs with an ambiguous purpose. Most of the basins are located at the low inclined valleys and elevated plains in the southern region of the research area. The first run of the hydrological model showed for the current state of the flood event that about 60% of the discharge volume was generated along the headwater areas of the tributaries Telčský potok and the upper reaches of the Natzschung and Bily potok.

Table 1. Storage capacity of selected retention basins

Retention area [Nr., name, river]	Storage capacity [Tm ³]	Storage level [m]
Nr. 1 Natzschung upper reach	24.3	3.6
Nr. 2 Natzschung upper reach	39.0	4.5
Nr. 3 Natzschung middle reach	17.0	4.1
Nr. 4 Bily potok outlet lower reach	44.6	4.4
Nr. 5 Luznice potok lower reach	15.0	3.7
Nr. 6 Jindrichova potok lower reach	11.8	3.1
Nr. 7 Rübenauer Bach middle reach	26.5	4.5
Nr. 8 Telcsky potok middle reach	12.7	4.3
Nr. 9 Telcsky potok upper reach	65.0	4.8
Locations: Nr. 1, 4-6, 7-8: Czech republic; Nr. 2,3: along the borderline Czech Republic / Germany; Nr. 7: Germany	28.4 mean value; 255.9 total sum	4.1 mean value

Consequently, a special focus was given on nine retention basins, which are concentrated along these areas [Fig.1 and Table 1]. With the exception of the site Nr.7 Rübenauer Bach, all locations are placed on the territory of the Czech Republic. These nine sites have a total storage capacity of 255,900 m³ and a mean dam length of 98 m. The storage levels of the embankments are between 3.6 and 4.8 m. The throttles of the dams were optimized for pressure heads occurred during the flood event between 12th and 14th of August 2002. Based upon the question if non local measures at the headwater areas can contribute to a decrease of discharge and time displacement of the discharge peak of an extraordinary flood event, the modelling focused on the event between the 12th and 14th of August 2002 as current status. The target status considered the impact of the retention basins listed in Table 1. For that mentioned period of 48 hours, a rainfall sum of 208 mm was recorded at the climate station Olbernhau.

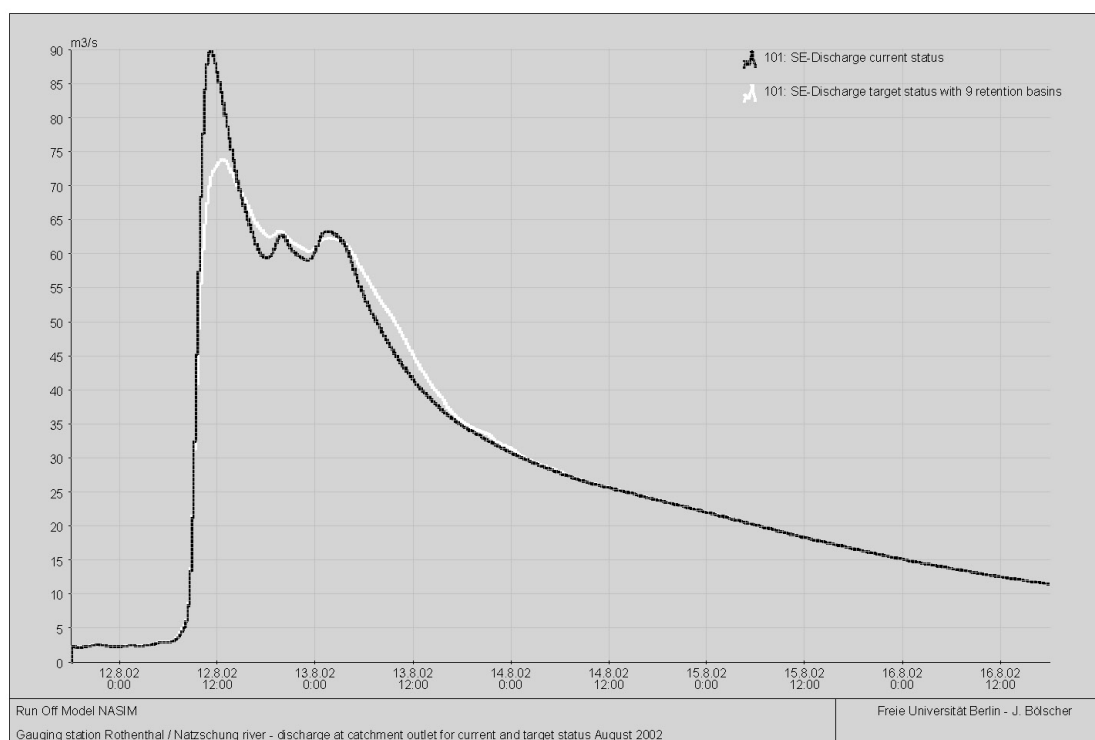


Figure 2. Gauging station Rothenthal / Natzschung river; current status and target status (white curve with 9 retention basins) for the run off situation between 12th and 14th of August 2002

The rainfall peak of 40 mm/h was reached at the 12th of August at 8:00 AM. At the gauging station Rothenthal the flood started at 12.08 at 6:45 AM (Fig.2). The highest peak was detected at 11:00 AM with 89.5 m³/s. 14.5 hours later the last peak occurred with a discharge of 63.4 m³/s. The results illustrated in Fig.2 show the impact on the run off situation by all nine retention basins, which were incorporated into the hydrological model. In Fig.2 this is listed as target status. Only the basins Nr.3 and the basin Nr.8 had almost no effect on the target status. Measures concerning the peat bogs, drainage systems, aspects of land use change and adaptation of land use systems could not be considered for these settings. The comparison between current and target status showed that at the gauging station Rothenthal the total outflow for the first peak decreased from 89.5 m³/s down to 73.9 m³/s. This means a reduction of 17 %. Both the second and third peak almost remained on the same level. The implemented retention basins also led to a time displacement of the first peak with about 1.5 hours. Compared with the current status the recurrence interval altered from 237 years to 150 years. The implementation of other retention basins into the model is in progress.

4 Discussion

In the past several approaches and investigations were made to estimate the hydrological effect of decentralised flood protection measures. The discussion is still in progress and it shows very obviously that a lack of data remains, especially concerning implemented measures and small-scale basin approaches [4, 6, 7, 8, 9]. The first results of the modelling could demonstrate that different opportunities for decentralised flood protection measures exist along the headwater areas of the Natzschung catchment. The capacities of the preselected retention basins are large enough to reduce the discharge peak of this extraordinary flood in August 2002 by 17 %. The ongoing research work will show the impact of these measures also for smaller flood events like the one in early spring 2006. However, up to now it becomes clear that these retention basins could be a serious addition to planned central measures along the valley of the Flöha river downstream of the Natzschung [2, 9]. Naturally, the realization of measures mainly depends on the final costs and benefits and on the political intention of the affected local German and Czech authorities [4, 9].

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Impact of heavy forest machinery on physical properties of forest soils

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Abstract

The use of heavy machinery for wood harvesting is assumed to cause partly irreversible damage to forest soils.

Three field experiments were carried out in the last 15 years to investigate the impact of heavy forest machinery on some soil and plant functions. The test sites were located on slopes in forest areas of Rhineland-Palatinate. The involved substrates ranged from dry and sandy to wet and loamy material. The dominant soil types were cambic podzols, cambisols and stagnic cambisols.

Harvesters with a total weight of 20-22 Mg and wheel loads of up to 4 Mg were used to produce traffic lanes by single and multipassing under typical working conditions in spring. During wheeling the induced soil stress was determined. Soil physical properties like bulk density, pore size distribution, air and water permeability and infiltration rates were measured after wheeling and the results were compared with undisturbed sites to derive information about the initial impact.

The results of the younger test sites showed that the induced soil stress was much higher than the internal soil strength. This causes severe damage to most soil functions within topsoil and subsoil. Water infiltration was hampered and air and water permeability as well as water storage capacity were reduced. Penetration resistance was higher. These effects were long lasting as demonstrated by measurements taken on a sandy test site harvested 13 years ago.

Under normal working conditions the compacted traffic lanes are placed directly downhill. Because water infiltration capacity is strongly reduced by wheeling the overlandflow in these linear structures is enhanced.

To establish a sustainable forest management harvest logistics have to be changed.

Keywords: forest soils, heavy machinery, soil compaction, physical properties, water balance

1 Introduction

In the last years streamlining measures are common in forest management to be competitive on world market. To reduce costs and to increase efficiency forest work is more and more mechanized. The growing powerful machinery for tree harvesting is becoming heavier too [5]. Today the total weight of loaded harvesters is up to 60 tons [8]. The traffic with heavy machinery on loose-packed forest soil often leads to strong mechanical soil stress and overloading followed by topsoil and subsoil compactions with partly irreversible soil damages [4]. Rooting is hampered because penetration resistance is increased, water and air balance as well as soil organisms are disturbed because soil structure and soil aggregation are destroyed.

Less is known about the regeneration of soil compactions by natural processes but it seems to be a very long lasting process of about decades or hundreds of years. Subsoil compactions may be irreversible [1], [2], [3], [7]. To get information about the impact of heavy forest vehicles on forest soils and the potential for the regeneration of forest soil compactions test sites with driving lines were established as a long-term programme.

2 Test sites, equipment and methods

Three field experiments were carried out since 1989 in Rhineland-Palatinate in cooperation with the Research Institute for Forest Ecology and Forestry Rhineland-Palatinate.

2.1 Merzalben

The test site, established in 1989, is located in the Palatinate-Forest south of Kaiserslautern. The soil is a podzolic cambisol derived from sandstone of "Middle Sandstone" age. The texture is a silty sand with increasing stone content in the subsoil. To create wheel tracks with 1 and 5 passes a "MB-Trac 1500" with a weight of 6,3 tons and forest equipment "Räumfix" (0,7 tons) was used.

2.2 Kempfeld

The experiment was carried out in 2003 near Kempfeld, a small village in the Rhenish Slate mountains between Trier and Mainz. The forest soil is a planosol-cambisol. The parent material is a mixture of solifluidal moved aeolian material and weathered quartzite.

A harvester from Ponsse was employed (Fig. 1). The maximum wheel load reached 4 tons, the total weight was about 22 tons. Tracks were created with and without chains on the rear wheels, each with 1 pass and 5 passes. A plot without driving lanes was the undisturbed control.



Figure 1. Loaded harvester at the test site Kempfeld



Figure 2. Chains on the rear wheels

2.3 Entenpfuhl

The third long-term site is also located in the Rhenish Slate mountains between Trier and Mainz. The substrate is comparable to that of Kempfeld but the soil is strongly affected by water-logging (Planosol to stagnic planosol). The test design was similar to the Kempfeld-design. But driving on the waterlogged soil was impossible for the loaded harvester with a weight of about 20 tons. After a few meters the vehicle was stuck in the 40 - 50 cm deep muddy tracks (Fig. 3, 4). Therefore the experiment was carried out only with the empty harvester (about 12 tons).



Figure 3. Driving lane of loaded harvester



Figure 4. Total soil destruction

2.4. Methods

Soil stress during traffic was measured with so called "Bolling tube probes", the internal soil strength with Oedometers, depth of ruts with a ruler. Infiltration rates were investigated with double-ring infiltrometers.

3 Results and discussion

The investigations in 1989 on the test site Merzalben immediately after the tracks were created showed clear negative impact on soil physical properties even in the coarse textured sandy substrate. The more the number of passes the more the bulk density increased in the uppermost 20 cm and the water and air balance got worse. Infiltration rate and water permeability were reduced. 13 years later regeneration effects were found only in a depth of 0-10 cm mainly caused by rooting. But in the depth of 10-30 cm the negative impact of traffic was preserved in the driving lanes.

The reaction of the loose, loamy soils with water-logging at the experimental fields in Kempfeld and Entenpfuhl is completely different from that of Merzalben soil.

The induced soil pressure - both without and with chains on rear wheels - exceeds the internal strength of the soils in the uppermost 30 cm as shown in Fig. 5. Deep rut depths of up to 11 cm on the dry soil at Kempfeld and up to 20 cm on the wet soil at Entenpfuhl were visible and measurable long lasting marks for the destructive impact of harvest traffic on sensitive forest soils. As a result strong negative impacts of the traffic on the physical properties were detected in both areas. Linear downhill orientated ruts with less infiltration capacity (Fig. 6) induced a high potential for surface runoff. Micro-morphological investigations showed that compaction reached the micro scale (Fig. 7 and 8).

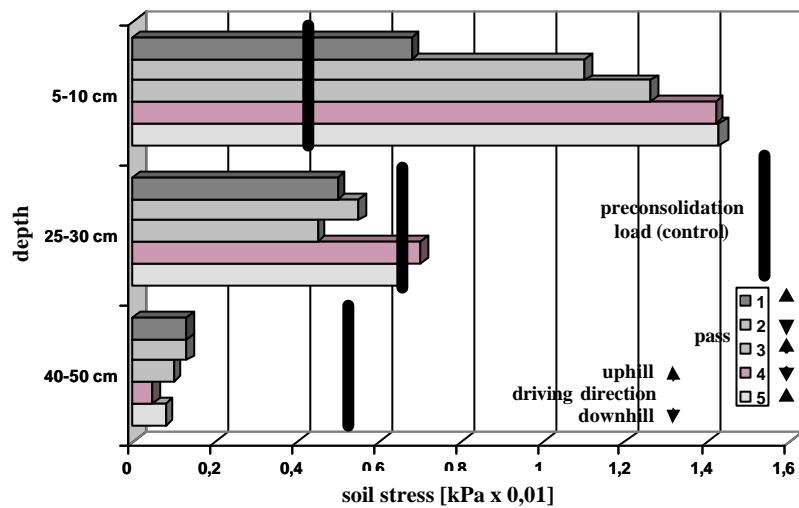


Figure 5. Soil stress induced by driving without chains and internal soil strength (preconsolidation load) at test site Kempfeld

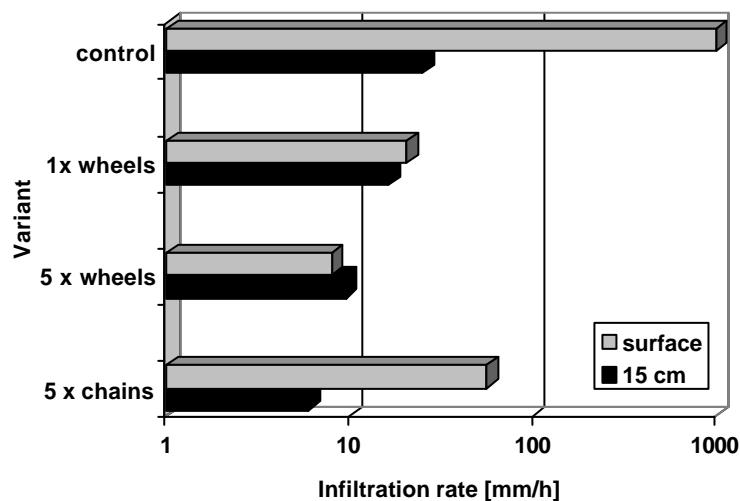


Figure 6. Infiltration rates of different treatments at test site Kempfeld

4 Conclusions

All well structured, intact, uncompacted forest soils reacted very sensitive to the traffic with heavy machinery. The negative impact may reach the level of complete soil destruction. Therefore a change in tree harvesting management has to be required to preserve the soil functions, to reduce soil compaction and to prevent soil from irreversible damages in present and future.

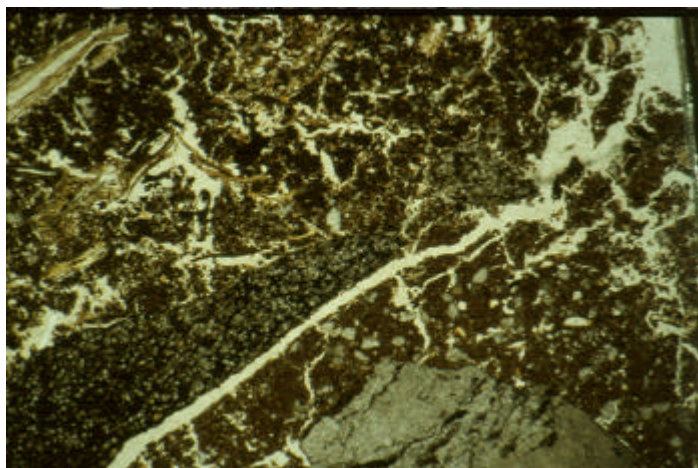


Figure 7. Uncompacted topsoil of control plot, Kempfeld (11x7 mm)

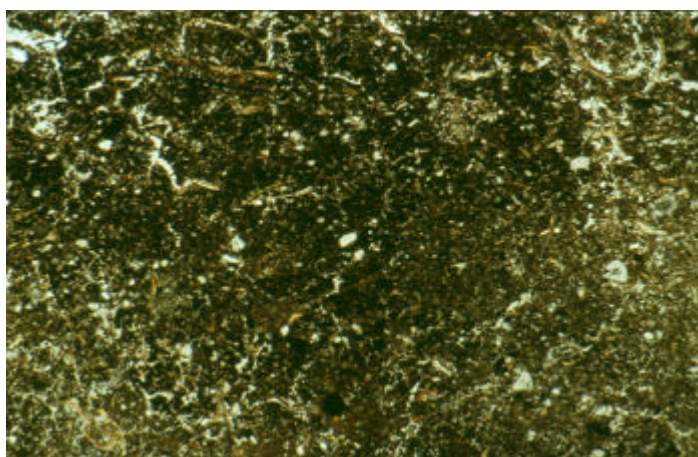


Figure 8. Strongly compacted topsoil after 5 passes without chains, Kempfeld (11x7 mm)

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Modelling of water retention and runoff processes on different land use types – plot and hillslope scale

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Abstract

Physically based hydrological models are suitable to simulate water retention potentials and runoff processes for different land use types as it is possible to integrate measurable structural information of different surface and soil hydrological properties into the model. Due to the uncertainties of the input data, it is challenging to parameterise these model types. In this study the CATFLOW model was parameterised by measured physical soil data of a silty clay loam under different land use types in order to test its applicability to analyse water retention and runoff processes on different land use types. The simulation results were validated at the plot scale based on runoff data from sprinkling experiments at the event scale and soil water measurements at the seasonal scale. The findings were incorporated in an artificial hillslope to analyse changes in water retention and runoff processes with respect to land use changes at the hillslope scale.

Keywords : physically based modelling, land use, soil hydraulic properties, surface attributes.

1 Introduction

There is a strong interest in modelling the effects of land use measures on water retention. Different approaches and models are used for different scales. In this study water retention and runoff processes at plot and hillslope scale are investigated. At these scales physically based models seem to be suitable to simulate soil water movement based on the integration of measurable structural information like infiltration rate and soil hydraulic conductivity into the model. The pivotal question is: Is it possible to determine runoff processes and retention potentials with a physically based model and limited and uncertain input data?

2 Material and Methods

On the plot scale rainfall simulations were performed and soil moisture data were recorded over a period from 1994 to 2001. Rainfall simulations were carried out on test plots of 5 x 10 m using a mobile sprinkling system. An amount of 40 mm/d rainfall was applied in 4 intervals of 15 minutes each day during a three day period. The surface and subsurface runoff were collected and measured for the inner 3 x 10 m to exclude lateral losses of water [3]. Soil moisture data from neighbouring sites were available on a weekly basis [4].

The water flow is modelled by the means of the physically based distributed hydrological model CATFLOW [1], [5]. The soil water dynamic is modelled using the Richards Equation in the pressure based form. Macropore flow is implemented by increasing the hydraulic conductivity at specific threshold saturation. The model was not calibrated for the different sites.

The van-Genuchten/Mualem-parameters of the water retention curves and the hydraulic conductivity of the matrix were derived from ROSETTA computer code [2] for each horizon. The soils are mainly Stagnic Cambisols with a clay loam to silty clay texture. The values of the hydraulic conductivity above threshold saturation (combined matrix and macropore flow) are taken from the hydraulic conductivity measures of undisturbed core samples. The threshold saturation (f_{mac}) initiating macropore flow is field capacity at pF 2.5.

3 Results

3.1 Rainfall Simulation

Figure 1 shows the results of three rainfall simulations on three different land use types. During the rainfall simulation on the forest site only subsurface runoff occurred with a runoff coefficient of 58.7 %. The modelling simulates an overall runoff in the same magnitude. But the runoff dynamic is different from the observed runoff hydrograph. The simulation registers also some surface runoff (9.5 %) which was not observed during the experiment.

The rainfall simulation on the arable field shows also only subsurface runoff (21.3 %). The modelling leads to the same runoff process, but with a much lower runoff coefficient of only 11.5 %. Deep percolation started at the second day and is much higher compared to the forest site.

High root density on the pasture site reduced the infiltration rate. The observed dominant runoff process was Hortonian runoff (54.6 %). The model simulated surface runoff in nearly the same range (58.7 %).

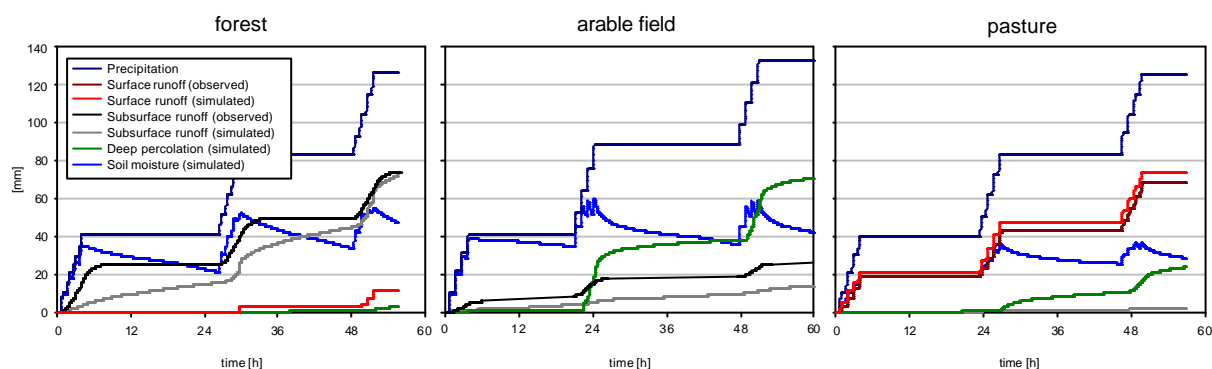


Figure 1. Measured and simulated runoff for different land use types

3.2 Soil moisture and runoff processes

Table 1 explains the mean saturation (%) of three sites for different depths during the observation period between 1994 and 2001. The forest site had the lowest mean saturation, followed by the arable field and the pasture.

Table 1. Mean saturation over the observation period 1994 – 2001

Depth [cm]	Forest	Arable field [%]	Pasture
0-10	68.5	71.8	78.6
10-20	51.9	69.4	77.7
20-30	48.8	62.5	75.0
30-40	52.6	73.9	81.0
40-50	66.5	72.9	90.1
50-60	69.0	86.4	93.1
60-70	78.0	96.4	89.4
0-70	61.4	71.2	83.1

Table 2 shows the simulation results of the soil moisture for the period between 1994 and 2001. The goodness of fit criteria indicates that there are large differences between measured and simulated values. The high uncertainty both, in measured and modelled data, is important for the simulation of saturated overland flow.

Table 2. Goodness of fit criterions of the simulated soil moisture content for the period 1994 – 2001 for different depths

	Depth [cm]							
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	0-70
Forest								
RMSE [Vol.-%]	10.24	8.19	10.22	10.31	7.92	7.58	5.47	6,90
Coefficient of determination	0.48	0.67	0.74	0.74	0.74	0.66	0.57	0,76
Nash/Sutcliffe coefficient	0.46	0.35	-0.51	-1.12	-0.67	-1.21	-0.25	0,10
Willmott coefficient	0.79	0.82	0.74	0.71	0.72	0.73	0.75	0,82
Arable field								
RMSE [Vol.-%]	6.08	4.72	5.49	4.39	4.57	5.80	4.48	3,31
Coefficient of determination	0.66	0.72	0.69	0.69	0.65	0.67	0.27	0,79
Nash/Sutcliffe coefficient	0.63	0.69	0.43	0.60	0.47	-0.30	-1.45	0,72
Willmott coefficient	0.88	0.92	0.86	0.90	0.88	0.72	0.54	0,93
Pasture								
RMSE [Vol.-%]	10.15	9.57	8.48	6.85	7.42	8.47	8.66	7.35
Coefficient of determination	0.39	0.29	0.31	0.38	0.36	0.30	0.31	0.39
Nash/Sutcliffe coefficient	0.23	-0.02	-0.07	0.10	-0.44	-0.91	-0.74	-0.19
Willmott coefficient	0.78	0.74	0.75	0.78	0.73	0.68	0.71	0.77

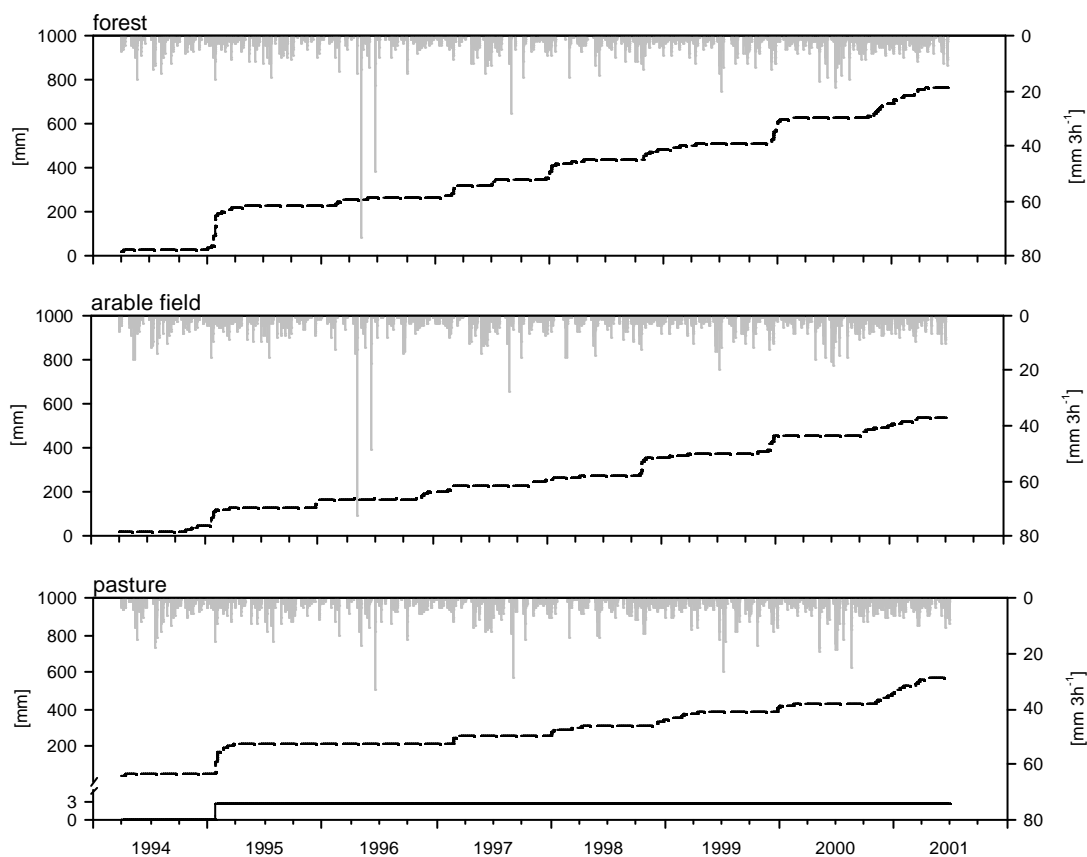


Figure 3. Results of the long term simulations for three different land use types

Figure 3 displays the cumulated surface and subsurface runoff of the long term simulations. As the rainfall simulations suggested, the forest and arable field sites present only subsurface runoff. One rainfall event on the pasture site creates hortonian overland flow. The results of the long term simulations confirm the results of the event scale.

3.3 Artificial hillslope

At the hillslope scale soil texture, soil composition and slope angle are identical for all land use types. Only thickness and hydraulic conductivity of the A- and B-horizons have been varied depending on the land use. The matrix conductivity depends on soil texture and bulk density. The macropore conductivity was taken from the rainfall simulation sites. The first results indicate the importance of the soil composition (permeable over impermeable horizons) for the dominant (subsurface) runoff process for this soil type. The land use type is relevant for surface processes. If the soil texture is not vulnerable to soil sealing only mismanagement of pasture land leads to Hortonian overland flow.

4 Conclusions

The modelling results show the possibility to simulate different runoff processes. Due to the model structure, especially the macropore concept the dynamic of subsurface processes can not be well reproduced. It is considerably more difficult to simulate the actual retention potential for a specific soil. Hence it is challenging to simulate saturated overland flow.

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Effects of land cover on runoff process using SCS CN method in the upper Chomutovka catchment

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Abstract

Mathematical representation of rainfall-runoff process has a long history, but since 80s of the last century has become, due to rapid computer technology development, an important instrument for hydrologist and water managers, whether for hydrology forecast or for design purposes. The aim of this article is to present first results of more extensive research which is focused on using different methods for runoff computation in different land use areas. With help of deterministic lumped model HEC-HMS (Hydrologic Engineering Center - Hydrologic Modeling System) several simulations of runoff changes by different basin conditions were carried out. As an experimental catchment a headwater part of the Chomutovka basin in the Krušné mountains/Erzgebirge was chosen (area 14,5 km²). For assessment of land cover changes impact to hydrological regime four scenarios were carried out – 10, 20, 50 and 100-year 1-day probability design precipitation events in combination with different initial conditions (soil saturation). These scenarios were applied to a state of the land cover in 1992 and 2000 (based on database CORINE Landcover) and for the so called 100% forest state. As the main model technique a method SCS CN (Soil Conservation Service Curve Number) was applied.

Keywords: Modeling of hydrological processes, rainfall-runoff models, land use changes, SCS CN method, floods, flood protection, Chomutovka

1 Introduction

A dilemma of water retention by vegetation is nowadays a great point of issue and together with global climate change also very popular. The aim of this article is to present first results of more extensive research which is focused on using different methods for runoff computation in different land use areas. As an experimental catchment a headwater part of the Chomutovka basin in the Krušné hory/Erzgebirge was chosen (area 14,5 km²) by its outfall in Tišina (Fig. 1).

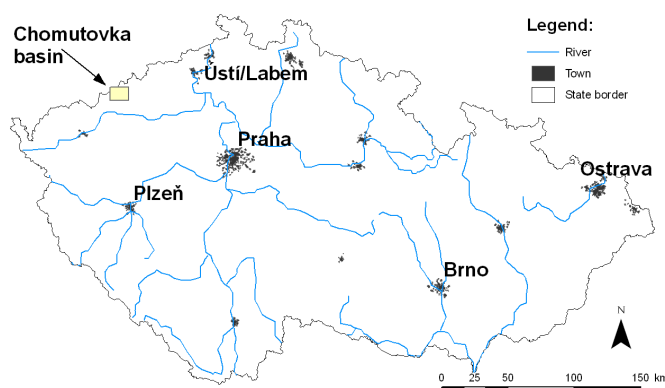


Figure 1. Location of the Chomutovka basin within the Czech Republic

Currently many authors deal with the issue of rainfall-runoff modeling, both in the Czech Republic and abroad. Soil and vegetation conditions are for runoff generation very important. The main research centre lies in the world, above all in articles and publications of [1], [2], [3] and many others. These authors focus mainly on rainfall-runoff regime changes caused by changes of land cover due to the human impact. Great importance is also given to forest effects [4] and problems of “scaling” [5]. In conditions of the Czech Republic also other specificity exists. Since 70s Czech landscape admits of large changes in agriculture land resources connected with hydrotechnical measures (amelioration, river straightening, etc.). These changes had unquestionable effect on hydrological regimes of

catchments. An importance of this is by publications by [6] or [7] confirmed. Also the problem of large deforestation in the Krušné and the Jizerské mountains (and generally a role of the forest) and its impact to hydrological regime is still actual in [8] and [9].

In the Chomutovka catchment within last 15 years to some changes in the land use has come, especially in areas of higher altitude and slopes. In these parts an arable land was replaced to grasslands and meadows. In the time period 1992 – 2000 (according to the database CORINE land cover) a change in area of 2,98 km² was detected (20,5 % of the total basin area). The most important change was transformation of 1,63 km² (11,2 % of the whole basin) of non-irrigated arable land to pastures. Second change was different classification of class 3.2.4 “Transitional woodland shrub” (in the Krušné mountains mainly dead forest) in 1992 and 2000. In 2000, 1,35 km² (9,3 % of total basin area) of this category became mixed or coniferous forest. This study comes out from the assumption that this change could change also runoff conditions in the catchment.

2 Methodology

The runoff response to rainfall event was assessed in two time periods – 1992 and 2000. These two years represent two different stages of the land cover. Besides this an ideal variant with 100% cover by coniferous forest was simulated. For vegetation assessment a database CORINE land cover was applied. For rainfall-runoff simulations a lumped deterministic model HEC-HMS (Hydrologic Engineering Center - Hydrologic Modeling System) was chosen [10].

For runoff-volume computation (*Runoff-Volume Model*) a SCS CN method was applied (Soil Conservation Service Curve Number). This method uses a CN method (Curve Number) for precipitation lost determination ([11], [10]). The main reason of its application was, above all, a simplicity and modesty of input data. The value CN was estimated based on the relation to a hydrological group of the soil (see [12]) and vegetation cover based on the [13]. For direct runoff computation (*Direct-Runoff Model*) a Clark Unit Hydrograph method was used. For computation two parameters are necessary to derive, namely T_c (Time of concentration) and R_c (Storage coefficient). Time of concentration was computed based on SCS methodology with help of T_{lag} – Lag time. Storage coefficient was derived based on USGS – U. S. Geological Survey [14]. For base flow computation (*Baseflow Model*) a method of exponential decrees was applied. This method defines a volume of the base flow in the certain time with the help of the initial flow. Channel flow computation (*Channel Model*), where a method Muskingum was applied requires two parameters – K [h] and X [-]. K defines a time, by which in certain catchment or subcatchment flows water through (travel time) and X is a weight, which expresses an effect of the wedged storage in the certain reach.

Modeling of the runoff change in the given time period and “ideal forest state” ran through four precipitation events of different extremity. First it was a designed daily precipitation of probability exceeding of 0,1 (10-years precipitation), next was 20-years, 50-years and 100-years probability design precipitations. For area precipitation a method of orographic regression was applied (based on elevation of gauge stations). Designed precipitation was computed base on the assumption of lognormal distribution of the maximal year precipitation from time series 1995 – 2006. For simulations a 15-hours time distribution of the precipitation event based on the methodology of [15] was assumed.

For expression of runoff changes in dependence on land cover changes four scenarios were simulated (based on various designed precipitation). Each of these scenarios was simulated for states in 1992 and 2000 and for the state of 100 % cover by coniferous forest. Automatic calibration by Univariate Gradient method at period from 6.8.2002 to 16.8.2002 (flood in August 2002) was made. A time step of computation was in all cases 15 minutes. Evapotranspiration was not considered.

3 Results

A general characteristic of the most of rainfall-runoff models is the basin decomposition to several zones, mainly vertically ordered. Each zone has its inflow and outflow, which is computed based on a concept of linear cascade [16]. By simulations a main factor was taken into account that by extreme event a hydrograph is made mainly by direct runoff and considerable part of base flow becomes important as much as on the falling limb of the flood hydrograph. Evapotranspiration that stands at the beginning of the runoff process was not taken into account. Their importance by peak or volume decreasing is too small and this approximation is therefore acceptable. Results for outlet profile Tišina are concluded in the Fig. 2.

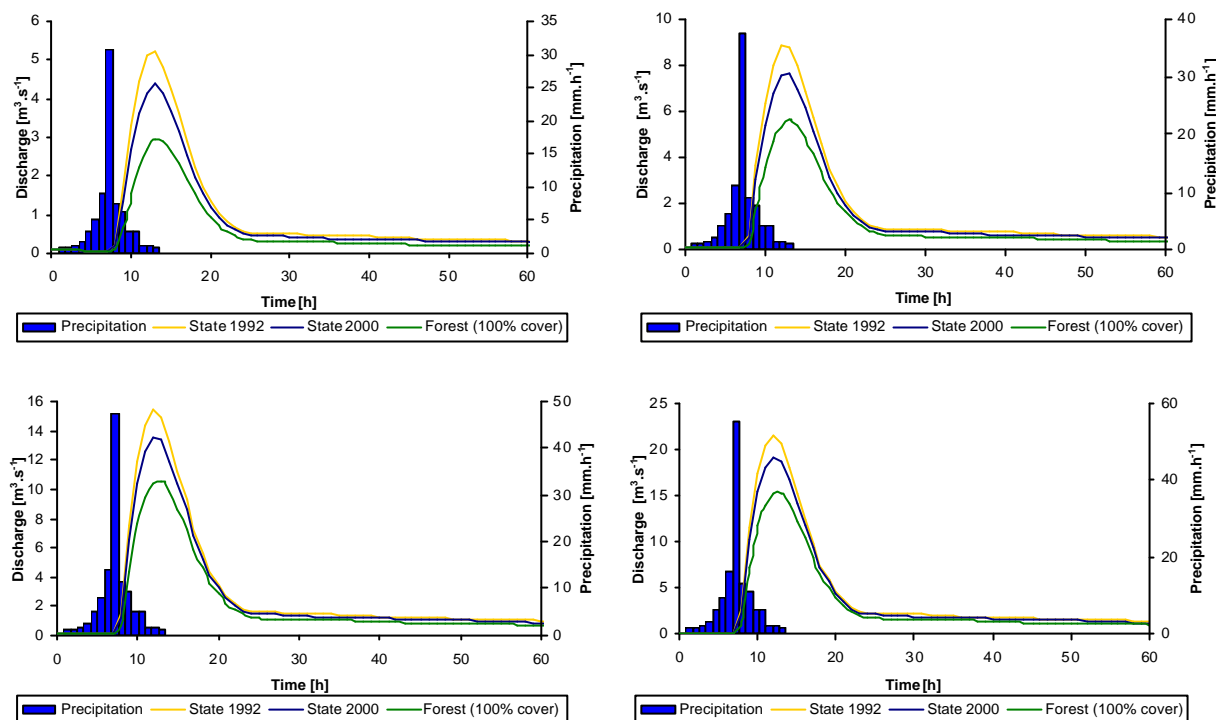


Figure 2. Simulated hydrographs in the outfall Tišina in years 1992 and 2000 and 100% forest state by probability designed precipitation of N=10 (top left), N=20 (top right), N= 50 (bottom left) and N=100 years (bottom right)

A decrease of the peak flow (2000 compared to 1992) by 10-years flood was in the outlet profile Tišina $0,9 \text{ m}^3 \cdot \text{s}^{-1}$ (17,0 %). A volume decrease of the same flood wave was 15,1 %. Delay of the flood wave in the 2000 compared to 1992 was 15 minutes (lowest time step of the model). Lower differences reached the 100-year flood simulation (10,2 % decrease – $2,2 \text{ m}^3 \cdot \text{s}^{-1}$). It is assumed that with increasing flood extremity a land cover influence on the flood peak will decrease. A decrease of the both flood peak and flood volume is more significant by ideal assumption of 100% coverage of the basin by forest (in comparison with 2000).

A change of the runoff height in dependence on the input precipitation and initial conditions (initial moisture) is evident from Fig. 3. Each of figures displays a basin in term of the different initial moisture (antecedent precipitation). An assumption that land cover influence on the flood flows generally decrease with the flood extremity and increasing initial moisture due to antecedent precipitation was confirmed.

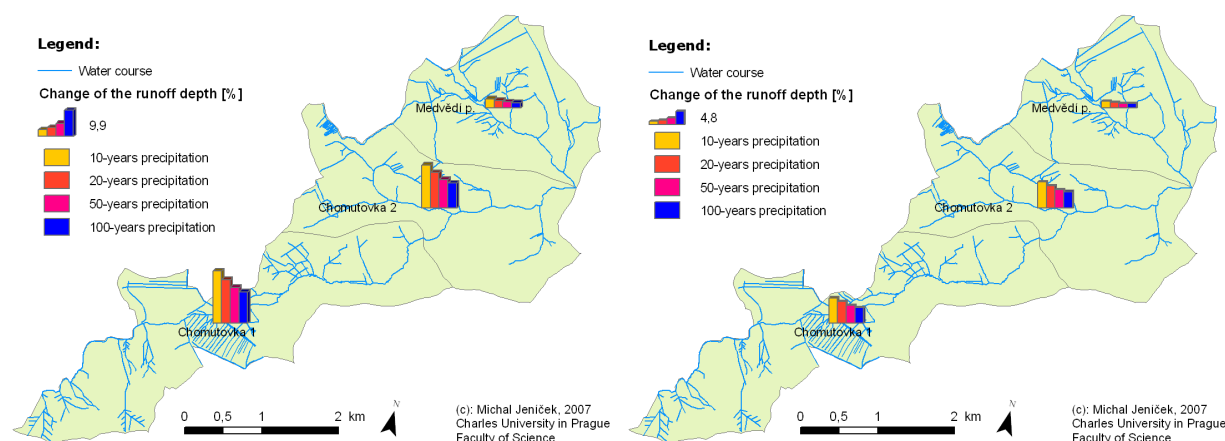


Figure 3. Decrease of the runoff depth between 1992 and 2000 (in %) at the subbasins by different precipitations and initial moisture condition (left figure – average moisture conditions, right figure – saturated moisture conditions)

5 Discussion

Generally it is possible to distinguish several categories of problems and uncertainties generated by the certain hydrological task. These problems and uncertainties are related to particular phases of model composition.

The main question by modeling of land cover influence to runoff process is an application of the suitable method. In this study applied SCS CN method is available as a modeling technique in the modeling system HEC-HMS. It is suitable mainly due to its simplicity and availability of the input data. But it uses numerous simplifications and its using is therefore limited (assumes homogenous rainfall distribution both in time and space, doesn't take into account a classic theories of flows in unsaturated soils, it concerns a model of saturation-excess type and potential infiltration rate exceeding – infiltration excess model – is not taken into account, etc.). After all is this method often applied, both in the Czech Republic and abroad. Within the project an application of other methods (Green-Ampt, SMA) is assumed.

Time series assessment (mainly precipitation) ran through with help of standard statistic methods. First of all a homogeneity control occurred, eventual measure faults were with help of regression analysis filled. Designed probability precipitation was with the help of lognormal distribution estimated. The biggest uncertainty appears by the interpolation of point values to the area. For the Chomutovka basin a dependence on the altitude (with determination coefficient 0,79) was used.

By data processing also a choice of suitable time and space scale is necessary. Modeling of processes between earth surface and atmosphere requires the knowledge of model reaction to space and time step changes. Many studies, for example [5] or [17] demonstrate the fact, that by time or space step change a new calibration is necessary (due to changes in parameters). In this study used time step 15 minutes appears suitably. It is possible to come out from similar catchments of the Cerná Voda in the Krušné mountains/Erzgebirge or the Blanice in the the Šumava/Böhmerwald [18].

Initial conditions play an important role by resulting hydrograph (outflow from catchment). Most important from these conditions is antecedent moisture of the soil. In SCS CN method is this condition contained already in Curve Number. According to [11] the user should make the correction of CN based on 5day antecedent precipitation. There are distinguished three categories of antecedent moisture – PVPI, PVPII and PVPIII. Simulations in this study were made mainly based on PVPII (average conditions) and PVPIII (full saturation).

Generally there are many parameters in rainfall-runoff model, which are burden with the certain degree of uncertainty. Some of them are let in model as they were measured, some of them can by calibrated. In the Chomutovka catchment an automatic calibration was made. The list of calibrated parameters is a part of table 1.

Table 3. List of calibrated parameters

Parameter	Model	Name of parameter	Ratio
Ia	Runoff- Volume Model	Initial Abstraction (SCS CN Method)	0,7
Rc	Direct-Runoff Model	Storage Coefficient (Clark Unit Hydrograph)	1
ReC	Baseflow Model	Recession Constant (Recession Method)	0,8
Ratio to Peak	Baseflow Model	Threshold Value (Recession Method)	0,3

6 Conclusion

Modeling of the influence of the land cover to hydrological process in the Chomutovka basin came through four scenarios – 10, 20, 50 and 100-year probably precipitation. In first scenario a decrease of flood peak about 17 % in outfall Tišina was simulated (in the year 2000 compared to 1992). In the fourth scenario (100-year precipitation) it was only 10,2 %. The fact of decreasing influence of land cover by increasing flood extremity was approved.

Applied SCS CN method appears for this kind of hydrological problem as suitable, however it requires a precision by parameters derivation. Simulated decrease of flood peak and flood volume is very significant, and thus the verification with other methods remains necessary.

By using SCS CN method a setting of Curve Numbers is the most important (with respect to initial conditions and space scale). Methods of space and time distribution of precipitation in the catchment are also essential.

In the following research also other model techniques (Green-Amp, SMA) as well as other model systems (MIKE, NASIM) will be applied.

ACKNOWLEDGMENTS

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An integrative agricultural management approach to improving flood protection in agricultural areas

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Abstract

One consequence of soil compaction is a reduction in infiltration- and water retention capacity, thus increasing the risk of intensifying flood incidents. A potentially effective approach to the melioration of compacted soils in cultivated areas is deep loosening combined with sustainable soil management. Physical soil data, 2D electrical imaging, infiltration and sprinkling experiments that were carried out as part of this study revealed that deep loosening of compacted soils followed by sustainable soil management increases infiltration and temporary water retention. It could also be shown that the discharge of the optimized site was lower and temporally delayed, a fact which was also confirmed by rainfall simulations. Using the soil physical-based hydrological model CATFLOW simulations were carried out to model the altered land use properties induced by deep loosening. The results indicate the general applicability of the model to simulate land use measures as a means of contributing to flood protection.

Keywords: Deep Loosening, Sustainable Soil Management, Flood Protection, CATFLOW, Modelling.

1 Introduction

Modern and conventional agricultural land use is assumed to intensify flood incidents. This is ascribed to the cultivation-induced compaction and degradation of soils resulting in a decrease in infiltration and water retention capacity. However agriculture also provides opportunities to reduce the discharge of water, thus contributing to flood protection [1],[3],[5]. The WaReLa-project pursues the quantification of the influence of landuse, landscape structures and geological factors on flooding. As part of the WaReLa-project the Department of Soil Science at the University of Trier focused on transferring results from test plot to field scale in order to minimise the impact of flood events in micro scale agricultural areas. This will provide a better basis for the understanding and assessment of effects related to sustained flood protection.

The main objective of our field experiments in the past had been to analyse how melioration methods (such as deep loosening of compacted soils or intermediate cultivation of field crops) affects infiltration and water flows (surface runoff, subsurface flow etc.). Up to now this was only possible on a plot-scale. In this project it was implemented on a micro scale hillside. In the particular context of the WaReLa-project sustainable agriculture measures were implemented to show the chances for flood protection in micro scale catchment areas like Zemmer. As sustainable cultivation practices comprise a variety of approaches and factors, specific strategies must take into account a wide range of influences such as: topography, soil characteristics, climate, pests, local availability of inputs and last but not least, the individual grower's goals.

2 Catchment Area

The implementation and investigation area (Zemmer, Eifel), 20 km north of Trier, lies in a typical low mountain range region. The bedrock geology of Devonian schist is overlaid by Mesozoic (Triassic) sediments. In higher reaches the surface geology is predominately made up of a heterogenic mix of tertiary sand, gravel and clay partly mixed with quarternary loess and pleistocene sediments. The dominating soil types in this region are cambisols, stagnic cambisols and leptosols, many of which suffer from compaction as a consequence of anthropogenic and geogenic factors. The catchment size is approx. 9,56 km² and is characterised by intensive agricultural land use.

3 Materials and Methods

As part of the WaReLa-project the Department of Soil Science at the University of Trier transferred results from test plot to field scale in order to minimise the impact of flood events in micro scale agricultural areas. An

integrative agricultural management approach to reduce soil compaction, flood risk and erosion in low mountain ranges was introduced, including a variety of measures such as conservative soil cultivation, mulch tillage, non ploughing, less root crop, intercropping, deep loosening of compacted soils, construction of retention basins, cascades and grass stripes below test site. In comparison to conventional intensive farming which is assumed to intensify flood incidents, these methods can help to improve (to meliorate) soil properties (e.g. infiltration capacity), to protect the subsoil and reduce erosion. To assess the combined effectiveness of these land use measures, field experiments as well as discharge monitoring and modelling were carried out both on a conventional cultivated field and on a field treated with the proposed sustainable management techniques.

Field experiments included precipitation and discharge measurements, tensiometering, electrical resistivity tomography, sprinkling and infiltration tests as well as the collection of physical soil properties data. For this purpose a gauging equipment, tensiometer measuring fields, flumes and weirs, precipitation stations, and mobile sprinkling systems were set up.

4 Results

The analysis of the physical soil properties data revealed that deep loosening of compacted soils and intermediate cultivation of field crops leads to an increase in pore volume (Fig. 1.1), infiltration and permeability as well as to a reduction in bulk density (Fig. 1.2). Due to the coarse breaking up of the topsoil layer by the blades of the MM 100 (deep loosening machine) the increase in pore volume mainly affected the wide pores, which have an important function for the perlocation of water thus the increase in permeability [5].

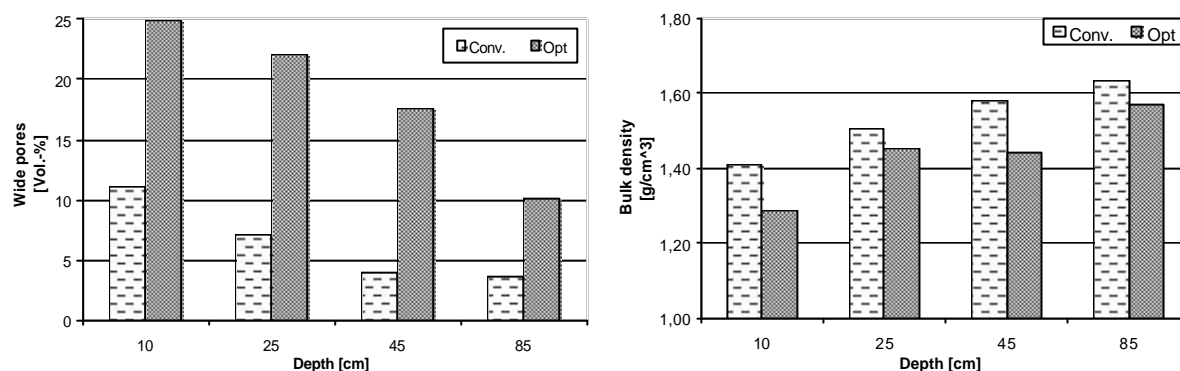


Figure 1.1 and 1.2. Effect of deep loosening and intermediate cultivation on pore volume (wide pores) and bulk density

The deep loosening resulted in a significant increase in volume percentage over the whole profile (85 cm). It could be shown that an additional soil water retention volume of up to 50 l/m^2 can be achieved in the first years after implementation [5],[6]. This is due to the extra pore volume and the related ability to store water.

The results of the 2D electrical imaging showed a higher moisture content of the deep loosened soil compared to the conventionally cultivated soil, reflecting the positive findings of the physical soil data analysis [2]. Based on precipitation/run-off data (Fig. 2) discharge at the optimized test site was lower (no surface run-off respectively) and temporally delayed compared to the conventional site (subsurface and surface flow). This is in accordance with the positive effects of deep loosening on physical soil properties (as mentioned above).

Furthermore using the soil physical-based hydrological model CATFLOW [4], [7] simulations were carried out to model the altered land use properties, mainly water flows, induced by deep loosening. Figure 3 shows the modelled water flows for both test sites. While the optimized site exhibited no surface run-off due to the improvement in infiltration and water permeability the discharge of the conventional cultivated test field was dominated by subsurface and surface flow. This was generally confirmed by the results of the sprinkling experiments. However the total discharge was overestimated by the model. Nevertheless the results indicate the general applicability of CATFLOW to simulate land use measures as a means of contributing to flood protection.

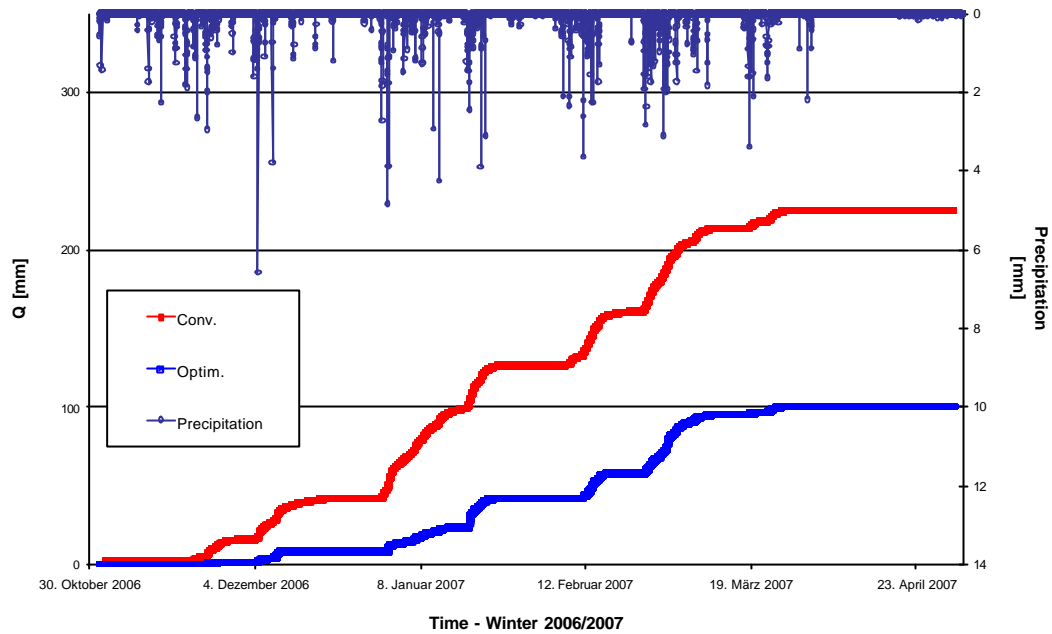


Figure 2. Precipitation vs. discharge of the two test sites for the period 11/06 – 04/07

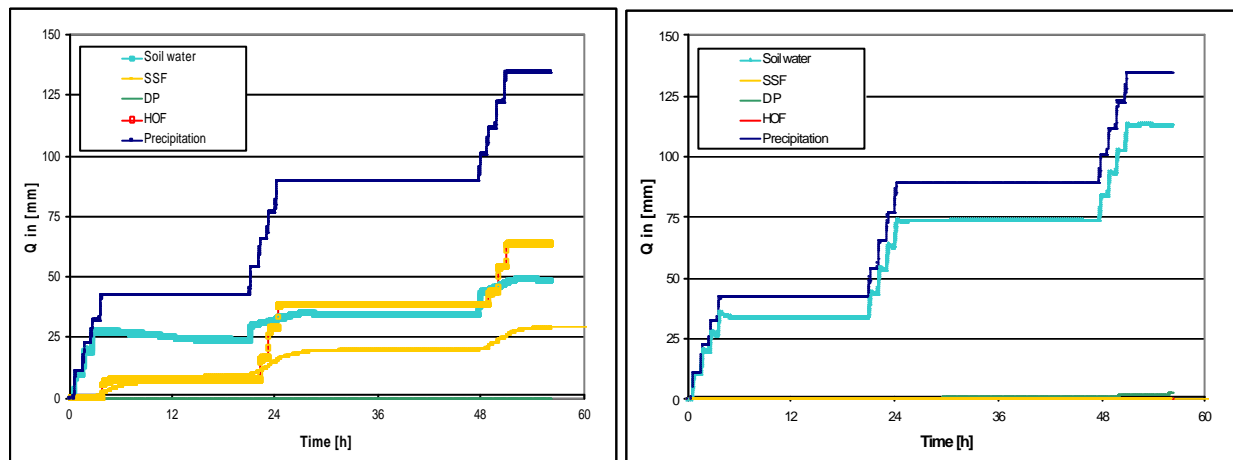


Figure 3. Modell (CATFLOW) results of the sprinkling experiments. Conventional field (left) vs. optimized field (right)

5 Outlook

Although the model still has room for improvement, its principal applicability to simulate discharge processes on a micro scale is apparent. As a consequence of the overestimated total discharge the input parameters of the model will be reevaluated and adjusted to the results obtained through the field experiments. Furthermore the field measurements will be continued in order to expand the time series and to be able to draw long-term conclusions about the effectivity of the combined land use measures. The results will then be reimplemented in the soil physical based hydrological model CATFLOW in order to test the effects of different measurements and their combinations.

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A concept for the evaluation of water retention within catchments

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Abstract

This document describes a concept for an application-oriented evaluation tool for water retention within catchments. Hydrological models are usually designed for the estimation and forecast of runoff and flood in rivers and floodplains. However, there is an absence of methods to classify the runoff formation and retention on the *area* of the catchment. Such a tool has to fulfil the demands of spatial planning as well as to display the actual condition of runoff formation and retention as exact as possible. Therefore, the modular integration of different factors of runoff formation, an adaption to spatial scales and an improved usability of results are the main intentions of the project.

Keywords: runoff, retention, decentralised flood protection, spatial planning, forestry, land use, spatial scale, Decision Support System.

1 Introduction

Although there are a number of hydrological models for the estimation and forecast of runoff and flood in rivers and floodplains, there is an absence of methods to classify the runoff formation and retention on the area of the catchment. Due to different responsibilities of spatial planning on one hand and water management on the other hand as well as a lack of interaction between these disciplines, there is no adequate consideration of the coherence between spatial and hydrological aspects [1].

To react adequately to today's challenges (e.g. the effects of global climate change or land use change on the hydrological cycle), spatial planning needs a method to evaluate the quality of water retention and runoff formation within catchment areas. Currently, there are several questions, which cannot be answered satisfactorily by spatial planning. For example, these questions are:

- Where are the origins of runoff within the catchment area?
- Where are areas with high or low runoff retention capacity?
- Where are the main areas for decentralised flood protection?
- What are the hydrological deficits of land use?
- Which measures of decentralised flood protection will be effective, considering the local conditions?

In order to answer these questions the possibilities of spatial planning, a method that can be applied easily is needed. In this paper, the authors introduce a concept to evaluate the water retention within catchments. This research project wants to react to the gap between water management and spatial planning and to the special requirements of hydrological questions in practical spatial planning. The goal is the development of an application to support decisions of planners who consider hydrological aspects in spatial planning procedures. It may also be useful in forestry and agricultural planning.

2 Reason for the project

To estimate the water retention quality in the mesoscale catchment area of the Schwarzbach river (Germany, Hesse, Taunus, Rhenish Slate Mountains), the authors used the classification of the so-called runoff regulation function ("*Abflussregulationsfunktion*") by BRÄUNIG & ZEPP [2]. This method is a simple classification of the main factors of runoff formation (soil texture, soil water, slope, land cover). To adapt the method to the existing data base and to improve the accuracy of results, the method by BRÄUNIG & ZEPP was modified by MAROLD [3],[4]. To make the classification more exact, each class was differentiated by the main factors of runoff formation or storage. The application of this method shows the water retention of spatial units in a generalised manner. However, the method is not exact enough to be used as a data base for the planning of flood protection measures. The method of

BRÄUNIG & ZEPP [2] shows several problems in terms of including results of basic research as well as practical application. The main problems are:

- The data requirement is not adapted to the hydrological scales: While the demanded data base for e.g. land cover is conform to the macroscale (demanded types of land cover: distinction between urban areas, fields, grass land, wasteland and forest), other demanded data, especially soil texture, are only suitable for the use in a microscale context. For an evaluation of retention in a macro- or mesoscale catchment, the user has to revert to microscale-evaluated data. In most cases, the efforts would be incommensurate with the expecting results. For evaluations in a microscale catchment, the required data base allows no exact results.
- The evaluation is not exact enough to display the effect of different types of land use to water retention. Some important factors are not considered, eg. different types of forests, linear landscape elements, geological underground, vertical structure of soil and seasonal variations. As a consequence, the method is not suitable to support decisions about decentralised flood protection.

With regard to the simple application, the method by BRÄUNIG & ZEPP [2] is convincing. On the other hand, this method contains several problems in application and does not lead to adequate results but only allows a general estimation of retention potential. This leads to the authors motivation to develop a runoff evaluation method which includes hydrological aspects, especially decentralised flood protection, in the procedures of spatial planning.

3 Objectives

3.1 General Demands

The concept for the runoff evaluation tool aims to fulfil the demands of spatial planning which considers hydrological aspects of the catchment area in the planning processes. It should be a Decision Support System for measures of decentralised flood protection *outside* of the floodplains. In contrast to hydrological models, the application should be as easy as possible also for planners without the background of hydraulic engineers. The tool should be easy to integrate in the planning processes. Therefore, it must be designed in a flexible structure. Therefore, the data requirement and complexity of the evaluation should be variable, depending on scale, reason for the evaluation and availability of data. In detail, these general demands will be realised as follows:

3.2 Integration of “Neglected” Factors of Water Retention

To guarantee evaluation results that are as accurate as possible, the evaluation needs to integrate additional factors of runoff regulation. At present, existing methods only include the main factors of runoff regulation and runoff formation (e.g. the method of [2], compare Sect. 2). This effects especially evaluations in micro- and mesoscale catchment areas (see also Sect. 3.3.).

The main factors of runoff retention may allow a general estimation about the origins of flood, but it cannot be helpful e.g. to identify “hot spots” of runoff formation caused by land use. Neither is it able or to support decisions considering decentralised flood protection. Next to the main factors of runoff formation, especially the following additional factors are included in the concept:

3.2.1 Identification of Interflow

In former evaluation methods, the interflow is not considered adequately. To identify the interflow, the vertical soil structure must be included. Therefore, the evaluation tool must be able to deal with changings of soil texture along the profile. In regard to soil compaction, this is also important to identify the impact of agricultural cultivation and forestry.

Furthermore, especially concerning shallow soil depth, the geological conditions are important. While permeable rocks, particularly gravel, allows deep percolation and groundwater recharge, a solid geological underground may cause lateral runoff.

3.2.2 Specification of land use

To consider hydrological aspects in spatial planning, in various cases the main land cover types (urban areas, fields, grass land, wasteland and forest) are not precise enough. Especially “forest” includes a number of several biotopes with some different hydrological qualities. In regard to the immense damages caused by the storm “Kyrill” in January 2007, there is a new focus on the forest’s contribution to flood protection. Not only forests, but also agriculture landscapes may show different hydrological conditions.

Because of the influence of the sewage system and different degrees of sealing, the water retention in urban areas is also difficult to estimate. In regard to decentralised flood protection measures in cities, a strategy to estimate the potential water retention of urban areas would be helpful.

3.2.3 Linear landscape elements

Linear elements, e.g. hedges, paths, drains or gullies are often neglected but may have a contribution to the retention or runoff formation of areas. An evaluation tool with the mentioned general demands (Sect. 3.1) should contain the possibility to integrate linear elements.

For example, the impact of storm “Kyrill” on runoff formation is not only the loss of interception capacity by trees, but also – as an indirect result of the storm – an immense volume of linear runoff in ruts caused by forestry machines after clearings.

3.2.4 Neighbourhood relations of hydrological units

In some cases, the neighbourhood relations of hydrotopes may be important for the evaluation, especially besides rivers and along slopes. It still has to be examined, if it is possible to include neighbourhood relations in the evaluation process.

3.2.5 Seasonal variations (time scales)

Depending on the evaluation question, the analysis of runoff retention has to consider several time scales, climate conditions and seasonal variations.

3.3 Adaption to Spatial Scales

In hydrological modelling, it is crucially important to consider spatial scales in order to get exact analysis results [5]. Therefore, a “mixture” of data from several scales, like mentioned in Sect.2, is not allowed. As a consequence, the concept will offer a separate calculation process for each scale. This is expressed in the data requirement as well as in the validity of the results:

On the macroscale, only generalised data are needed. The results offer an overview of flood origin areas. On the mesoscale, there is a medium requirement of data and a medium validity of results. On the microscale, there is a high requirement of data, therefore the results allow the most exact description of local hydrological conditions.

3.4 Usability of Results

In addition to the classification of retention in the catchment area, the concept provides further steps to increase the usability of the results. For example, the results show not only the total quantity of retention (e.g. expressed in classes like “high” or “low”), but also the main local factors of runoff formation (e.g. “low retention caused by steep slope”).

To facilitate a maximum amount of transferability and comparability, it is planned to summarize the results as “areal retention types” (*Flächenretentionstypen*, [FRT]). This will also be helpful when choosing the measures for flood protection: The Decision Support System will include a matrix based on the FRT. In this matrix, the measures of decentralised flood protection and their requirements for local conditions will be connected to each FRT and their characterization.

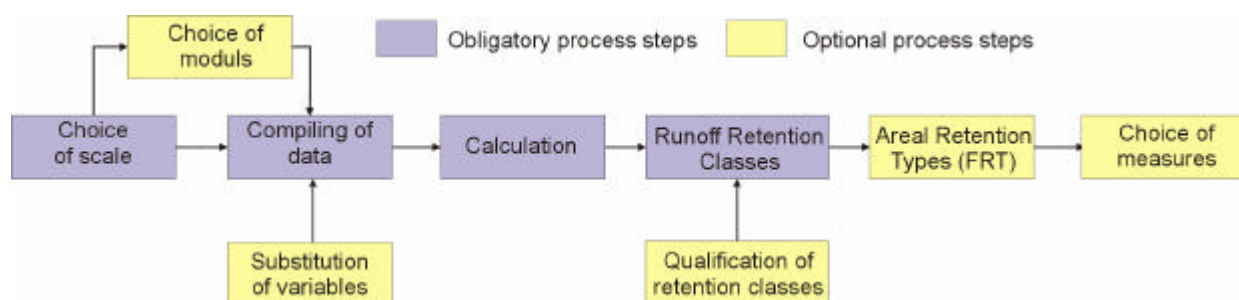


Figure 1. Runoff evaluation tool process scheme

4 Runoff evaluation tool process scheme

To fulfil the demands, the runoff evaluation tool has the following process structure (see also Fig. 1): As a first step, the user has to choose the spatial scale of the request. Each scale owns a separate calculation process. After that and

in regard to the question, the user has the possibility to choose moduls. Next to a basic procedure considering the main factors of retention and runoff formation, the user can optionally add process modules with additional factor groups mentioned above. The following compiling of data varies depending on chosen scale and factor modules. To maximize the flexibility of the tool, in some cases it will be possible to substitute one variable for another, e.g. soil type with soil texture. This will, of course, reduce the exactness of the results. After the compiling of data, the calculation of the retention classes will take place. Optionally, the resulting classes can be qualified as mentioned in Sect. 3.4. After this, the FRT profiles and the matrix for the choice of measures can complete the application.

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Session 3

Land-use change and water retention on the basin scale

Quantifying flood reduction effects due to land-use change in the Rhine basin

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Keywords : land-use, environmental change impacts, Rhine, scale, floods, flood management

The frequent occurrence of extreme flood events in the last decade has brought up an ongoing debate about the human impact on this phenomenon. There is no doubt that changes of land-use as well as river training activities in large parts of Central Europe have lead to altered flood conditions in this region. Due to the diversity of the processes and factors involved, so far their consequences on flood generation can only be estimated. Up to what extent the soil surface conditions as well as the composition and density of the vegetation cover are likely to affect storm runoff generation in the catchment scale is still uncertain.

The effects of land-use changes on flood generation is investigated by means of a multi-scale modelling study, where the hydrological cycle, in particular storm runoff generation of catchments of different sizes (macro, upper meso, lower meso scale), different land-use (urban, agriculture, forest use) and morphological (different soils and soil depths, different slopes) characteristics is simulated in a nested manner. The macro-scale covers the Rhine basin (excluding the alpine part), the upper meso-scale covers various tributaries of the Rhine and the three lower meso-scale study areas (100 to 500 km²) represent three different characteristic land-use patterns: the Lein catchment representing the agricultural land-use type, the Körsch catchment as a heavily urbanised area and the upper part of the Lenne river, which is mainly covered by forest. The models applied in this study are not newly developed but have been adapted and partly extended to meet the requirements of the different scales and the hydrological and hydraulic processes investigated. Thus the main innovation of this work is the combination of models at different scale and at different levels of process representation in order to account for the complexity of land-use change impacts for a large river basin in the sub-humid climate conditions as found in Central Europe (Figure1).

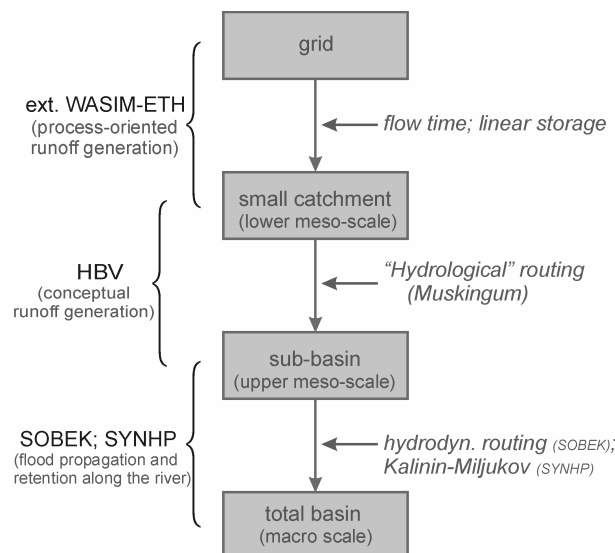


Figure 1. Scheme of the interaction of the different models at different scales

Spatially distributed land-use change scenarios have been developed at all scales representing a likely development of land-use in the coming decades, such as an increase of urban areas (at the expense of agricultural areas) and the establishment of urban storm water retention and local infiltration measures. At the macro scale the land-use scenarios were complemented by scenarios of the planned controlled flood retention in polders. In addition to that, two meteorological scenarios have been developed representing a meteorological forcing which exceeds all flood triggering rainfall and snowmelt situations observed until now.

The presentation illustrates the multi-scale, process oriented coupling of different models in order to simulate and evaluate the impacts of land-use and river training measures on the flood discharge of a large catchment. For the first time it was possible to give quantitative estimates for the impacts of land-use change and river training measures on the flood conditions for the River Rhine. The study as a whole is documented in a CHR report [2].

When assessing land-use effects on storm runoff generation, we consider it rather important to account not only for precipitation amount but also for the intensity of the rainfall. We have shown that this enables the distinction of different surface runoff generation processes, and thus, the identification of soil surface conditions effects on such processes. The conventional approach, assigning a runoff coefficient to different land-uses, such as done, for example, in the SCS-Curve Number Method [5] or in the WETSPA-model [3], does not bear this option.

Some general results from the whole study are summarised in the following:

- 1) The influence of land-use on storm-runoff generation in the meso-scale is stronger for convective storm events with high precipitation intensities than for long advective storm events with low precipitation intensities, because only storm events associated with high rainfall intensities are at least partially controlled by the conditions of the land-cover and/or the soil-surface.
- 2) An estimated - rather dramatic - further increase of urban areas of about 50% may result in an increase of medium-size flood peak discharges (for example, return intervals between 2 and 8 years) in catchments of the lower meso-scale:
 - Between 0% and 4% for advective rainfall events, and
 - Up to 30% for convective rain storms.
- 3) The decentralised storage, detention, and infiltration of urban storm water yields reduction of flood peaks by the same order of magnitude as the increase due to urbanisation in catchments of the lower meso-scale.
- 4) The flood impacts in the macro-scale due to a more realistic urbanisation scenario are in the order of 1 cm to 5 cm in the main channel. Due to the dominance of advective precipitation conditions for macro scale flooding events, limited water retention capacity due to high soil saturation for such kind of events and super-position of flood waves from different tributaries, the land-use change effects at the macro scale are very small.
- 5) Convective storm events are of minor relevance for the formation of floods in the large river basin of the Rhine Catchment because the extent of convective rainstorms is usually restricted to local occurrence. This conclusion is of rather high importance for flood management not only for the Rhine basin but probably also for other large river basins in Europe with similar climatic and morphological conditions.
- 6) The superposition of flood waves originating in different tributaries of the Rhine shows that the maximum effect of water retention in the macro-scale generally occurs in the rising limb of the flood wave in the main channel. The flood mitigation effect at the peak is considerably smaller.
- 7) Water retention measures in polders along the Upper and Lower Rhine under the given boundary conditions yield flood peak attenuation along the Rhine all the way down to Lobith of between 1 cm and 15 cm. The optimised and co-ordinated control of the polders can result in a considerably stronger decrease of the peaks.

The study examined the responses to the different scenarios in a purely deterministic way, as a tool to evaluate the changes in process dynamics due to the postulated scenarios of climate and land use change. If one establishes and applies such a large-scale model, including a variety of processes at certain (smaller) scales, it is inevitable that different kinds of uncertainties come along. For example, we can distinguish uncertainty due to imprecise or incomplete input data, uncertainty due to non-unique, non-identifiable, or non-representative model parameter, and finally uncertainty due to an imprecise or at least inappropriate model structure. In this study, we did not aim to analyse comprehensively or even to quantify these different uncertainties.

We tried to minimise uncertainty in the precipitation input, which is by far the most important meteorological variable for flood generation, by using the highest available number of daily precipitation observations (1514

precipitation stations in the catchment) and to apply a interpolation scheme specifically adapted to large-scale precipitation fields [4].

Our main intention was to setup a model system and structure which includes the relevant processes for modelling land-use change impacts. Such processes are on the one hand infiltration and runoff generation related processes, and on the other hand the routing and water retention processes in the channel system and linked polder systems. Through introducing relatively small scale process knowledge about land-use influences on runoff generation and its transfer to larger scales we have reduced the corresponding structural uncertainty. The structural uncertainty regarding river hydraulic processes has been approached by setting up a fully connected hydraulic model for a large part of the River Rhine and the main tributaries. We have to emphasize that this has been the first time that the River Rhine network has been modelled in such a comprehensive manner. Furthermore, the retention processes in polders are included.

The parameter uncertainty was dealt with in a fairly conventional way. For example, at various steps of the modelling procedure the sensitivity of the model results to uncertain parameters has been assessed and the values of the more sensitive parameters were varied in a plausible range. For the transfer of the small-scale process knowledge to larger scales only the “best parameter estimates” were used. We acknowledge that this is a somewhat simple and incomplete handling of parameter uncertainty. However, we refrained from applying comprehensive parameter analysis procedures, such as GLUE [1], because first, such techniques applied to such a complex multi-scale and multi-mode system would require an enormous computational effort (which – to our knowledge – has not yet been accomplished on such a large river system anywhere else) and second, as mentioned earlier, our focus was not on the analysis parameter uncertainty. Nevertheless, future research should also attempt to evaluate the uncertainties in the predictions of change for such large and complex systems. It is of particular interest if methods can be developed to handle uncertainty analysis in multi-model and multi-scale simulations and if these methods will allow us to evaluate the limits of predictability.

We acknowledge that all the results and conclusions are derived from simulation results. However, the simulations are anchored – at least partially – in observations. For example, the simulation of land-use change effects on storm runoff generation processes is consistent with both field experiments and observations of flood events in small rural and urban catchments [7].

Furthermore, the observed changes in flood routing conditions along the Upper Rhine due to the river training measure along that river reach in recent decades are well simulated by the flood routing model. These agreements in observations at different scales and simulation results give us confidence in the performance of the modelling system. However, though we adapted a procedure to transfer small-scale process knowledge to a larger scale, the corresponding information base is still not fully satisfactory. The regional equations for the estimation of the parameters of the conceptual upper meso-scale model were developed for limited ranges of proportions of different land-use classes, as they were dictated by the prevailing land-use distribution and the calibration was made against observation. The performance of the model in simulating the runoff for slightly extrapolated proportions of land-use classes has been validated. For a large deviation, however, the model simulation could be uncertain. Further work should be done to model the runoff for all ranges of land-use distributions coupled with uncertainty analysis of model predictions.

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Flood formation based on contrasting socio-economically founded land-use scenarios on

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ABSTRACT

A small catchment (6,8 km²) in the recently defined flood originating areas ("*Hochwasserentstehungsgebiete*" - SächsWG) in the Central Ore Mountains (Saxony, Germany) was analyzed to describe the development of the land-use to the present situation and its spatial distribution (historical background, site properties, subsidy policy etc.). From the scientific view the potential and the need of land-use changes for natural flood retention on land-cover in the study watershed is evident – yet present socio-economic and legal conditions (e.g. subsidy policies) do not sustain the implementation of relevant measures. Thus, the objective of our study is (1) to describe scenarios that reflect a close-to-reality future development with different boundary conditions which could be guided by political authorities; (2) to consider climate change especially assessing the site conditions before a flood originating rainfall event.

1 Introduction

As a partner in the Integrated Project (6th EU-FP) „FLOODsite” we investigate the impact of land-use on runoff generation and runoff concentration. Flood protection is only one component of the complex landscape functioning and therefore only one and often not the most important target of landscape planning. As a result of the disastrous floods during recent years, especially the Elbe flood in August of 2002, the novel water law of Saxony (SächsWG) contains regulations concerning flood originating areas ("*Hochwasserentstehungs-gebiete*"). Such areas were defined by the flood protection authority (Sächsische Landeshochwasser-zentrale). For such flood originating areas the novel law addresses the conservation and improvement of the natural water retention. The soils should be unsealed or afforested if possible. In case of an unavoidable loss or reduction of the natural water retention in these areas a suitable compensation is required (e.g. afforestation). To investigate the practicability of measures considering an increased water retention the present land-use situation in one of these areas was analysed. The aim was to detect the reasons of the present land-use and its spatial distribution (historical background, site properties, socio-economic constraints etc.). Five well-founded future land-use scenarios based on the socio-economic approach from the "Foresight programme" [3] were developed and the impact on several historical flood events was modelled. The changed climate situation is considered by the climate future scenarios from Umweltbundesamt [2]. On the one hand it was the idea to bring spatially distributed scenario modelling of the future in a more realistic context to other future investigations. On the other hand, the results give a good overview of the present land-use guided by the present EU subsidy policy.

2 Land-use change to increase the water retention

We have used different types of models to evidence the increase of water retention in the overall catchment area by adapted land-use. To describe the runoff generation by observing and calculating the water fluxes in detail plot models (e.g. BROOK90: [4]) are used. The expert knowledge from these modelling results is generalised and summarised in expert systems (e.g. WBS-FLAB: MERTA 2005) to obtain spatial distributed result of site specific general runoff behaviour. The runoff concentration within a whole river basin as well as the rainfall intensity dependence can only be assessed by establishing spatial distributed rainfall runoff models (e.g. AKWA-M®: [9]). The potential of natural flood retention on land-cover depends on runoff processes that can essentially only be influenced by man in changing the land-use. The rule of thumb reads: "possibly most high-growing, deep-rooting, dense, all-season vegetation-cover on possibly least compressed soil matrix". However the impact of land-use is highly dependant on the site-specific soil and relief conditions and the rainfall event characteristics. For that reason measures will vary with respect to their effectiveness. Nevertheless, measures - like non-intensive pasturing, preservative tillage, nature-orientated forestry (contains soil conserving harvests, adapted forest road building, high biodiversity with regard to the stand stability, revitalization of wetlands), afforestation, depaving measures - that conserve and improve the hydraulic functions of the soil can contribute to flood prevention [6], [17], [11], [12].

3 Investigation area and Present Land-Use

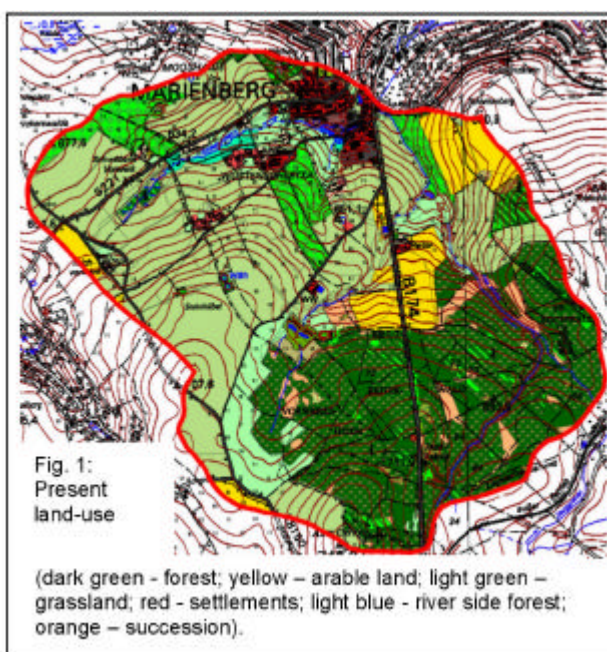
The investigated area is a subcatchment of the Schwarze Pockau River (Schlettenbach), which belongs to the Mulde. This catchment is located in the Ore Mountains in the south of the town Marienberg and is a flood originating area (according to SächsWG). It belongs to the basin of the Elbe river, where the most serious flood damages ever in Europe occurred in August 2002. It is 6,8 km² large with a 52 % grassland cover. The forest portion is ~35%, the arable land covers 7 % and 6 % of the catchment area is sealed. The soils are dominated by Cambisols (sandy loam – Ls3) and Stagnic Cambisols (Ls3). Along the rivers Gleysols was mapped.

Today's land-use in the Ore Mountains, Saxony, is the outcome of thousands of years of natural and man-made landscape conversion. Sedentary settling, the right to own land, economic exploitation, plot-mapping and finally the German-Constitution-based right of individual freedom and property are historical landmarks to current constraints in implementing land-use changes [13]. Especially mining activities from the 12th to 17th century led to an intensive clearing of forest land. Thus, at the end of the 16th century the area around Marienberg was nearly free from forest. After the depletion of the orebody succession reinstated. In the 18th century, the agricultural and silvicultural needs associated with the beginning of cartography led to the assignment of a specific land-use pattern to every location. That spatial distribution of forest and arable land in the considered area has nearly been unchanged since that time. Considering the above named required land-uses, for the investigation area can be stated:

Table 1. Present Land-use in the investigation area [13]

<u>Forest (35 %):</u>	<p>Spruce monostands, except the succession at the border of the forest and the some small places protected by the NATURA2000 programme.</p> <p>Change in species composition (spruce-beech-mixed stands) started with subsidies from the Saxon government although the difficult tenure conditions.</p> <p>Afforestation was planned (Waldmehrungsplan Sächsisches Forstamt Marienberg 2000; LEP 2003). Although there are subsidies in Saxon afforestation is not attractive to the land owners (farmers). The loss of arable land means to lose of other EU agro-subsidies where a minimum area is required. Additionally, the environment protection postulates a structured landscape with hedges, grassland, forest, and alluvial forest alternating.</p>
<u>Grassland (52 %):</u>	<p>Forage production (e.g. clover).</p> <p>20 % non-intensive pasturing supported by Saxon subsidies for close-to-nature agriculture.</p> <p>Only a very small part of the grassland is uncultivated.</p> <p>Change of cultivated land into uncultivated is uneconomical.</p>
<u>Arable Land (7 %):</u>	<p>Only on the low sloped hill tops, dominated by corn and rape (regenerative energy subsidies).</p> <p>No preservative tillage – conservative plough cultivation.</p> <p>Change of cultivated land into uncultivated is uneconomical.</p>
<u>Sealed Area (6 %):</u>	<p>Depaving measures (unsealing and removal of unused buildings from the former agricultural cooperative) will be done in the future dependent on the financing.</p>

The historical as well as the present-day vegetation pattern has always been affected by human activities. It is obvious for some reasons implementations improving the potential water retention in the catchment by land-use change is practiced in the investigation area. But flood protection is not the main idea of these measures because the EU subsidy policy regarding land-use changes is often not part of the water policy. Subsidies with respect to land-use are primarily guided by the agricultural policy (CAP) followed by structure and cohesion policy. Other partially competitive interests come from forest policy, environment policy etc. However, the Water Framework Directive as new approach aims at a integrated river basin management. The main goal is to achieve a good ecological and chemical status of surface water. Secondary, the Flood Directive stipulates to decrease the danger of floods by finding synergy effect between EU-WFD and



developing flood protection strategies. As long as flood protection is not in the direct focus of the EU policies controlling subsidies for land-use land owners will continue to choose the most profitable land-use. And an increased water retention will stay at the best a additional benefit of a supported measure.

4 Future Scenarios

FLOODsite is an integrated project and covers the physical, environmental, ecological, and socio-economic aspects of floods from rivers, estuaries, and the sea. It considers flood risk as a combination of hazard sources, pathways and the consequences of flooding on the “receptors” – people, property, and the environment. In cooperation with socio-economic researchers (IÖR Dresden) we chose the generally accepted Foresight approach to develop our future scenarios. The Foresight Futures socio-economic scenarios [3] are intended to suggest possible long-term futures, exploring alternative directions in which social, economic, and technological changes may evolve over coming decades. Under the Foresight Futures, one futures axis is concerned 4 primarily with the scale of governance from global to local, while the other reflects values from those that are community orientated to individual consumerism.

Table 2. Summary of Foresight Futures [3]

Scenario	Aims	Consequences
1 - world markets	Globalisation; personal independence; material richness; Policy: Minimal, enabling markets	Multinational trusts, high productivity and mobility, rural migration, income differentials increase
2 - national enterprise	personal independence and material richness influenced by a national identity Policy: State-centred, market regulation to protect key sectors	Decline of small and medium-sized enterprises slower than in Scenario 1; growth in service sector; specialisation on products for the regional market and luxury goods; agriculture subsidised
3 - global sustainability	Common welfare, equal opportunities and intact environment realised by communities of values Policy: Corporatist, political, social and environmental goals	World-wide regulation of economical growth; international trade with high social and ecological standards; agriculture balances yield, biodiversity and sustainability; renewable energy; income decreases
4 - local stewardship	Sustainable standards of common welfare on a local scale, shelter of local markets Policy: Interventionist, social and environmental	increment of small and medium-sized enterprises; high social, ecological and quality standards; production site specific fragmented; agriculture for self-sufficiency; mobility and income differentials decrease

Thus, we developed 5 land-use scenarios for the investigation area. A far-reaching afforestation or tree species adaptation (considering the scenario boundary conditions) and the maintenance of the village Wüstenschlette is valid for all scenarios. The potential natural vegetation [15] – a nearly complete forest cover with oak-beech-stands in the lower altitudes and spruce/fir-beech mixed stand in the higher regions is used as a “maximum retention scenario”.

Table 3. Foresight Futures

World markets: (WM)	Agriculture unprofitable. Multinational timber trust use nearly the whole catchment for spruce production. Landscape show an alternation of clear-cut areas, spruce stands of different ages (10 yr., 30 yr. and 70 yr.) and grassland around the buildings in Wüstenschlette.
National enterprise: (NE)	Private agriculture focuses on extensive pasture production. The woodside areas which are difficult to till are afforested with spruce. The other forested areas maintain. Around the village Wüstenschlette fish and fruit production is established. All activities are considering national or “home-“ production aspects.
Global sustainability: (GS)	Natural water retention is a general European interest. Afforestation and soil conserving agriculture is subsidised by the EU. Crops for energy production are planted.

	Forestry develops species-appropriate mixed stands. Continuous riverside forests are established. Products are exploited with “according to flood protection” -sign.
Local stewardship: (LS)	Small sized and site specific soil conserving tillage (pasture, crops). Close-to-nature forestry and afforestation. Continuous riverside forests are established.

Table 4. Land-use portions [%] for all scenarios

Scenario	Forest							Intensive Grassland	Extensive Grassland	Conven- tional arable land	Soil conserving arable land	Settlements	Hedges with fruit-trees	sealed
		Clear cut	10 a spruce	19 spruce	30 a spruce	70 a spruce	Wet							
IST	35							41	11	7		4		2
1 (WM)	81	11	11	19	34	6			12			4		3
2 (NE)	44							41				4	9	2
3 (GS)	53										42	3	1	1
4 (LS)	63								15		18	2	1	1
PNV	99											1		-

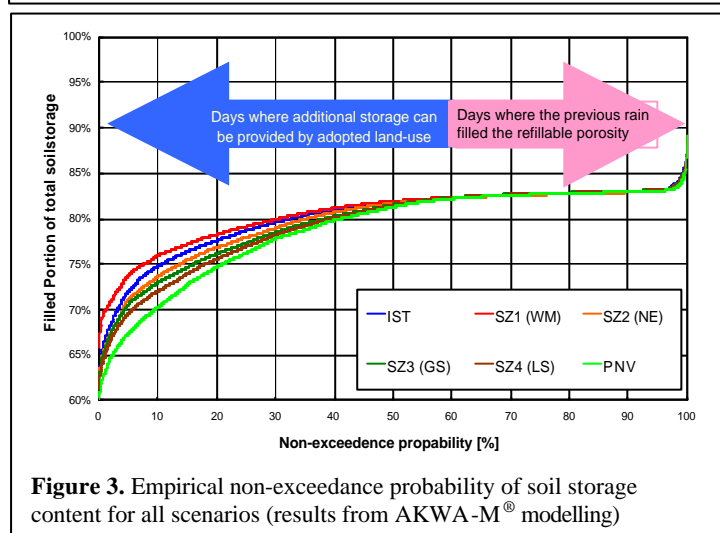
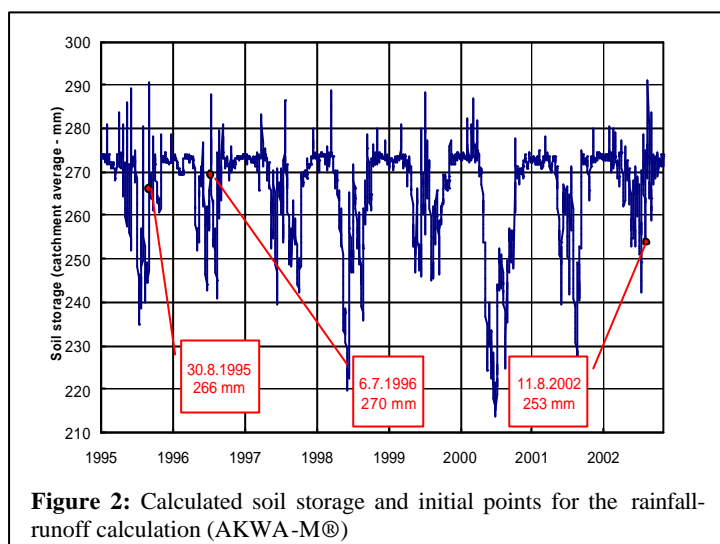
The climate future scenarios are outcomes from an investigation by the Umweltbundesamt [2]. The results base on the climate model run ECHAM 5 which takes into account two different changes CO₂ concentration until 2100. The ECHAM 5 results were downscaled with the WETTREG-model, which produces daily climate data for every meteorological observation station in Germany. The feedback between the socio-economic future and the climate future was neglected in this investigation.

5 Results

For a number of rain events between 1984 and 2005 the runoff was simulated. Three of these rainfall-runoff calculations of analysed events are shown here with different precipitation sums and different pre-event soil moisture conditions. Fig. 2 shows the average pre-event soil moisture situation (present land-use).

Table 5. Rain events and there statistical placement (KOSTRA 1997) with Precipitation (P); Duration (D) and Return periode (T)

D [h]	1		4		24		72	
Date	P [mm]	T [a]	P [mm]	T [a]	P [mm]	T [a]	P [mm]	T [a]
31.8. – 1.9. 1995 P = 155 mm	8	< 0,5	27	0,5	108	appr. 100	124	appr. 20
7.7. – 11.7. 1996 P = 77 mm	6	< 0,5	15	< 0,5	67	5 - 10	77	2 - 5
11.8. – 15.8. 2002 P = 200 mm	22	1 - 2	50	appr. 10	173	> 100	198	> 100



If we look at the different soil storage distribution functions (empirical non-exceedance probability) for the present weather situation (1984 – 2005) it is evident that the effect of the land-use increases with decrease of the soil moisture (Fig. 3). If the weather situation before a heavy rain event was dry the difference between the land-use types (interception, evapotranspiration, root depth) leads to different water consumption. In the case of a wet pre-event situation the limited refillable porosity is filled.

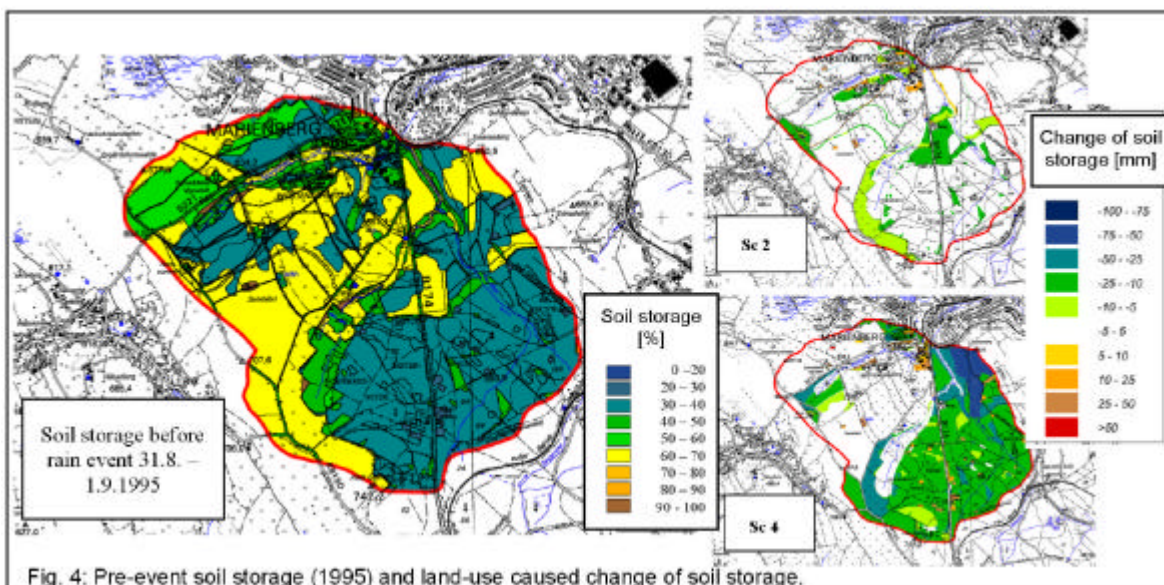
But not only the additional storage in the soil provided by different forms of land-use is important. Another dominant factor is the ability of the soil to conduct the water from the surface into deeper layers. The infiltration routes water to free storage in the deeper soil or brings it to subsurface pathway which normally decelerate the runoff. The superposition of these processes causes the intended peak reduction. The peak reduction for the event with the highest pre-event soil moisture (1996) is very small for every scenario. The runoff for the 1995 event shows an observable peak reduction in scenario 3 and 4 and a notable reduction for the PNV scenario. The rainfall characteristics in 2002 cause a pronounced two-peak behaviour. The resulting runoff points out the effects of the lateral components and the limited soil storage. There is a high reduction of the first peak especially in scenario 3 and 4 the peak is reduced by of more than 40 % of the IST-runoff. The second peaks show not such

strong reductions. PNV-runoff for the second peak of this event (70 % reduction for the first peak) is even higher than scenario 3 and 4 because the retained runoff from the first peak is still part off the runoff when the second peak reaches catchments outlet. So, the second peak equals a flood event with a high pre-event soil moisture. Table 4 summarises the peak reductions. The results demonstrate that conserving and improving the hydraulic functions of the soil by non-intensive pasturing, preservative tillage, nature-orientated forestry and depaving measures can provide a distinct contribution to flood prevention. Especially forest cover results in an increased water consumption due to higher interception and transpiration rates and in case of conifers with an all-year high LAI. In sum, all these forest effects lead to a lower pre-event soil moisture. However, they are limited by the available soil storage. As a consequence, the ‘forest effect’ can be splitted into two general parts: retention by additional provided storage (1) and decelerating runoff by shifting water into slower pathways (2). The following figures (Fig. 4. and 5.) show these effects in their spatial distribution for scenarios 2 and 4 (Sc 2 and Sc 4).

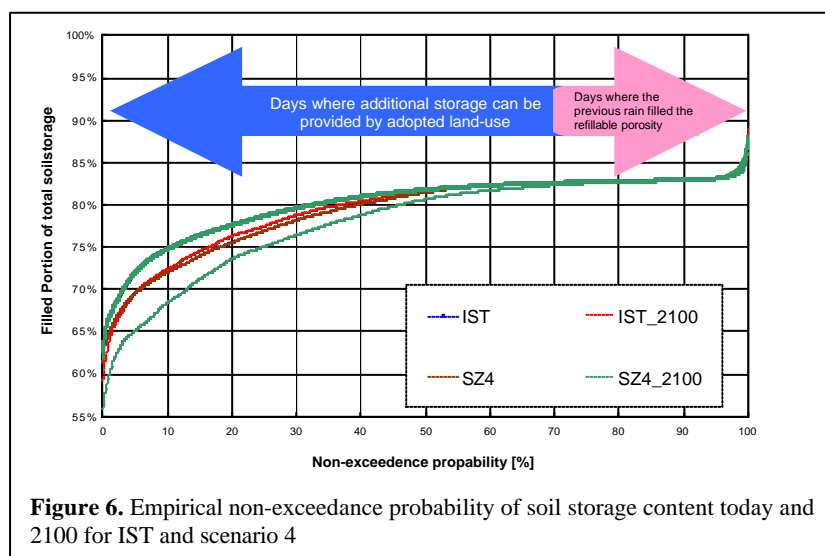
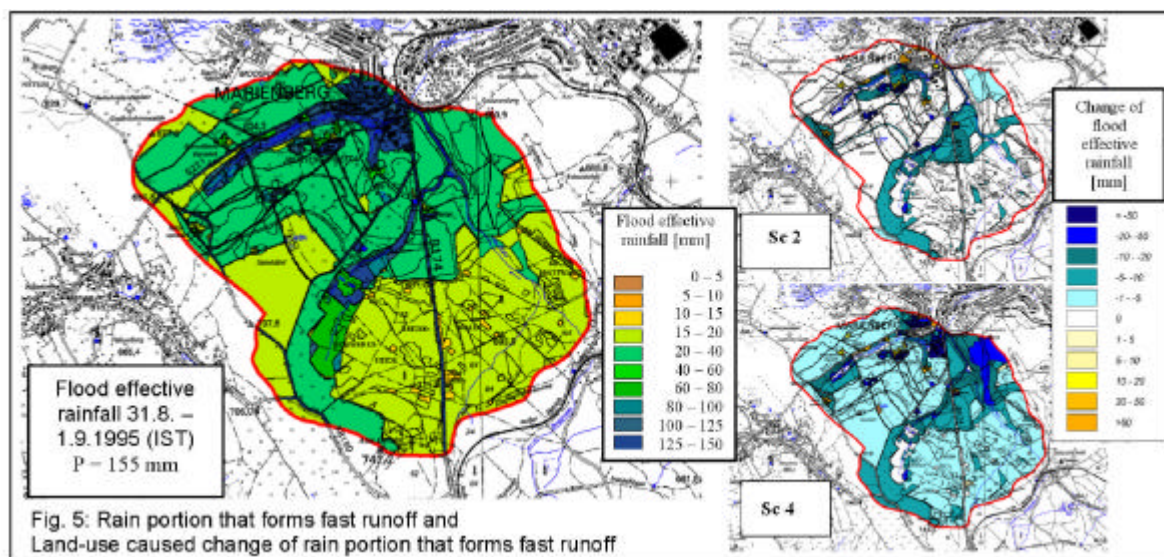
Table 4. Calculated runoff peaks (p) and percental differences for all scenarios (pRed)

Scenario	1995		1996		2002 peak 1		2002 peak 2		peak reduction for all investigated rainfall events [%]
	p[mm/h]	pRed[%]	p[mm/h]	pRed[%]	p[mm/h]	pRed[%]	p[mm/h]	pRed[%]	
IST	1,95	-	0,84	-	4,0	-	3,3	-	-
1 (WM)	1,92	1	0,84	0	3,0	23	3,3	0	from -1 % to 23 %
2 (NE)	1,90	2	0,84	0	3,6	9	3,1	5	from 0 % to 15 %
3 (GS)	1,85	5	0,76	9	2,4	40	2,8	14	from 2 % to 40 %
4 (LS)	1,74	11	0,76	9	2,2	46	2,8	17	from 9 % to 46 %
PNV	1,41	26	0,74	11	1,2	70	3,0	8	from 11 % to 70 %

(1)



(2)



If we at first neglect processes like hydrophobicity and long-term soil formation it can be stated that the climate change will influence the provided storage much more than the infiltration behaviour. Fig. 6 shows for the present land-use and scenario 4 (LS) the empirical non-exceedance probability of soil storage for both the present weather conditions (1984-2005) and the future conditions (2100) given from the more moderate B1 scenario by [2]. There, it is assumed that in Saxony it becomes drier and warmer, but the abundance of heavy rain events will increase. The

differences in water storage at different forms of land-use will become more pronounced as the number of drier days will increase. Therefore, it should be placed greater importance on land-use considering water retention.

6 Conclusion

Land-use change measures are mostly long-term challenges and the appearance of the benefits may take decades. Another major restriction of adopted land-use as a component in an integrated flood risk management is that benefits of water retention in the landscape are mostly not directly noticeable at the point a measure is implemented. In the investigated area in Saxony the local authorities and the land owner are convinced they do the possible considering their financial budget. Therefore, societal/legal constraints to improve the situation are required. It has been shown that the more community oriented scenarios are able to establish conditions for land-use types that consider water retention in conjunction with other targets of a sustainable development. That means flood protection in the field as announced in the European Flood Directive especially by searching for synergy effects to the EU-Water Framework Directive must find its way to both the law and the subsidy policy. The tools for predicting effects of land-use changes have to be improved especially considering questions of:

- developing model tools to describe changes in relevant soil properties under changed land-use;
- implementation of new or existing approaches for hydrophobicity, surface roughness, and upsilting;
- assessing the impact of measures considering the improvement of natural water retention to areas downstream.

Even though there are distinct short-comings in simulating the actual processes in nature model calculations will stay an adequate way to give well-founded prognosis with respect to drastic impacts into the landscape. The climate future research shows that the influence of the land-use will increase in the future. The combination of the long-term planning requirements and the growing importance will not (at least in Saxony) keep this discussion vital.

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The Pontbren catchment study: A multi-scale experimental programme investigating the impact of UK upland land use on flood risk

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Abstract

This paper describes ongoing, field-based research in the Upper Severn catchment investigating the effects of upland UK land management on flood risk. The study is part of a multi-scale programme which aims to bridge the gap between plot-scale experiments and prediction of catchment-scale response. Plot and hillslope scale measurements are nested within instrumented 1st and 2nd order catchments. Instrumentation includes stream flow gauges, tipping-bucket rain gauges, tensiometers, 1 weather station, plus time-series data on interception by trees, soil moisture and groundwater levels. Detailed monitoring of an instrumented hillslope has revealed the changing nature of the hydrological response resulting from antecedent wetness, and structural changes in the soil linked to climate. Overland flow is an important runoff process from these clay-rich, heavily grazed soils that often remain saturated for much of the winter. A significant amount of water is rapidly transported through land drains which are common in these land use systems. Dye tracing experiments have illustrated the importance of preferential flow paths in the movement of water through these soils. Preliminary results from wooded buffer strips suggest that infiltration capacities are increased and overland flow reduced due to the presence of trees and/or absence of sheep. Stream flow hydrographs have identified a possible influence of land management regime on hydrological response. The effects of land management on hillslope runoff are currently being explored using a 3D physically-based model, and catchment-scale effects are being simulated using an upscaling procedure based on meta-modelling.

Keywords: Land use, runoff, overland flow, drain flow, flooding, soils, multi-scale.

1 Introduction

A multi-scale experimental programme has been established at Pontbren, mid-Wales, in response to the growing concern over flood risk in the UK, and lack of knowledge regarding the potential catchment scale impacts of upland agricultural land management. Although flood risk is concentrated in lowland regions, the management of catchment headwaters, with their flashier response and generally higher precipitation, are an area of particular interest. The programme aims to deliver data to bridge the gap between plot scale experiments and catchment scale responses. Specifically, the aims are: 1. Quantify the local scale impacts of upland land management. 2. Develop multi-scale data to support development of multi-scale modelling tools. 3. Support extension of the analysis of impacts to the Upper Severn catchment and, 4. Support land management policy recommendations for flood mitigation

Pontbren is a headwater catchment (~ 18 km²) of the Upper Severn situated between 130–425 m above Ordnance datum (AOD). Although not an ‘upland catchment’ in a global context, it is considered as upland in terms of UK agriculture. Local topography exhibits the characteristic undulating hills of mid-Wales. The climate at Pontbren is characterised by warm, moist conditions with an annual average precipitation of approximately 1230 mm [1]. Pontbren streams are mostly perennial, many of them fed by a network of drainage ditches. Anecdotal reports in recent years suggest an increased frequency in the occurrence of no flows during summer and significant increases in overland and flood flows since the 1960s. Slowly permeable, heavy textured clayrich soils dominate the catchment. These are widespread in Wales on glacial drift derived Ordovician and Silurian sediments [2]. Fifty eight percent of the land in the Pontbren catchment is agriculturally improved grassland, with 30 % left as unimproved pasture. Most agriculturally improved grassland is artificially under-drained and receives regular fertilizer applications. The land is used mainly for sheep grazing, with some beef and dairy production.

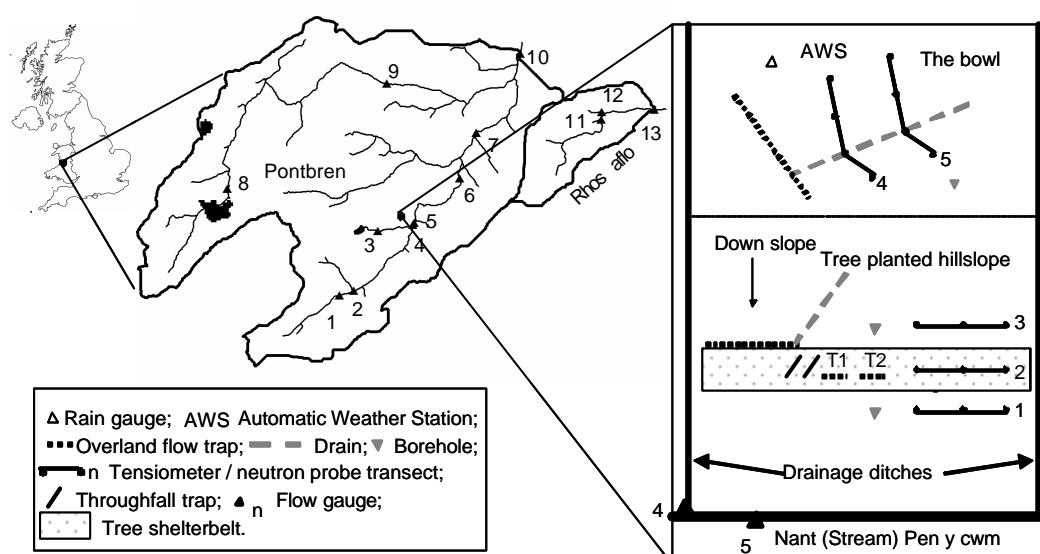


Figure 1. Pontbren, Rhos aflo catchments, and instrumented hillslope locations and experimental layout

Approximately 43 % of the catchment is farmed by the ‘Pontbren Group’, a consortium of 10 contiguous farms, whose aim, amongst others, is to provide a more sustainable approach to farming. Part of the group’s management strategy has been to plant trees to provide shelter for livestock and thereby reduce the cost of animal housing. An initial study at Pontbren showed infiltration rates were up to 60 times higher in these tree-planted areas compared to adjacent pasture, and that significant differences were observed in as little as 2 years following tree planting [3]. The multi-scale experimental programme described here builds on this initial study and is based on plot and hillslope scale measurements nested within 1st and 2nd-order catchments which will identify changes in soil hydraulic properties and, through appropriate modelling, investigate their potential impact at the catchment scale. At four sites, changes in soil hydraulic properties and runoff processes are being measured at the plot scale under experimentally imposed grazing, no grazing, and woodland buffer strip management regimes. The impact of drainage and tree-planted shelter belts on runoff processes is also being investigated at the hillslope scale and stream and ditch flow is being continuously monitored at 13 locations across the catchment. Figure 1 shows the location of the instrumentation within the Pontbren and adjacent, smaller Rhos aflo catchment.

This paper focuses on results from an instrumented hillslope which are described in the context of hydrographs from flow monitoring sites located across the catchment.

2 Method

Figure 1 shows the location and the instrumentation layout of the experimental hillslope site at Tyn-y-Bryn Farm. The hillslope extends for ~ 300 m at an average slope of 8% divided into a series of benches with an easterly aspect and elevation range from ~ 270–310 m AOD. The field is under-drained improved grassland used exclusively for sheep grazing. Between the lower 2 benches a tree-planted shelterbelt has been established and, for purposes of experimental design, the hillslope is divided into 2 distinct segments, namely the ‘Bowl’ and the ‘tree-planted hillslope’. The Bowl is a 0.52 ha under-drained natural depression and is the most elevated section of the hillslope. The soil at the hillslope is predominantly classified as slightly stony clay loam (Cegin series) but approximately 1/3 of the Bowl is classified as a slightly stony silty clay loam (Sannan series). The Cegin soil series is described as seasonally waterlogged, indicating that the topsoil is wet for most of winter and early spring, so that most excess water is expected to move laterally through the upper parts of the soil. The Sannan soil series is slightly more permeable with only slight seasonal water logging [4].

At each site, transects (20 m apart) of tensiometer arrays (5 m apart) and neutron probe access tubes are installed to measure soil water potential (cm H₂O) continuously and moisture content (cm³cm⁻³) at weekly intervals. Tensiometers are installed at 10, 30, and 50 cm depths (apart from within the tree planted area where they are only installed at the 10 and 30 cm depth). Instrumented boreholes provide continuous data on groundwater height AOD (m). Any overland and drain flow occurring in the Bowl and a section above the tree-shelterbelt is measured continuously using V-notch weir boxes and tipping buckets connected to electronic data loggers. Within the tree

planted area, the volume of overland flow collected from two representative 5 x 5 m isolated plots (T_1 and T_2) is measured bi-weekly.

The effects of young and established trees on runoff response is being investigated at three sites located in established woodlands of differing ages. At each location, rainfall is measured on the windward and leeward side of the plantation along transects perpendicular to the trees. Throughfall is measured beneath the tree canopies, together with stemflow from a representative number of trees. Changes in soil moisture status are monitored using continuously logged tensiometers and periodic neutron probe measurements.

Water flow in streams and ditches (Figure 1) is measured using a combination of appropriately calibrated Acoustic Doppler Velocity (ADV) meters [5], two V-notch weirs, and a rated natural section.

3 Results and discussion

Figures 2a and b show rainfall intensity (mmhr^{-1}) and soil pore water pressures, Ψ ($\text{cm H}_2\text{O}$), measured from a tensiometer array on transect 4 within the Bowl study site, for two rain events occurring in December '05 and December '06 respectively. The rapid response of pressure at 50cm depth (tensiometers at this depth responded within 2 hrs following the onset of rain) is indicative of macropore flow. The presence of preferential flow paths was confirmed by a dye tracer experiment. Brilliant Blue FCF dye solution was ponded on the soil surface (after the turf had been lifted), of a 1.2 x 1.2 m plot in a field adjacent to the instrumented hillslope. Once the solution had infiltrated, layers of soil were excavated from within each plot. Staining was visible around the surfaces of stones, earthworm channels and cracks, confirming macropore flow. Excavation of a trench down-slope of the plots also revealed lateral preferential flow paths.

The positive pore water pressures at 10 cm depth shown in Figures 2a indicate that the soil surface is remaining saturated for longer during the December '05 event compared to the event '06 despite lower rainfall intensities and volume. As a result of drier soil conditions, there are significant differences in runoff response (Figures 3a and b). During the '05 event, overland flow intensity often exceeds that of the drain flow, whereas during the '06 event overland flow intensity never exceeds that of the drain flow despite greater rainfall intensities and volume. There is also a significant decrease in the relative amount of rainfall coming off the land in the form of overland flow. Both events demonstrate the importance of drain and overland flow in the movement of water at the hillslope scale.

Figure 4 shows groundwater elevation AOD (m) in the borehole at the Bowl study site. During December '05 little of the incoming rainwater reached the water table and groundwater elevation remained no closer than 145 cm from the soil surface. This suggests the presence of an impermeable layer below 50cm depth resulting in a saturated upper layer to the soil profile which is consistent with the description of the Cegin soil series. In December '06 groundwater elevation is relatively responsive. MORECS¹ estimation of soil moisture deficit

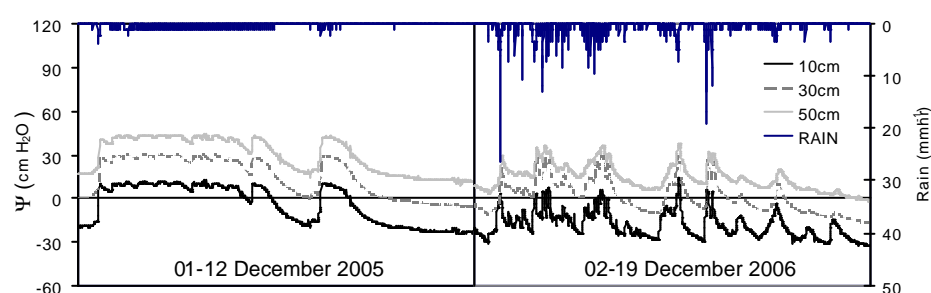


Figure 2a and b. Rainfall, Soil pore water pressures measured from tensiometer array at transect 4 within the bowl study site during 2 rain events in December 2005 and 2006 respectively

¹ UK Meteorological Office Rainfall and Evaporation Calculation System

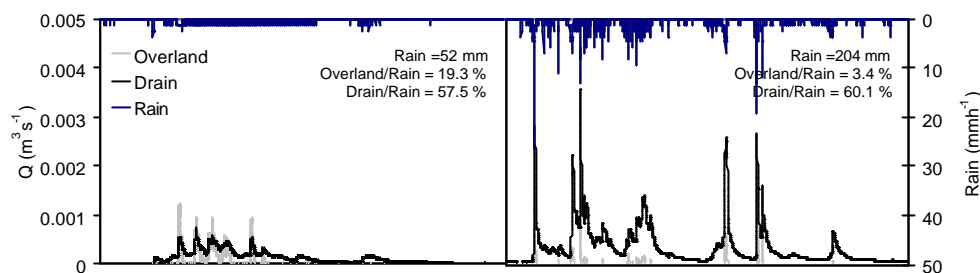


Figure 3a and b. Rainfall, Overland and drain flow at the Bowl study site during 2 rain events in December 2005 and 2006 respectively

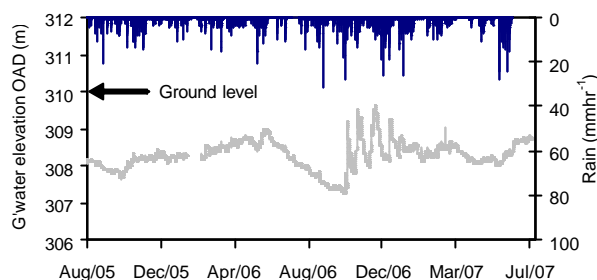


Figure 4. Rainfall and Groundwater elevation measured at the Bowl study site

indicated that the ‘unusually’ hot dry experienced at Pontbren in the summer of 2006 resulted in extreme drying of the soil profile leading to the development of preferential flow pathways in the form of large cracks which allowed water to bypass much of the soil matrix and reach the groundwater. Consequently the soil surface remained drier for longer during the following winter resulting in significantly less overland flow compared to the previous years ‘normal’ conditions.

Significantly less overland flow is observed within the tree-shelterbelt compared to the Bowl. For the same December ’05 event 3.7 and 3.8 % of incoming rainfall was collected from T_1 and T_2 respectively, compared with 19.3 % from the Bowl. For the monitoring period 28/11/2006 – 03/01/2007 the amount of overland flow collected from T_1 was 0.8 % compared with 2.9 % from the bowl (T_2 was out of operation). Differences between the shelterbelt and the Bowl may result from an increase in the infiltration capacity [3] due to the trees and/or due to the exclusion of sheep, coupled to a reduction in the amount of precipitation hitting the soil surface as a result of interception by the tree canopy.

Recent data indicate that the amount of rainfall water reaching the ground below trees as throughfall is greatly reduced compared to incident rainfall. (Annual interception losses will be calculated once a full year of throughfall and stem flow data have been collected). Neutron probe data from the three transects above, within, and below the tree shelterbelt also indicate that the top 80 cm of the soil profile within the tree planted area remains drier at all times than the soil within the adjacent grazed areas.

Figures 5a – c show rainfall and the normalised hydrographs of total runoff (overland and drain flow) from the Bowl along with those from Sites 5, 6 (both on the Nant Pen y cwm), and 9 (at the outlet of the Nant Melin y grug subcatchment) for the period 01/11/2006 – 31/01/2007. Sites 5 and 6 are the stream outlets from subcatchments where there is a high proportion of improved grassland (70 and 77 % respectively), compared to only 14 % for Site 9. The Nant Pen y cwm has a flashy response (similar to that of the bowl) whereas the Melin y grug response is visibly more damped. It is speculated that the contrast in stream flow responses between these sites is due to a lake at the source of the Melin y grug plus differences in land management practices. More specifically, the land management factors that may have contributed to the flashier runoff responses at sites 5 and 6 include the removal of native flora, installation of drainage systems, intensification of livestock production and associated compaction of the soil surface, and modification of natural wetlands and lakes. Current challenges include identifying the relative importance of these and other factors such as soil type and channel routing plus the analysis of responses under more extreme flood events.

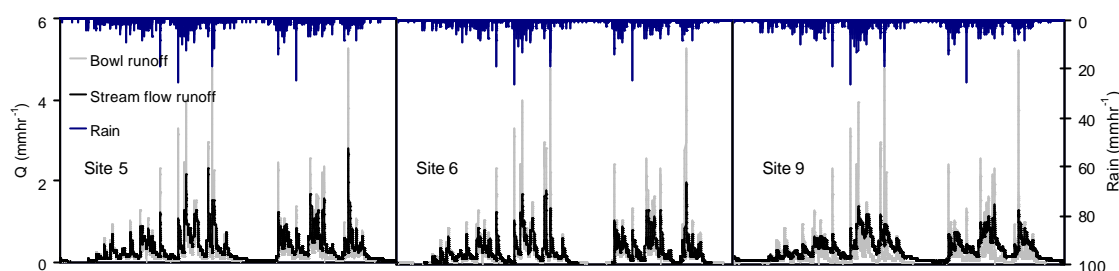


Figure 5a-c. Hydrographs of runoff from the Bowl and stream flow gauging sites 5, 6, and 9 respectively for the period 01/11/06-31/01/06

4 Conclusion

Under typical climatic conditions for upland Wales, peak overland flow rates from an ‘improved’ grassland hillslope exceeded that of drain flow. Following an unusually dry summer, surface runoff was much reduced in response to winter rainfall because soil cracking had created preferential flow pathways allowing water to infiltrate to depth. Identification of runoff pathways and the understanding of land management effects on flood risk are thus complicated by inter-annual climate variability. The evidence from our experiments suggests that tree shelterbelts protected from grazing can significantly reduce local surface runoff. Additional experiments are underway at Pontbren to quantify interception losses from tree shelterbelts. Plot scale manipulation experiments will also help dissociate the effects of the trees from those of protection from grazing.

The Pontbren data show that a relatively natural subcatchment stores more water and produces smaller flood peaks than an adjacent subcatchment which has been subject to more intensive agricultural management. The reasons for these differences in response have yet to be fully identified whilst their significance under more extreme floods and at larger scales remains to be discovered. A programme of simulation modelling [6] will test a variety of hypotheses at the full range of scales so that the effectiveness of different local land management options can be evaluated at the catchment scale.

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Hydrological Impacts of Afforestation Activity in Liupan Mountains Region, China: a Case Study Based on Simulation of TOPOG in Caogou Catchment

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1 Introduction

Forest area in Liupan Mountains is well known as a “green island” on Loess Plateau since more than 60 rivers emanate from here. As important water source reserve area of Loess Plateau, this area experienced long-term afforestation, especially from late 80's 20th up to now, and the landscape has been changed greatly during the past 4 decades. The area ratio of artificial forest increased remarkably from 8.5% to 62.5% in total forest area after two large-scale afforestation during 1986~1998(Li, 1999). The changes of landscape pattern will change the function of landscape, including ecological processes (Forman & Gogron, 1986). Large-scale afforestation projects are still managed and planned since this area is regarded as of high ecological significance in ecological rebuilding framework of whole China (Liu, 2003). Although there is controversy about the ecological effect of forest vegetation enlarging (such as artificial afforestation) on runoff generation (Whitehead, 1993; Jackson et al, 2005), it is accepted generally that the change of vegetation and landscape patterns will make direct impact upon forest hydrological processes and runoff generation. Taking Cgaogou Catchment as objective area, this paper discussed possible changes of landscape and their hydroecological impact based on simulation results made by TOPOG to offer a hydroecological view for the undertaking afforestation activity in Liupan Mountains region.

2 Methods

Caogou catchment is located at the eastern slope of northern Liupan Mountains, and it is a subbasin of Xiangshuihe River (which is a branch of Jinghe River) Basin (E106°12'~ 16', N35°27'~33'). The base belt of study area is located in a region between semi-arid and semi-humid temperate continental climate zone. With an elevation ranges from 2200 to 2930 m, this area shows wide-ranged meteorological characteristics. Little original vegetation is kept, and current vegetation is mainly composed of natural secondary forest and artificial woodland. The main species of artificial woodland is *Larix principis-rupprechtii*. Considering the complicated landform of Caogou catchment, we choose TOPOG among some other available models at the time. It is one of the distributed hydrological model with most detailed representations of flow topography and processes.

3 Application of TOPOG: calibration and validation

The observed runoff volume at outlet of catchment is our main calibration targets. Soil moisture dynamic and rainfall interception of rainfall events are also used to estimate calibration result. Transpiration of upper vegetation layer and soil evaporation are considered additionally. Observed data on hydrological and vegetation growth process during growth season of 2004 and 2005 are available in our study, and data of 2005 is used to make preliminary calibration. The runoff simulation with calibrated parameters can meet the statistical requirement and $R^2 = 0.6465$. R^2 for soil moisture and interception of upper vegetation layer are 0.8687 and 0.7288 respectively.

Simulated hydrograph represents the actual hydrograph quite well (Fig. 1a). With lagged peak discharge during flooding process and flattened, long recession curve, such hydrograph implicates that subsurface soil flow might be the major form of runoff generation in this catchment. The ratio of surface runoff component is only 1.79% in total simulated runoff discharge, just the same with our field observation in this area, implying that infiltration-excess flow mechanism works restrictedly during rainfall events. Continuous simulation from 2004 to 2005 shows higher simulating efficiency ($R^2 = 0.6793$) than that of separate simulation in 2005 (Fig. 1b).

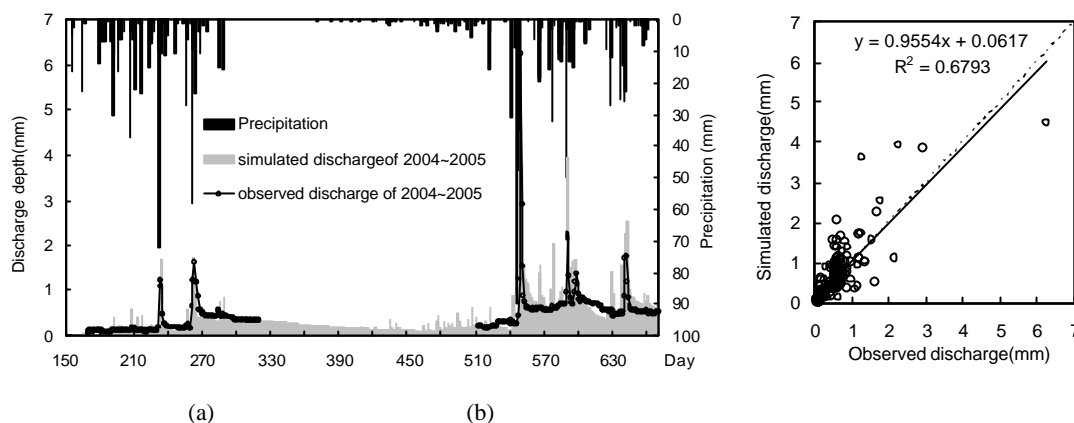


Figure 1. Continuous discharge simulation from 2004 to 2005

4 Sensitivity and error analysis of parameters

We focus sensitivity analysis on the following 4 parameters: saturated soil conductivity, saturated soil moisture content, depth of soil layer and initial soil moisture content. They impact total runoff level in different way, and characteristics of hydrograph show high sensitivity upon changes of depth of soil layer and initial soil moisture content. However, continuous simulation over long periods may avoid substantial uncertainty in estimating this parameter. Its value can be viewed as reasonable and acceptable only when it is proved to be able to simulate flow discharge and soil moisture within a period including two or more growth seasons.

The general trend of runoff discharge is been represented quite well in our simulation, however, the detailed characteristics of hydrograph are not described accurately. Complex landform in mountainous region can often result in spatial variation of meteorologic factors, especial precipitation. Moreover, hydrological processes of Caogou catchment behaves fairly sensitive to variation of such meteorologic factors as precipitation because of its quite small area. Therefore, the difference between extrapolating and actual weather data still might result in simulation errors and decline the simulation efficiency. As long as our study area is concerned, the absence of representation for snow-melting process in the model could also be a source of simulating errors. An accurate peak discharge for the rainfall event at 587 day (June 30, 2005) is not obtained in our final continuous simulation. According to the comparison between simulated and observed hydrograph after that day and sensitivity analysis of parameters, this inaccuracy is resulted mainly by a lower soil moisture content than actual soil moisture content, while the water recharge of melting snow to soil moisture is quite important in this region, especially during the early growth season.

5 Scenario simulation and analysis

The setting of scenario to be simulated is based on the analysis of historical records and current management strategy about afforestation activities in Liupan Mountains, i.e. transferring natural broadleaf woodland and shrub into artificial *Larix principis-rupprechtii* woodland. Current actual area ratio of artificial woodland in Caogou catchment is 11.5%, lower than the ratio 24.5% in Xiangshuihe River Basin. The ratio of artificial woodland in Caogou will increase to 23.0% when we transfer current Populus woodland into Larix patches and almost reach the ratio of Xiangshuihe, thus such a transferring is set as scenario I (Fig. 2a). Based on this transferring, the area ratio of artificial woodland will increase to 57.8% when Betula patches transfer into Larix, too, and this is set as scenario II (Fig. 2b). If we transfer shrub instead of broadleaf woodland patches into Larix, the area ratio of artificial woodland will be 21.0%, and this is scenario III (Fig. 2c). In scenario analysis, we mainly discuss the difference of total amount of interception, transpiration, runoff discharge and soil evaporation between scenario and actual landscape.

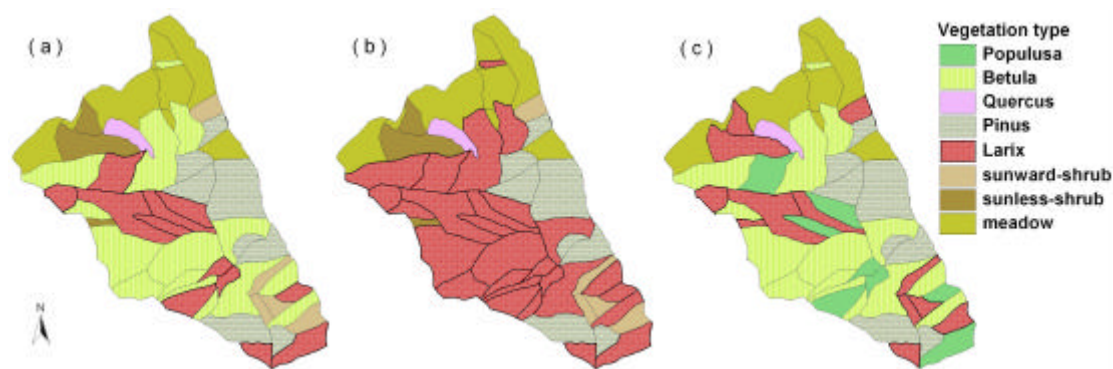


Figure 2. Scenario simulation for landscape management

- (a) Scenario 1: Populus patches alternated by Larix and Larix ratio increase to 23.0%
 (b) Scenario 2: Betula patches alternated by Larix and Larix ratio increase to 57.8%
 (c) Scenario 3: Shrub patches alternated by Larix and Larix ratio increase to 21.0%

The trend of hydrograph changes in scenario I and II are quite similar with each other when comparing with actual hydrograph. Nevertheless, the difference between scenario II and actual hydrograph is more obvious than scenario I because of its larger area that has transferred to *Larix*. In terms of hydrological components, (1) total evapotranspiration increases prominently: interception increase in a degree and transpiration of upper vegetation layer increase obviously. Total transpiration of under vegetation layer decreases because there usually is poor under layer vegetation in current artificial woodland. Soil evaporation shows little difference. (2) Total runoff discharge decreases remarkably (Fig. 3a) with the ratio of subsurface soil flow against total discharge raises in a degree. Total discharge is decreased by 12.35% in scenario I and 28.01% in Scenario II. The increase of total evapotranspiration can account for major part of the decrease of runoff discharge. Total runoff discharge will decrease more evidently after the under layer vegetation in artificial woodland developing better than current situation. The fluctuating of runoff is weakened in general because of the decline of runoff level (Fig. 3b), and the increase of subsurface flow ratio probably accounts for the flattening of hydrograph in addition. Hydrograph fluctuates more sharply than actual in some part of hydrograph, especially during storm rainfall events, however, fluctuating in these parts should be weakened after the under layer vegetation in artificial woodland developing well enough.

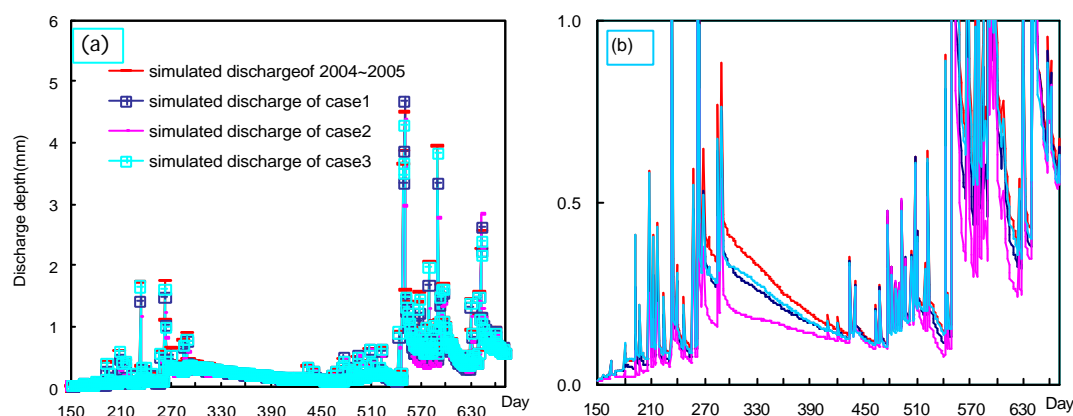


Figure 3. Simulated discharge under given scenarios and actual landscape from 2004~2005

- (a) general trend of peak discharge (b) detailed characteristic of hydrograph

Total evapotranspiration increases while interception, soil evaporation and total transpiration of upper layer vegetation show little difference with actual ones. Transpiration of under layer vegetation increases. Total discharge is decreased by 7.85%, and should decrease more evidently when the under layer vegetation in artificial woodland well developed. The ratio of subsurface flow changes little. The fluctuating of runoff is magnified in general (Fig. 6b), with peak discharge increasing and baseflow level cut down. It is mainly because of the difference of soil characteristics between *Larix* and shrub patches. Such changes can be observed mainly in growth season, and runoff fluctuating flattens in a degree during non-growth season.

6 Discussion and conclusions

- (i) The simulation efficiency for such main hydrological process as interception, soil moisture and runoff of Caogou catchment are fairly acceptable and can be applied to found the ecohydrological research and landscape management. However, since snow-melting process will change the response mode of soil to precipitation, absence of consideration upon snow-melting may reduce simulate efficiency during non-growth season and early or late growth season. In order to avoid the limitation of TOPOG application in middle and high latitude region, we suggest and will try to take snow-melting process into account in the representation of hydrological processes of TOPOG.
- (ii) With good coverage of vegetation and loose forest soil, the main component of total runoff in Caogou catchment is subsurface soil water flow, and the ratio of surface runoff is less than 5%.
- (iii) The preliminary scenario simulation and analysis imply that total runoff at catchment outlet will decrease total runoff of catchment if increasing area of *Larix principis-rupprechtii* woodland through cutting natural broadleaf woodland or reclamation of shrub patches. The decrease of total runoff can reach 28% when the area ratio of *Larix principis-rupprechtii* patches enlarges from 11.5% to 58%. While reclamation of shrub patches also might reduce availability of water resources because runoff undulating will enlarge. Since the forest area in Liupan Mountains and circumjacent region is water sources area for Loess Plateau which is suffering short of water resources severely, landscape management of this region should take the impact of afforestation and other change of vegetation patterns upon runoff generation into account, i.e. optimize the landscape programming by well balancing between soil conservation and maintaining of certain level of total runoff.

Experimental evaluation of process variability after land management and land-use changes

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Abstract

Land use and land management changes affect runoff and erosion dynamics. So, they are often directed to the reduction of natural hazards like floods. The effects of these changes are mostly i) very slow, like the ones after reafforestation of extensification agriculture, or ii) they are hardly detectable with conventional methods.

For this, sprinkling experiments have been applied under different land-use systems and at different scales to elucidate dominant processes of runoff generation, to quantify them and to relate to them the detachment and transport of solids. The experiments were performed i) with a small mobile rainfall simulator with high rainfall intensities (40 mm h⁻¹) and ii) as lope experiments simulating high rainfall amounts (120 mm in 3 days).

Results from plot scale rainfall simulator show a high variability of runoff generation. With this, it reflects management variations affecting soil surface and subsurface structures within hydrological homogeneous sites. When simulations are carried out at the slope scale, clear differences could be observed between different soil management types: deep loosened soils tend to transfer more water by interflow processes, retaining large amounts in the subsoil. Under forested land use runoff, as determined by plot scale rainfall simulations, shows a high variability, depending on forest type.

Experimental measurements are a suitable tool to reflect varying runoff generation conditions depending on management practices and land use. They deliver valuable information of process variability over space and time under varying environmental conditions.

Keywords: Land use changes, land management, runoff processes, rainfall experiments.

1 Introduction

Land use changes have been identified to affect runoff generation at a regional scale [1, 2], at the catchment scale [3, 4] and within hillslopes [5]. Most of these changes are the consequence of changed hydrological components like water consumption and interception, but also the result of variation in soil and soil surface structure following the land use and management changes. These changes may affect the generation of water resources at one side, but on the other side they might be able to reduce the magnitude and frequency of flood events. Land management is therefore a necessary tool for sustainable catchment management. But it is necessary to understand and to quantify the changes induced by different land uses and land management. Only with this, the quantification and evaluation of the effects and the prediction of the changes in water regime by modeling are possible.

For the generation of the detailed and spatial distributed knowledge of process dominance and process variability, great effort has been done during the last decades. The investigation included the analysis of long term catchment data, the monitoring of experimental catchments as well as the design of experimental setups for determination of dominant runoff processes [6]. They allow the typification of catchments or slope areas with homogeneous process dominance. Furthermore, there have been developed methods for determination of dominant runoff processes (DRP) e.g. with GIS-support [7] or from forest inventory data [8]. As these process definitions are the result of data abstraction and deduction from hydrological expert knowledge, they may be a reliable hint on the process dynamics of a catchment. But they might be not able to reflect changes related to management strategies, or to include factor combinations and their spatial and temporal variability that are determinant for runoff generation.

Sprinkling experiments have found a widespread use for explanation of runoff and erosion processes. Despite of the fact that their results are not always correlated with soil and soil surface properties [9], they help to understand and differentiate the runoff behavior of different sites. Aim of the present paper is to demonstrate the effectivity of rainfall experiments for quantification of the effects of land management one hand, and to show that the experimental methods may be used for understanding the spatial variability of runoff processes, even when they cannot be reflected with other measurements.

2 Material and Methods

2.1 Sites

The investigation were carried out within 2 of the areas investigated by the WaReLa-Project for the evaluation of diverse measures for water retention.

The Frankelbach catchment, located in the Pfälzer Bergland, is typical for the central european low ranges. The gentle slopes uphill are under intense agricultural use (23 % of the area), the steep slopes of the deeply incised river into the clay, silt and sandstones of the Rotliegendes are covered by forests (41 %). The narrow valley bottom is occupied by meadows (30 %) or is urbanized (5 %). The agricultural areas are characterized by fast surface runoff processes (Hortonian overland flow (HOF) and saturated overland flow (SOF1), forested areas show a dominance of subsurface flow (SSF).

The Zemmer site comprises mainly the gentle upslope areas of the southern Eifel heights. The agricultural fields are placed on loamy pleistocene deposits overlying the Muschelkalk. The cartography of DRP identified mainly SSF and SOF on shallow soils. Here we find 2 different management types, a conventional one and an optimized one including deep loosening.

2.2 Methods

Two kinds of sprinkling experiments were performed: one at the slope scale with an irrigated area of 30 m², and one at the plot scale with an area of 0,28 m² plot surface. Slope scale simulations were carried out on moderately sloped test areas of 5 x 10 m on agricultural land of the Zemmer site. A daily amount of 40 mm rainfall was applied during a period of three days in 4 daily intervals of 15 min duration, resulting in rainfall intensities of approx. 40 mm h⁻¹. Surface and subsurface water flow were collected and measured for the middle 3 x 10 m to exclude lateral losses of water [10]. The analysed land-use types have been mapped as SSF2 (moderate SSF). Plot scale experiments were performed with a small mobile rainfall simulator in autumn 2006 and spring 2007. During 30 min of experiment a rainfall intensity of approx. 30 mm h⁻¹ is applied. Superficial runoff is collected in 5 min intervals for quantification and further analysis. A detailed description of the methodology is found in [9]. 7 experiments were carried out on the Zemmer agricultural sites (4 on the conventional, 3 on the optimized field), another 5 on forested and greenland areas of the Frankelbach catchment, classified as prone to SSF with varying response velocity and intensity.

3 Results

Soil physical data revealed that the optimized soil management, this is deep loosening of compacted soils and an intermediate cultivation of field crops, reduces bulk density by an increase in pore volume. Especially amount of wide pores increases even in depth (Figure 1). The plot simulations reflect a similar behavior, but runoff generation on the conventionally managed field oscillates here between very low 0.004 and remarkable 0.29 (Table 1). The runoff start varies according with the runoff results. Noteworthy is not only the wide range of runoff coefficients, but also that we find only very low or high runoff amounts. Both simulations with high runoff contribution were carried out near the field borders. In this area, soil physical degradation is especially high due to the repeated turning of the tractors on this area. As expected, no runoff was observed on the field with optimized management.

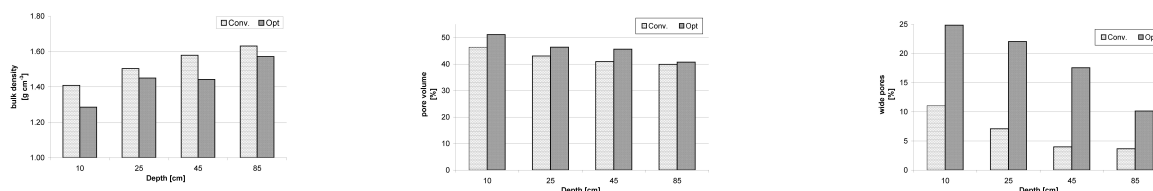


Figure 1. Selected soil physical data of the conventional (Conv.) and optimized (Opt.) agricultural land management. Displayed are bulk density (left), total pore volume (center) and wide pore amount (right)[11]

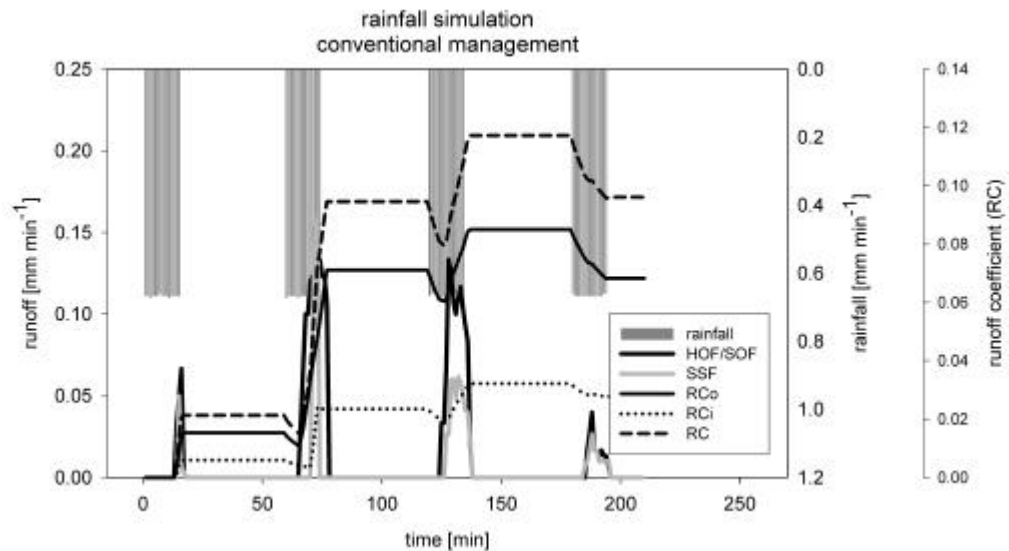


Figure 2. Results from slope scale rainfall simulation on conventional management. Displayed are the rainfall amount per minute, the runoff components per minute (HOF/SOF for surface, SSF a interflow). Also the runoff coefficients for the different components is shown

Table 1. Rainfall plot simulations on DRP SSF2 within the areas of Zemmer and Frankelbach. Indicated are selected plot characteristics as aspect (Asp.), slope, rock fragment cover (rfc), vegetation cover (vc), ther rainfall intensity (I), the runoff start (RS), the total runoff coefficient (RC) and the amount of suspended sediment eroded (E)

Site	Land Cover	Land Use	DRP	Asp. [°]	Slope [°]	rfc [%]	vc [%]	I [mm h ⁻¹]	RS [sec]	RC	E [g]
Zemmer	Agri-culture	conven-tional	SSF2		4,1	3	12	37,3	435	0,004	0,04
Zemmer	Agri-culture	conven-tional	SSF2	325	4,7	5	3	37,7	55	0,132	1,61
Zemmer	Agri-culture	conven-tional	SSF2	358	5,1	5	5	42,6	1297	0,002	0,14
Zemmer	Agri-culture	conven-tional	SSF2	7	4,9	5	3	39,0	126	0,295	3,18
Zemmer	Agri-culture	opti-mised	SSF2	0	4	3	10	40,3	n.a	0,000	0
Zemmer	Agri-culture	opti-mised	SSF2	330	2,45			39,4	n.a	0,000	0
Zemmer	Agri-culture	opti-mised	SSF2	340	7	3	12	40,3	n.a	0,000	0
Frankel-bach	Pasture	pasture	SSF2	320	20,1	0	100	39,2	112	0,080	0,12
Frankel-bach	Forest	conifer	SSF2	82	10	0	5	39,1	84	0,859	8,1
Frankel-bach	Forest	mixed	SSF2	330	21,4	0	10	40,2	28	0,005	0,02
Frankel-bach	Forest	deci-duous	SSF2	128	23,9	0	5	38,8	242	0,018	0,16
Frankel-bach	Pasture	pasture	SSF2	320	20,9	0	100	39,4	156	0,04	0,06

Rainfall experiments confirm the observations. Slope experiments lead to no runoff on the optimized field. The simulation on the conventional field lead during the first day (Figure 2) as well as during the consecutive days after every interval to runoff, superficial as well as sub-superficial, with changing intensities. The runoff coefficient reached a maximum of about 0.12 after the third rainfall interval, the surface runoff contributing about 0.08, the subsurface flow about 0.04. Summarizing the first day's results, the proportion of superficial runoff doubles the one of SSF. The plot simulations on forest sites are extremely variable as well. An xtremely high runoff coefficient, and linked to it an also high erosion rate, could be observed on the conifer site. The forests where there is a considerable

proportion of deciduous species show low superficial runoff coefficients. Very similar, and also low, are the runoff coefficients on meadows within the Frankelbach catchment.

4 Conclusions

As maps of dominant runoff processes are a useful tool for catchment evaluation and understanding, the results of rainfall experiments show that process variability within the areas defined may be very high. Especially areas where soil management introduces high variations in soil physical and soil surface properties, like the turn-around areas on agricultural land, show a substantial increase of the superficial runoff. Variability of soil surface conditions on forest sites may be another factor leading to high process variability. Here, the quality of litter composition or of soil organic matter, combined with the effects of harvesting machines induces a partially extreme runoff generation. This is especially evident when regarding moderate to high rainfall intensities and rainfall volumes. Therefore, experimental investigations are a suitable tool for better understanding runoff processes.

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Sustainable management of riparian woodlands: Environmental attributes and institutional perspectives

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Abstract

In riparian zones water bodies and woodlands continually interact to produce an optimum balance of the ecosystems. Trees, shrubs, and herbaceous vegetation located in upslope from the body of water create riparian woodlands. Presently the riparian woodlands are often disappeared, exposing the riverbanks to erosion, and reducing the biodiversity and productivity of the streams mainly due to the mismanagement and misuse by the people. Hence, the sustainable management of riparian woodlands have become a focal point in conservation of riparian ecosystems. The objective of the paper is to ascertain the environmental attributes of the riparian woodlands and examine the institutional perspectives required for its sustainable management. The paper reviews the current state of knowledge and creates an understanding of the riparian woodlands by discussing the findings presented in available literature.

The main environmental attributes of the riparian woodlands are recognized as the preservation of ecosystems; improvement of biodiversity; enrichment of soil fertility; supply and purification of water; mitigation of hazards; and enhancement of visual quality. The preservation of ecosystems is mainly focused on food chain, aquatic population and Wildlife of the riparian ecosystem. The institutional perspective of sustainable riparian woodland is examined in terms of institutional setting; critical area protection and environmental regulations; and policy issues. The institutional setting is further discussed as social organizations, forest services, research and development, education and outreach programs related to riparian woodland management. Moreover, stream buffer ordinance, livelihood orientation, forest stewardship, conservation partnerships, incentives and compensation are explained as main policy issues vitally importance for sustainable management of riparian woodlands.

Key words: Ecosystem, Biodiversity, Erosion, Institutions, Regulations, Policy

1 Introduction

Streamside trees and shrubs create riparian woodlands. Riparian woodlands cover the area from the stream bank in the floodplain including an area of trees, shrubs, and herbaceous vegetation located upslope from the body of water. The dimensions of the riparian woodland area remain largely unspecified and have been drawn from subjective assessments rather than experimental trials. However, the influence of the riparian forest on the stream depends upon the dimensions, species composition, structure and management of the vegetation (Broadmeadow and Nisbet, 2002). Numerous economic, social, spiritual, recreational, and environmental benefits would be associated with riparian woodlands. These benefits are not limited only to the individuals who install and manage the woodland, but to the larger public community. Hence, Riparian woodlands are considered as an important attribute among the most productive natural ecosystems.

During the early days trees were planted close to streams or grown up to cast shade over the water and riverbanks. Presently the herbaceous riparian vegetation often disappeared, exposing the riverbanks to erosion, and reducing the biodiversity and productivity of the stream mainly due to the mismanagement and misuse by the people. Riparian woodlands have become a focal point as an integral part of the forest ecosystems which is normally established concurrently with other practices as part of a conservation management system. Healthy riparian woodland would be considered as a starting point of sound watershed management. The riparian woodland management has to be explored through an ecosystem-based approach which varies in the temporal and spatial scale (Bernard and Terry, 2001). The sustainable management of riparian woodland buffer areas is therefore required by forest and water protection agencies when they manage the forest resources. The multiple perspectives have recognized the riparian woodland as vital to environmental conservation and an essential element for social and economic security for the people. Hence, this paper attempts to ascertain the main environmental attributes of riparian woodlands; and to discuss the sound institution support vital to develop the strategies for sustainable riparian woodland management.

2 Methodology

The paper reviews the current state of knowledge presented in available literature on major environmental attributes of the riparian woodlands and type and role of institutional support extended to the management of riparian woodlands. Based on the concept of sustainable management of riparian woodlands comprehensive key terms were developed for searching the relevant literature. Further, the review of the literature examine and create an understanding of the vital importance of the environmental attributes of the riparian woodlands and the requirement of sound institution support for the implementation of the sustainable management of riparian woodlands.

3 Environmental attributes

3.1 Preservation of Ecosystem

3.1.1 Food chain

Riparian vegetation is an essential source of food for fish and terrestrial invertebrates which form the food chain. The vegetation provides food for wildlife which is a critical part of complex food chains and the natural ecosystem. Further, the vegetation of riparian woodland provides not only the food but also a favourable environment for the high productivity of different terrestrial food resources.

3.1.2 Aquatic population

The amount of solar radiation reaching the water's surface is regulated by physical characteristics of the riparian woodlands which effectively control the water temperature. The moderate shade protects behaviour and life cycle of cold-blooded invertebrates and fish against potentially damaging water temperature. Further, the shade keeps the water cooler and moderates temperature fluctuation, increasing the water's ability to hold oxygen, and support aquatic habitats. On the other hand too much shade limits fish productivity while higher stream temperatures in cleared streams accelerate fish egg development and growth rate, as well as increase invertebrate productivity (O'Grady, 1993). Vegetation of the riparian woodlands contributes material to the river system such as leaves and woody debris, which provide food and physical habitat in the stream and rivers. Native tree species provide a high quality of leaf litter to the benefit of the aquatic habitats. The stream flow slows around fallen trees and branches in the stream or riverbed, creating favourable areas for fish population. There is a increasing possibility of flooding when they are washed away and become entangled in structures at times of flood.

3.1.3 Wildlife

Within the riparian woodlands birds, mammals, and other animals find the food, cover, water, and nesting sites they need as well as corridors and pathways for movement between areas. Vegetation provides sustenance and habitat for wildlife and birds with the riparian ecosystem. Tree and shrub canopies of the riparian vegetation moderate microclimate and leaf litter and coarse woody debris enhances the quality of wildlife habitat. On the other hand, the vegetation in riparian woodlands preserve habitat for wildlife, prevent wildlife emigration to new areas, reduce vulnerability to human conflicts and increase wildlife populations.

3.2 Improvement of Biodiversity

Riparian woodlands improve the biological diversity of surrounding areas. The vegetation of riparian woodlands maintains riparian health, creating great biodiversity. The riparian woodland is an important component within a forest and will typically form a hotspot of biodiversity providing the conditions required by many invertebrate species, nectar and foraging areas, and roost and nest sites for birds (Ferris and Carter, 2000). Tree species create the greatest diversity, abundance of terrestrial invertebrates and promotion of aquatic habitats compared to other ecosystems (Broadmeadow and Nisbet 2002). Dead wood such as root plates, logs and trees forms an important habitat for many invertebrates, bryophytes, lichens and fungi, particularly in the shaded and moist conditions within riparian woodland. The native vegetations within riparian woodlands represent an important opportunity to increase the biodiversity. Riparian woodland with native vegetation represents the least disturbed natural habitats and refuge for many species has conservation value.

3.3 Enrichment of Soil Fertility

The riparian woodland traps sediments and nutrients from surface runoff and shallow groundwater, and reduces nutrient losses to streams in uplands. The riparian vegetation, consisting of different-aged woodland communities, has great nutrient retention capacity (Haycock et al. 1993). Leaf litter, root decay and root exudates available in riparian woodland soils are become easily mineralisable sources of organic carbon. However, the microbes in organic forest soils may convert nitrate into nitrogen gas through denitrification reducing the soil fertility in the riparian woodlands.

3.4 Supply and Purification of Water:

The buffer's capacity to hold large amounts of water and allows percolation to deeper water aquifers, replenishing groundwater supplies. The runoff water moves sediments, and transfer nutrients and pollution from land upstream into streams and rivers. The riparian woodlands often act as sinks, filtering excess nutrients, pollution and sediments that are transferred from uplands to the stream flows (Gregory et. al, 1991). Riparian woodland can form an important buffer or nutrient sink for agricultural run-off intercepting pollutants draining from adjacent agricultural land. Riparian woodlands reduce the risk of pesticide contamination of stream waters in agricultural areas by buffering the pesticide residues. The riparian soils and vegetation retain pesticides in waters draining from the adjacent crop land. The woodland protects the chemical quality of stream water retaining nutrients, pesticides and other agricultural pollutants also available in the surface runoff and ground water flowing into streams and rivers (Phillips, 1989). Moreover, riparian woodlands reduce the draining of nutrient to streams from uplands and thus prevent nutrient enrichment and algal problems which create eutrophication in water bodies. The riparian woodland in lowland regions remove nitrate from drainage water flowing through the riparian zone and reduces the risk of any short-term acidification effect (Phillips, 1989). The main cause of the accelerated nitrate leaching is the disruption of the nitrogen cycle in the absence of plant uptake on bare sites. Clear felling in riparian woodlands can result in a marked release of nitrate with a risk of increasing stream water acidity and aluminium concentrations in acid sensitive areas (Neal et al. 1998).

3.5 Mitigation of Hazards

3.5.1 Sediment removal

As a part of the natural structure of low-lying grounds, riparian woodland play an important process in preventing flood events by retaining sediment in the runoff water draining to the rivers and streams. Filtering sediments and eroded materials moving into the streams and rivers prevent flooding and other devastating impacts on the terrestrial environment, and aquatic environment in the riparian area (Binford and Buchenau, 1993). The riparian vegetation acts as an effective filter and a barrier removing sediments in drainage waters collected from soil disturbance caused by silvicultural operations on the adjacent agricultural land. Woodland can increase sedimentation by slowing down water flows. Woodland soils have the ability to receive and absorb surface run-off, and woody debris and surface roots can act as sediment traps. Ground vegetation also traps and fixes sediment deposits. Riparian woodlands provide a more effective barrier to sediment transport when a vigorous herbaceous ground flora with heavy shading species interspersed with lighter foliated species (Forestry Commission, 2000).

3.5.2 Stabilization of stream banks and erosion control

Riparian woodland can play an important role in stabilising river banks and controlling soil erosion. Riparian vegetation helps to impede surface runoff by encouraging sheet rather than channelled flow increasing the rate of infiltration. Plant stems slow water velocity and root systems keep the soil porous, so excess water is absorbed into the ground and flooding potential is reduced. The shade of the vegetation avoids bare stream banks preventing erosion, and widening shallow streams. A vigorous under-storey and ground cover also is the most effective cover for minimising bank erosion (Phillips, 1989).

The framework of tree roots of the vegetation improves the soil structure and binds soil, thereby stabilising stream banks (Castelle et al. 1994). Trees with deeper rooting systems provide much stability to high banks and steep slopes, and anchor trees better where there is repeated flooding (Weber, 1999). The age structure of woodland contributes coarse woody debris to reduce the rate of water flow and the stability of stream banks. Even herbaceous and aquatic vegetation also protect stream banks from erosion.

3.6 Enhancement of Visual Quality

The boundary of the riparian zone enhances the visual quality of the landscape and makes the environment aesthetically pleasing. Similar to the other woodlands the physical characteristics of the riparian woodlands such as the height, density, width and slope have great impacts on the visual quality. Some aesthetic theories consider that visual quality depends upon forest sustainability (Gobster, 1999). All aesthetic concerns emphasize broad and long-term future benefits over tangible current gratification. Varying width and irregular vegetation reflect the visual diversity within the riparian landscape (Maitland et al. 1990). The people prefer natural landscapes over man-modified landscapes (Kaplan et al., 1998). Therefore, the riparian vegetation has an important role in controlling the unity and naturalness of the woodland landscape. The riparian woodlands often replicated native riparian woodland, with an open canopy of mixed species of varied age class and structure. Significant proportion of dead or dying trees and sizeable patches of open ground provide sunlight adequate to sustain a cover of herbaceous ground flora and marginal vegetation (Broadmeadow and Nisbet, 2002). Native riparian woodland of mixed species reflects the

changing seasons with a variety of hues, colours and textures along the rivers and streams. Local community may manage individual riparian woodlands as landscape units on all issues including aesthetic and spiritual values.

4 Institutional perspective

4.1 Institutional Setting

4.1.1 Social organizations

Getting people involved in a process of a community based initiative for riparian woodland restoration and sustainable management is of vital importance. A supportive, educated and active community will be the stronger support for future scenarios (Lawrence, 2002). Leadership should take place through the involvement of communities who have a direct stake in the current state and future of the woodland management. Strong collaboration has to be built with local organizations, regarding conservation and restoration of woodlands. The agreements bring the opportunities for dialogue, vision and continuity with multidisciplinary background. Priority actions, contacts and collaboration opportunities may enlighten to proceed with community participation for the identification of improvement opportunities for sustainable ecosystem conditions.

4.1.2 Forest services

With the recognition of the importance of the management of riparian woodlands there is an increased demand on forest service to achieve the goals to increase multi-purpose riparian buffer. Capacity development of forest services is required to provide technical assistance to community groups, local governments, and private forest landowners. The field staff of the forest service needs rebuilding to meet its increased duties to assist the public, community groups and individual land owners in managing the vital natural resources in riparian woodlands.

4.1.3 Research and development

The effectiveness of restoration of riparian woodlands for improving surface or ground water quality have had to be assessed to improve fish habitat, stabilize stream banks, remove or reduce nutrients and protect human health. Changes in riparian plant species composition alters ecosystem dynamics, reducing risk of disturbance processes such as forest fire, wind damages, flood etc. Hence, information is needed on riparian disturbance processes and vegetation patterns of various riparian woodland types and geophysical settings. For the research to mitigate numerous disturbance processes of riparian woodlands may requires geographic information systems databases of topography, stand inventories, treatment history, disturbance history, and ecological information of the vulnerable areas (Kennedy and Finch, 2003). Research supplies guidance for restoration efforts in riparian woodlands suitable for maintaining vegetation and animal species appropriate to the disturbance frequency intervals, and for averting damages.

4.1.4 Education and outreach program

The principle on community commitment through getting people educated, seeks for the communities to assume responsibility and change their behaviours is the leading policy of the outreach program for sustainable management of riparian woodlands. Environmental education is critical in changing public perception about riparian woodlands. Educating the public about their importance and build awareness of the value is the key to sustainable riparian woodland management. Therefore, education and incentives are considered as the primary tools to achieve the goals of woodland conservation.

Designing of educational tools to communicate to management practices on the health of riparian woodlands needs long-term knowledge of different aspects of the riparian resources. Availability of data, use of personal contact and in-depth understanding of the site issues may better facilitate user education. Technical assistance and extension programs for farmers and ranchers provide guidance how to adjust production practices and land management decisions to optimize net farm income while minimizing the impacts of commodity production on riparian woodlands.

4.2 Critical Area Protection and Environmental Regulations

Legal condition should support the development of special guidelines for utilization of products and services in the critical area, especially in relation to environmentally sensitive riparian woodlands. The promotion of these guidelines of restrictions is required also for the use on private lands in the critical area even on a voluntary basis. However, despite the legislative instruments to protect the riparian woodlands by the local people, they continued to find access to forests making it difficult to fully administer the laws (Pathak, 1994).

Every management and renovation plan of woodlands in riparian ecosystem should consider the conservation and wise use of the wetlands based on Conservation Acts. The regulations mean not only habitat restoration, but

public involvement in the protection and wise use of woodlands and associated habitats. Environmental law enforcement is easy to implement when sharing common problems, and making local people aware of what kind of support is available, who and where to contact.

4.3 Policy Issues

4.3.1 Stream buffer ordinance

An ordinance should be developed and adopted setting up riparian corridor conservation woodlands consist of designated streams, intermittent watercourses, lakes and wetlands (Browne, 1997). The riparian woodlands will remove or buffer pollutants, provide wildlife habitat, control water temperature, and weaken flood waters. Recreation within the riparian woodlands should be balanced with the impact it may have upon existing features or to the adjacent landowners. Even agricultural activities would be permitted only after conforming adequate soil conservation practices, which should include erosion, nutrient, fertilizer, herbicide and pesticide control. However, the vegetation should generally remain in its natural state with periodic maintenance such as minor landscaping to minimize concentrated flow and removal of exotic plant species.

4.3.2 Livelihood orientation

In spite of many competing demands and pressures on forests, forest dwellers in developing countries continue to depend on forests for their livelihood. State policies driven by conservation demands may be in direct conflict with the customary use of forests by forest populations. Therefore, policy issues on riparian woodlands should be given enough publicity, and formulated considering adequacy to rural social conditions, natural resources availability, and economic activities present in the area. The new conditions should be negotiated, and agreements need to be updated in order to restore the woodlands and conserve habitats, and satisfy local community needs in the riparian areas.

4.3.3 Forest stewardship

Public policies that encourage sound riparian woodland management require stewardship plans with the use of public funds. Maintaining existing and creating new riparian woodlands may facilitate conserving game and non-game wildlife, water quality, aesthetics, and recreational opportunities. Further, forest stewardship policies on private land discourage forest fragmentation. However, the woodlands have to be managed under a professionally prepared stewardship plan for the productive use. The stewardship may lead to renewing utilization and marketing program for products of the riparian woodlands.

4.3.4 Conservation partnerships

Conservation Partnership combines riparian woodland conservation with state and local governments, as well as private interest groups, to fund specific conservation activities at a larger scale. These partnership arrangements are important to improve water quality and habitats encouraging farmers and landowners to plant grass filter strips, establish forest buffers, or adopt other conservation practices along environmentally sensitive streams and rivers.

4.3.5 Incentives

The government may support the community and land owners with cost-sharing benefits from riparian buffer and other forest plantings in riparian woodlands. Farmland owners who plant forested riparian buffers can receive cost-sharing and the standard rental price for the land (Stevens et al., 2002). In addition to the technical assistance the land owners may be supported for reforestation and various forest management activities such as wildlife habitat enhancement, protection of soil and water quality etc., in the riparian woodland area. Property rights arrangements create incentives regarding the management of riparian woodlands. Resource owners generally are better stewards than renters because ownership creates an economic interest in the long-run productivity of a resource (LaFrance and Watts, 1995). Owners of private woodlands are much more likely to make investments that improve long-run land productivity than who lease riparian woodlands. However, it is useful to view resource ownership in terms of separate interests because each interest such as growing crops, grazing livestock, logging, mining, recreation, etc., conveys the right to use the resource in riparian woodlands in a specific way

4.3.6 Compensation

Streamside policy directives and streamside protection regulations require the protection and development of free areas where riparian areas are intact or have a high potential for restoration. These regulations on forest practices in riparian woodlands create greater burden on private landowners to provide ecological services from their timberlands. They may call upon the government to compensate them if the regulation results in restrictions on the use of their land. Their provision of ecological and public services can be promoted with contracts compensating the equivalent or greater private ownership values. The farmers and ranchers have to be paid for economic losses

they incur as a direct result of riparian woodlands enhancement or protection programs. However, the primary responsibility of implementing compensation measures lies with the continuous monitoring of its progress.

5 Conclusions and policy implications

The sustainable management of riparian woodlands requires knowledge and understanding about the environmental harmony and institutional perspectives. The strategy of riparian woodland management has to be focused towards more sustainable forestry concerning main environmental attributes through sound institutional arrangements. A new vision for sustainable management of riparian woodlands is required to identify the needs of scientific research, sharing of technologies, educational opportunities and incentives for active participation of the stakeholder.

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Identification and model based assessment of the potential water retention caused by changes in land-use

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Abstract

Since the recent flood events in central Europe forest conversion and afforestation are discussed as efficient measures for preventive flood protection. To quantify the effect of forest conversion and afforestation on flood runoff from catchments reliable model calculations are essential. The paper shows a practical application as an example for a model-based assessment of potential water retention caused by land-use changes.

1 Introduction

The European Flood-Directive points out the need of flood risk maps. On the basis of such maps flood risk management plans may focus on prevention, protection, and preparedness. This work has to be done river-basin-oriented and directly linked to the EU-Water-Framework-Directive. These considerations are centered in the detection of synergy effects between the good ecological status (e.g. minimize technical impacts) of the water bodies and flood protection. The revitalization and increase of natural water retention potentials – notably in headwater catchments – is a major component of sustainable flood prevention strategies. It is logical that changes in land-use (e.g. settlements including road-construction, deforestation, distinct practices in arable and grassland management) contribute to an increased frequency and severity of flood generation. For forest land-use, it has been stated that afforestation and the promotion of close-to-nature silviculture will considerably increase the water retention in landscapes. However, there is a controversial debate on the general applicability of such non-structural flood risk management measures with respect to event size and scale-based physical conditions. To quantify the impact of land-use changes on the behaviour of flood generation in river basins well-founded model calculations are needed. Furthermore, such information is needed for land-use planning and creation of a legal framework (e.g. novel §100 Water Management Law in Saxony (=SächsWG) and/or implementation of specific aspects of the EU-Water-Framework-Directive). Our research is undertaken within the framework of the running projects “Analysis, Assessment, and Implementation of Measures for Preventive Flood Protection in the Jeseniky Mountains/Czech Republic” (financed by the DBU) and „FLOODsite - Integrated Flood Risk Analysis and Management Methodologies“ (Integrated Project 6th EU -FP).

2 Challenge

As a result of the disastrous floods during recent years, especially the Elbe flood in 2002, the novel water law of Saxony (SächsWG) has now introduced regulations concerning flood originating areas (“Hochwasserentstehungsgebiete”). The localisation of such areas is nearly done by the flood protection authority (Sächsische Landeshochwasserzentrale). The law regulates for the flood originating areas to conserve and improve their natural water retention. The soils should be unsealed or afforested if it is possible. In case of an unavoidable loss or reduction of the natural water retention in these areas a suitable compensation is required (e.g. afforestation). In order to assess the effectiveness of potential land-use changes at a given location the following two questions are essential [9]:

- Do the physical settings (notably soils and relief) allow an improved water retention if land-use is changed? ⇒ runoff generation
- To what extent does runoff from this location contribute to the flood hydrograph of the total catchment? ⇒ runoff concentration

Therefore, suitable methods and strategies are required. There are different types of models which are used for the identification of the land-use impact on the flood behaviour of catchments. To assess all spatial site information from maps or field investigations to estimate the general runoff behaviour expert-systems were developed like WBS-FLAB [6] or PBS (“Scherrer-key”: [6]; [14]). These tools provide (without any complex rainfall-runoff

calculations) a rough overview about catchments with respect to their runoff generation behaviour. Based on this information areas in which fast runoff components are dominant can be identified. However, if individual rainfall events have to be assessed with respect to flood dynamics, e.g. to estimate the impact of the pre-event soil moisture, plot model calculations are indispensable. For this purpose, we use the plot model BROOK90 [3]. To scale up the results from the plot model and to consider the runoff concentration components spatial distributed rainfall-runoff models are applied. For this purpose we apply a set of different models, e.g. AKWA-M® [8]. The main goal of the ongoing project is to assess land-use options especially afforestation with respect to water retention during flood events. In the following we present an example.

3 Calculation Example (Schwarze Pockau River)

3.1 AKWA-M®

The rainfall-runoff model AKWA-M® is based on the water budget model AKWA-M [4], [7]. The model was advanced by Dr. Dittrich & Partner Hydro-Consult GmbH [2]. This water balance and rainfall-runoff model simulates the water balance and flood runoff in watersheds and transforms the different processes from a site to a larger area. It contains physically based components as well as a conceptual background. The application of AKWA-M® are manifold tasks in practice, research, and education. With the help of this model the following processes can be simulated and quantified: the available water for changing land use and climate change; water balances for management and controlling (dams, water stores, groundwater recovery); influences to the water balance done by river revitalization, hydromelioration, groundwater use, urbanization, or change in land-use; anthropogenic influences to protected natural area or landscape; water balance of specified areas (mires, waste disposals); changes of groundwater recharge in urban areas with artificial infiltration of precipitation; prognostic determination of the system status for flood models; flood runoffs from historical precipitation and statistical design storms for different dimensioning tasks; calculation of storage or dimensioning for dams, flood detention reservoirs. The structure of the model-catchment results from subareas (unit areas or hydrotops), combined to partial and balance regions (Fig. 1). In the preprocessing the subareas are provided by uniting the relevant geodata with GIS applications (e.g. ARCVIEW). For simulation of vertical and horizontal processes different calculation modules are available in the program.

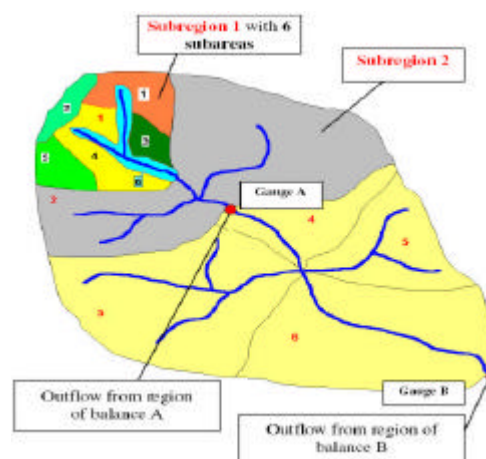


Figure 1. Structure of a model-catchment AKWA-M®.

Subareas	characterized by geodata as land-use, elevation, slope, orientation, soil type, type of groundwater and others. simulated processes: adoption of climate data, interception, transpiration, evaporation, infiltration, soil water balance, surface and hypodermic runoff, depth infiltration.
Subregions	characterized by lithofacies, stream network, and the sum of all subareas. simulated processes: classification of climate data, runoff concentration, wave propagation.
Regions of balance	characterized by the superposition of the sub-region results.

The advantage of AKWA-M® is that it allows to calculate the pre-event situation with the water budget model (time step 1d) and than to increase the time discretization for the flood event using actual conditions (storage, water contents etc.) as initial state. All model calculations are limited by the availability of the required data. The following data are needed for the AKWA-M® calculation.

Water balance	Daily or monthly mean climate data (precipitation, air temperature, air humidity, sunshine duration or global radiation, wind speed) Observed data optional (flow rate, soil moisture, groundwater level).
Flood	Precipitation high resolved (1 h to 5 min); to calculate HQ(T) statistical sum of precipitation P(T) Optional observed data



Figure 2. Catchment of the Schwarze Pockau River with gauging station Zöblitz (Mulde Catchment, Ore Mountains Elbe Catchment)

	(flow rate).
Geodata	Land-use, geo- and morphological stream data, soil, geology (preparation with geographic information systems (GIS) preferred).

All these data has been available for the catchment of the Schwarze Pockau. The AKWA-M[®] model was calibrated for this catchment for the “FLOODsite” project (pilot study “Elbe river” - <http://www.floodsite.net/>). The geodata from the Czech part (~20 % of the total catchment area) are not in the same resolution as the data for the catchment area in Germany. Thus, we decided to use the more detailed soil and land-use maps (BKKonz 1:25,000 and CIR 1:10,000) for the German part and the less detailed maps (BÜK 200 1:200,000 and Corine 1:100,000) for the Czech part. It is logical that this approach produces inhomogenities but the advantages of the high detailed information for the German part preponderate.

3.2 Changed land-use

Two different land-use parameterizations have been modelled in order to show the potential impact of land-use on the hydrological response of local subareas and the total catchment, respectively. Especially the soil water budget is considered in this investigation (change of storage, conductivity, preferential flow etc.). The catchment of the river Schwarze Pockau as a subcatchment of the Mulde river basin was chosen to compute land-use effects (Fig. 2). This catchment located in the Ore Mountains is a ‘flood originating area’ (SächsWG) and belongs to catchment of the Elbe river, where the most serious flood damages ever in Europe occurred in August 2002. The choice of the two parameterizations (Fig. 3) should represent afforestation to demonstrate the maximum forest caused change in water retention like the novel water law of Saxony advises. Forest instead of grassland or farmland is simulated by the following parameter changes:

- an increase of root depth, that means a larger part of the soil storage is emptied by transpiration;
- an additional organic layer on top of the soil;
- a higher amount of organic matter in the top layers of the soil;
- more macro-pores represented by a higher macro-pore conductivity.

3.3 Results

Two events were calculated in order to estimate the effects of land-use changes in their spatial distribution. A more frequent event (~60 mm d1) and the highly infrequent event from August 2002 (~230 mm within 2d). Fig. 4 shows for these two events the change in flood effective rainfall. The flood effective rainfall is the portion of the storm rainfall which is neither retained on the land surface nor which infiltrates into the soil – it is that part of the rainfall which is

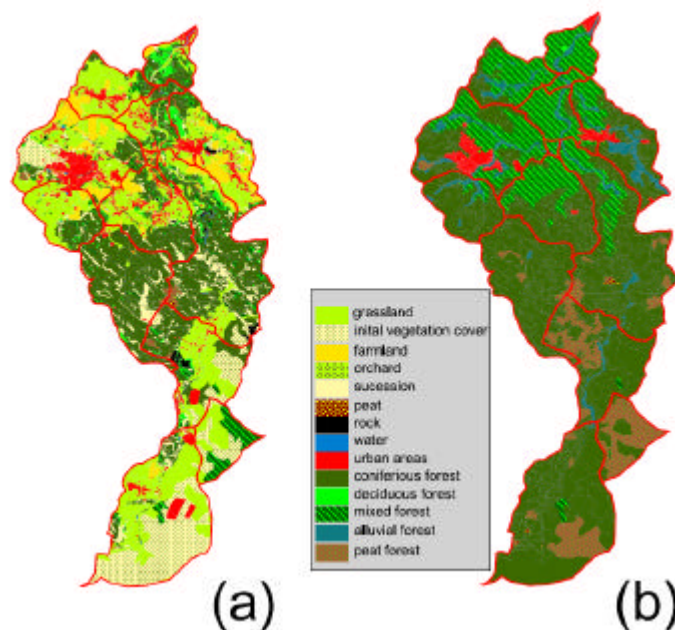


Figure 3. Land-use parameterizations:

- (a) present land use given by CIR-data (LfUG 2006): 41 % forest; 47 % grassland; 7 % farm land – calibration
 (b) potential natural vegetation (PNV) except urban areas given by PNV-data (Schmidt et al. 2003): 97 % forest predominant oak-beech mixed forest and spruce forest

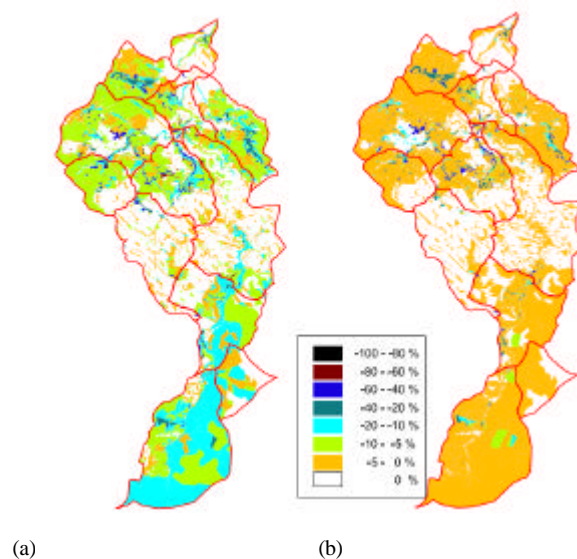


Figure 4. Difference of flood effective rainfall [%] scenario (b) – (a) for two rainfall events

transformed into fast runoff components. It is obvious that there is nearly no change for the very seldom flood event because the storage capacity is limited. It appears that the role of land-use during such heavy rain events is negligible. However, for the more frequent event the afforested areas show a decrease in flood effective rainfall from 5 % up to 20 %. So it is evident that the impact of the land-use on flood formation decreases with the increase of rainfall intensity. Fig. 5 shows the corresponding runoff hydrographs for both events. The peak discharge for the very infrequent event from August 2002 is nearly unchanged. For the more frequent event the decrease of the peak flow is ~20 %.

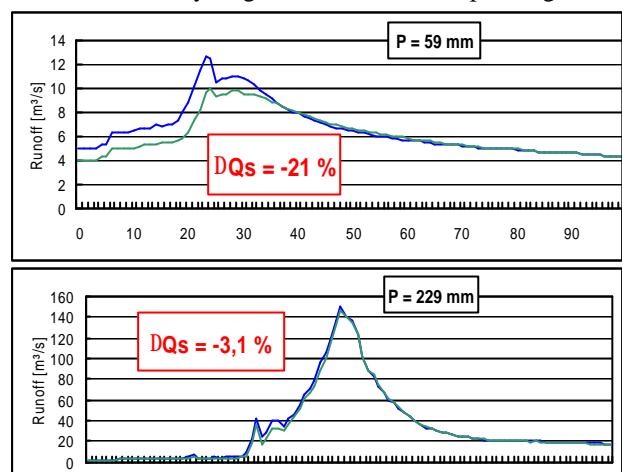


Figure 5. Changed peak flow (Qs) and runoff hydro- Graph due to changed land-use (blue – CIR(a), green – PNV(b)) for different rainfall situations.

4 Conclusions

Spatial distributed hydrological models like AKWA-M[®] are efficient tools to predict effects on water budget and floods due to changes in land-use or climate. Especially the pre-event soil moisture conditions can be taken into account with the approach as outlined here. The results are water budget and flood components for both single hydrotops and for the catchment in total. The produced simulation indicates that a projected canopy change might cause a runoff reduction which can be explained as follows:

- A higher interception leads to a decreased throughfall (net precipitation). This causes a lower soil moisture and thereby a greater storage.
- The larger root penetration and higher fine root densities in the subsoil in forested sites cause a larger depletion of the soil moisture during the growing season. Therewith a larger storage capacity is created. Thus, also intense rainfall events can be buffered more effectively dependent on the soil depth and the storage ability (large available field capacity). This increased storage capacity may also be available during the winter months, depending on the atmospheric conditions.
- The high infiltration capacity of forest soils is another important factor in forested areas. Therefore less surface runoff is generated in comparison with grassland or agricultural crop land. Not only erosion might be reduced or avoided also the rainfall is disposed through macropores in parts of the soil where it can be stored.
- With increased infiltration the critical point of runoff creation shifts from the soil surface in deeper parts of the soil where infiltration happens very limited (interface to bedrock, C-horizon). If soil moisture is high, more hypodermic runoff might be generated.
- The potential of flood control by land-use management measures is highly dependant on the site-specific soil and relief conditions and the rainfall event characteristics.
- Reliable model calculations are essential for successful implementation of measures. However, there is a considerable lack of data for model parameterisation with respect to short-term vegetation changes and long-term effects on soil properties.

5 Outlook

The poster briefly reviews a present calculation example from our ongoing project work. It is quite clear that there are many uncertainties in the models and their parameterisation. A viable approach to point out the weaknesses of single model approaches is the use of different models and the combination of the results. Our focus is not the best fit of a runoff hydrograph on a measured discharge. We try to model the process as plausible as possible on the plot and transfer this knowledge to the next scale of smaller landscapes.

Accordingly, the future challenges are:

- to develop model tools to describe changes in relevant soil properties following changes in land-use;
- to implement new or existing approaches for hydrophobicity, surface roughness, and upsilting;

- to assess the impact of measures considering the improvement of natural water retention to areas downstream.

The main goal is to develop a rule type to find an optimized land-use in flood originating areas by qualifying and quantifying the potential effects of such land-use changes on water retention and related pattern of runoff formation, notably with respect to mid- and long-term changes in the soils.

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Regional climate change and competitiveness of tree species

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Introduction

As a matter of fact the current natural species' composition to be found at a particular habitat is the result of inter- and intra-specific competition [1],[2]. In view of climate change, it has to be asked which tree species will be the most competitive during that change and which tree species or ecotype should be prospectively considered for reforestation. Climate changes implicate humid winters, varying distribution of precipitation in summer on the one hand resulting in stronger periods of aridity during summer, on the other hand attending with heavy rainfalls (thunderstorms) and an increasing frequency of storms. It is expected, that tree species or ecotypes of them will change in their ability to compete, because existing trees are adapted to previous climate conditions. So it could be expected, that the competition between species will alter. The results of competition under altering climate conditions decide which tree species will prevail in the future and which species composition will be reached. The main altering ecological factors will be the water supply and the temperature as well as indirectly reacting factors like insect or fungi pests. Varying water supply and temperature will alter the gas exchange of plants. Terrestrial plants have to pay their carbon dioxide uptake by diffusion through stomata with loss of water (transpiration) [2], [3]. The influence of these changes and the species' competitive ability could be measured in the form of Water-Use-Efficiency (quotient of transpiration and production) of species or ecotypes [2]. The strongest competitor will be that species or ecotype producing the highest amount of biomass at lowest water consumption.

1 Investigation area

On this issue a research program was started in Hunsrück, Rhineland-Palatinate in spring 2007. The investigation area (450 m altitude) is located in Holzbach headwaters between Zerf and Weißkirchen in Schwarzwälder Hunsrück.

1.1 Geology and soils

Substratum is Pleistocenian loam cover above Devonian quartzite weathering/shale. Predominating soil type at the upper slope area is brown soil affected by solifluction. Down along the slope soil development is increasingly affected by hydromorphology. Sub-terrestrial soils with peat cover of 40-60 cm thickness (degraded by drainage and spruce forestry) as well as backwater-influenced soils (Pseudogley, Stagnogley) are to be found. In many places of Holzbach headwaters terrestrial and hydromorphologic soil profiles are frequently alternating at a small scale, depending on soil depth.

1.2 Vegetation and utilization

The whole area of Holzbach headwaters has formerly (possibly 100 to 200 years ago) been drained, in order to cultivate spruce. Today the vegetation is dominated by spruce at high forest stage. Forestry ambition is to renature the once wet sites during the coming decades. Moist forest conditions as well as ecologically appropriate target species (related to altering climate conditions) and peat formation should be reestablished. Mixed forest stands and extensive forestry are aspired.

Focussing on WaReLa aims the renaturation of peat contributes to lagging the runoff by increasing the retention body. As a result the drainage channels all are refilled since spring 2007. Consequently parts of the area began to get superficially wet.

Within the spruce monocultures clearings, caused by storm event Wiebke in 1990, are to be found. Soon after the crack some of these clearings were reforested with durmast oak (*Quercus petraea*) as target species and black alder (*Alnus glutinosa*) as shelter canopy. These areas were fenced in order to prevent vegetation from browsing damage by game animals. Within the fenced areas spruce (*Picea abies*) and downy birch (*Betula pubescens*) joined spontaneously.

Four of these fenced areas, containing 15-20 years old mixed stands, were selected as study sites. They show similar conditions with regard to tree species composition, age of tree individuals and ecological conditions like stagnant moisture, most likely combined with changes in soil drought during summer months.

2 Methods

In order to assess the competitive capacity of different tree species in certain states of competition various measures are necessary. One, amongst other indexes, going to be used is the Water-Use-Efficiency (WUE) [2], i. e. the ratio between water-use and biomass-production (CO_2 assimilation) above ground. Water is not the limiting factor and not the resource individuals compete on, but root (nutrients) and canopy sphere (light). Nevertheless WUE will give hints on the species' ability to compete with regard to distinct fluctuations in soil water level that are to be observed.

2.1 Measurement of water-use

Water-use will be captured by gauges measuring xylem sap-flow of single individuals after the Stem-Heat-Balance (SHB) method [4], [5]. The Dynagage system used is working on the following principle (fig. 1, [6]):

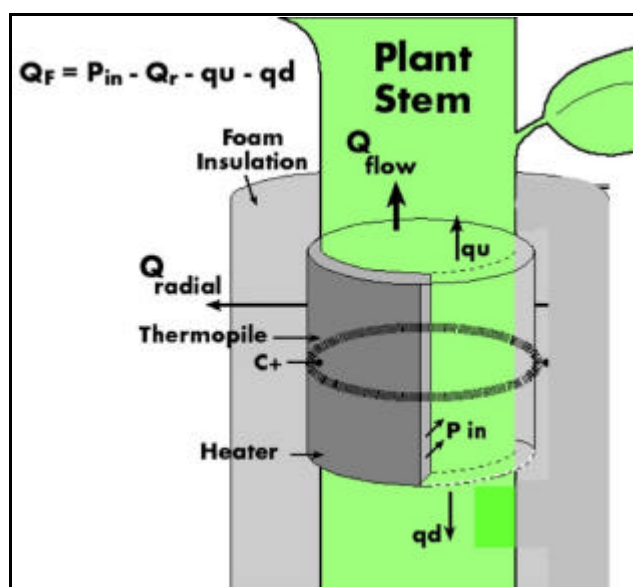


Figure 1. Stem heat balance theory (6, modified)

A steady state and a constant energy input (therefore insulated from changes in the environment) from the heater strip inside the gauge body are required. Fig. 1 shows a stem section and the possible components of heat flux, disregarding heat storage. Stem is surrounded by the heater supplying a constant amount of heat, P_{in} . Q_r is the heat radially conducted through the gauge (insulation) to the ambient. Q_v is the vertical heat conduction through the stem wood, occurring downwards (q_d) and upwards (q_u). Q_f is the heat convection carried by the sapflow. Q_f can be calculated by measuring P_{in} , Q_v ($=q_d + q_u$) and Q_r . After dividing by the specific heat of water and the sap temperature increase, the heat flux is converted directly to mass flow rate [6].

Needed power is supplied by solar panels. Random sampling of transpiration should validate the sap-flow data. Biomass production during a certain period of time (growing season) will be randomly sampled by recording growth of trunk wood as well as litter fall (appropriate litter collectors), using special calculating approaches from forestry. In addition seasonal growth will be estimated by the use of simulation models.

In January 2007 the tree species' distribution on the selected sites was mapped in order to develop a study conception. From this and from the impressions during working in the fields it was decided to assume spruce as dominant competitor. Oak, birch and elder will be examined in competition with spruce, i. e. surrounded by spruce. Up to now one individual of every species in the following combinations is equipped with instruments on two sites: spruce/oak, spruce/birch, spruce/elder and spruce/spruce. Data recording has just begun (Fig. 2).

Currently it is worked on the right sensor setup and calibration as well as on the validation of the measured data. In addition an appropriate method of litter collection is developed.

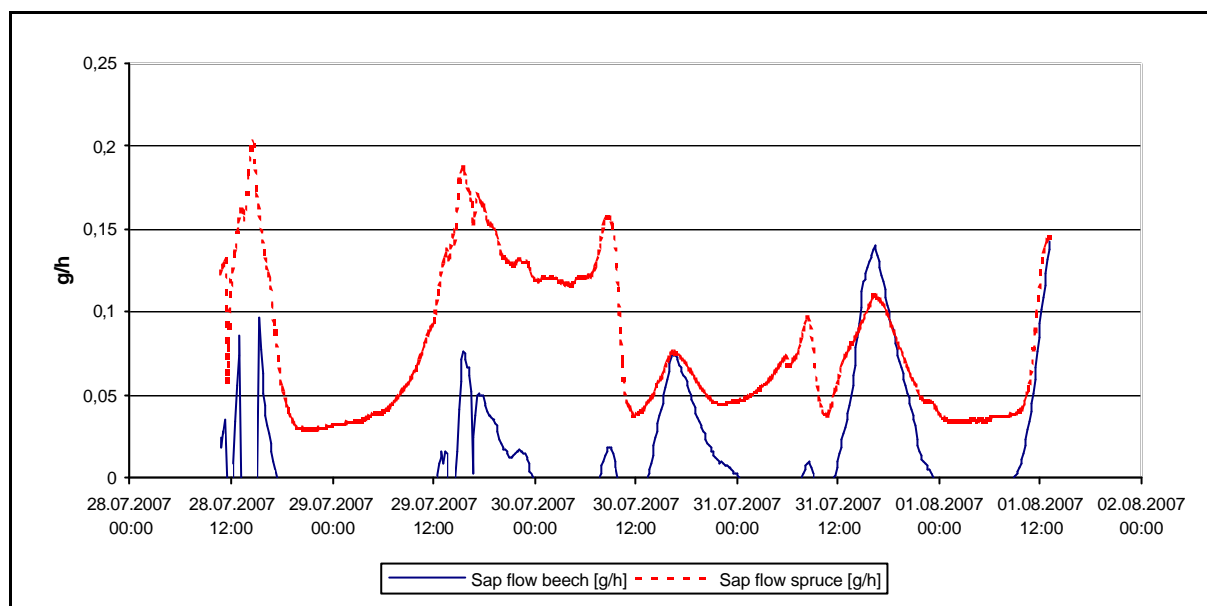


Figure 2. Daily sap flow curves of two species' individuals equipped with instruments at the study sites in Holzbach headwaters

3 Prospect

In order to understand and assess the expected differences in WUE and to draw conclusions on species ability to compete it is essential to examine more local habitat conditions, like soil moisture, state of acidification, trees nutritional condition and root distribution. Besides it will be necessary to extend the study to other, more terrestrial, sites and to consider other species (e. g. beech, ash, white fir).

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Management of riparian woodlands: Experiences from Wales, UK

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Abstract

The forests and woodlands in the UK cover about 2.4 million hectares comprising 13.7% of the land surface of Wales. Presently, forestry and environmental conservation in the country have become important concerns. The government policy provides the protection and conservation of many species and habitats associated with rivers and streams. Although the management has not been precisely defined and is difficult to interpret, there is an increasing concern about multiple goods and services that could be reaped from riparian woodlands in Wales. Hence, the paper attempts to explore the current experiences of riparian woodland management in Wales in multidimensional perspectives. Due to the lack of pertinent research findings, the paper reviews the work done by many forest scientists and available literature on related subjects.

The paper discusses the management of riparian woodlands in Wales in terms of management strategies; environmental concerns; social participation; and institutional interventions. The management strategies are explained through management purposes; and the management of key factors. The management purposes of riparian woodlands in Wales mainly cover the forestry, agriculture, ranching and wildlife, aquaculture and fisheries, protection, and urban riverine and recreation. Width, structure and species selection are considered as the key factors of management of riparian woodlands. The major environmental concerns in riparian woodland management in Wales are identified as preservation of ecosystem; promotion of biodiversity; enrichment of soil fertility and water storage; and mitigation of hazards. Only the owners' responsibility and few career opportunities could be recognized as the social participation in riparian management. The existing institutional setting of forest / conservation services, research and development, education and outreach program all make much effort to promote the riparian woodland management. Critical area protection, environmental regulations and riparian rights could be recognized as the prevailing legislations and legal conditions. Among the current policy issues the following are directly applicable for the riparian woodland management: stream buffer ordinance; livelihood orientation; forest stewardship; conservation partnerships; and incentives and compensation. It could be concluded that many attempts have been made to manage the riparian woodlands in Wales even though they have not given formal recognition for research and development. Although the environmental impacts and institutional interventions have been recorded, the social involvements and the economic benefits of riparian woodlands have yet to be quantified.

Key words: Management strategies, Environmental concerns, Social participation, Institutional interventions

1 Introduction

The forests and woodlands in the UK cover about 2.4 million hectares contributing to 5 billion hectares of the global forest cover [1]. The forest cover of the UK increased since the beginning of the 20th century stood at 5% largely with exotic species. There are no remaining natural forests but Ancient Semi-Natural Woodlands (ASNW) make up approximately 1% of land area [2]. The land area carries about 12% of tree cover comprising 17% of Scotland, 8.5% in England and 13.7% in Wales. The UK domestically produces only 13 per cent of the national timber demand [1]. Native tree flora in the UK is limited to 32 species while many exotic species have been introduced since Roman times and particularly during the twentieth century [2] According to the Countryside Survey conducted in 1990, broadleaf and coniferous woodland have increased only by 1% and 5% respectively during the period between 1984 and 1990 while significantly reducing the biodiversity [1].

The Forestry Commission was established in 1919 with the aims promoting the interests of the UK forestry [2]. Forestry and environmental conservation has become important concerns which also covers associated landscape management, maintenance and conservation of rivers coast and waterway. There are approximately 4,851 organizations employing just over 56,100 people in forestry and environmental related activities in the UK. Even in Wales 343 organizations are involved in the environmental conservation with their 5,049 workforce. National Guidance Research Forum Promoting evidence-based policy and practice in careers work [3]. The Forestry

Commission was responsible for providing grant incentives for private forestry in the 1970s. Nearly two-thirds of the UK's woodland resource is privately owned often as part of mixed estates or farms [2].

The UK Government's policies on nature conservation have been largely implemented through the Wildlife and Countryside Act 1981 and provided for the protection and conservation of many UK species and habitats. There was increasing concern about wider forest goods and services particularly landscape, recreation and biodiversity encouraging multiple use forestry by the 1980s. Following the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992 the UK committed to pursue sustainable forestry and the conservation of biological diversity [2]. Presently, biodiversity, landscape, conservation and recreation included as multiple objectives in management planning. The Countryside Survey 2000 conducted to assess habitats in the UK Countryside including Wales records land cover changes which can be interpreted as land use changes. Although the riparian area can be isolated from the survey data as a component of the landscape their definitions are often imprecise and difficult to interpret [4]. The objective of the paper is to explore and analyse the current experiences of riparian woodland management in Wales in multidimensional perspectives. However, the available literature very lightly exposes some experiences as background information about the riparian woodlands in Wales.

2 Methodology

At the initial part of the search strategy several key scientists and institutions in the field of riparian woodland management were approached concerning work in progress or which might be unpublished or in draft form. A search methodology was undertaken to identify relevant literature and to review the literature collected. Field observation was carried out to perform reliability checks to prove the accuracy of the information collected through the literature. An unstructured informal interview of forest dwellers also was conducted in the research process to collect information concerning more practical experiences of riparian forest management.

3. Management strategies

3.1 Management Purposes

3.1.1 Forestry

Wales has a variety of wet woodland settings such as successional habitat around water bodies, along streams, and in floodplain situations [5]. The key idea of the Forest Habitat Networks which has been developed and incorporated into the strategies of the Forestry Commission in Wales is that the large core forest areas are connected by well-wooded belts concentrated mainly along rivers and streams. In addition to the ecological values, the commission expect that the riparian woodlands of forest habitat networks would produce quality hardwood timber, long-distance recreation facilities and improvements in water quality [6]. Full scoping report of Forestry Commission Wales on Management Planning has reported that the Penrhyn Estate has planted small riparian woodland with oak, willow, alder [7]. A considerable delay occurs to become ecologically effective riparian woodlands after clearing stream banks within conifer crops. The retention of leaf litter within conifer forests in moorland streams in Wales is inadequate due to the lack of large coarse woody debris; regular thinning and the felling before maturity limits the supply of such material [8].

3.1.2 Agriculture

Strategically planting forest in riparian buffer zones helps to reduce soil loss from arable cropping sites in Wales [9]. National Farmers' Union (2004) which represent the business interests and policy concerns of farmers in Wales have identified the potential contribution of agriculture to flood mitigation through land management and recreation of riparian woodlands. According to them, the recreation of riparian woodlands on farms have positive impact on flood management and it may desynchronize farm run-off, increase aquifer recharge, act as a barrier to diffuse pollution and result in biodiversity benefits. Conflicts of land drainage and nutrient buffering from adjacent agricultural land in wet woodland corridors along rivers and streams in Anglesey need special considerations [11]. Riparian woodlands particularly floodplain woodlands in Wales are highly fragmented through past clearance for agriculture [5]. Decreasing trend in salmon stock in rivers in Wales pay main concern about chronic environmental degradation caused by changing land-use practices, especially agriculture and forestry. High pesticide levels and acidification still occurs in Welsh upland streams [12].

3.1.3 Ranching and wildlife

The broad fertile plains and riparian zones of the Rivers Severn and Vyrnwy in Wales, predominantly grazing land for cattle and sheep offer further habitats for many species of flora and fauna. [13]. The biodiversity, soil and water project conducted habitat assessment and negotiated with landowners along the Cleddau Rivers in Pembrokeshire to protect and enhance the riparian habitats for wildlife interests [14]. According to Countryside Agency & Rural

Development Service, wildlife and habitat protection is perceived as a reason to exclude access to riparian woodlands in Wales. They explain that many of the flood plains and meadows containing rare species are maintained on grazing thus the moderate trampling may not cause a significant damage. They have agreed that some very sensitive sites need special protection from any general right of access [15]. According to the Environment Agency Wales [16] the dairy farms have significant environmental impacts on watercourses. Therefore, they recommend including riparian habitat up to 5% of the holdings [17].

The British Waterways and other conservation bodies are involving in water Vole conservation. They hope that the decline in the number of water voles will be halted and conserved a range of other important riparian species once they are allowed to breed without threat of predation from Mink. Therefore, the Environment Agency encourages the new Mink control project which is being co-coordinated by BASC Green Shoots in North Wales [18]. Since otters occur in all wetland and riparian habitats, a species action plan has been recommended in conjunction with the Habitat Action Plans of rivers and streams, canals, reed beds, standing open waters and woodlands [19]. Planning and development committee meeting held in 2006 the Countryside Council for Wales has confirmed that they would leave a riparian woodland buffer strip along the river, where otters and bats are present and prevent detrimental impacts on reptiles and breeding birds [20]. European otter population in Britain has been dramatically declined since 1950s. The Severn and its tributaries are recognised as a key recovery 'gateway' linking the thriving otter populations of mid-Wales to the waterways of southern and eastern England. Otter population has undergone a rapid decline in Wales partly due to loss of scrub and riparian woodlands important as breeding and cub rearing sites [21].

3.1.4 Aquaculture and fisheries

Too much shade in moorland catchments limits fish productivity, while too little may result in excessive summer temperatures in lowland streams. The higher stream temperatures in cleared streams accelerate fish egg development and growth rate, as well as increase invertebrate productivity [22]. The bank side clearance of conifers to 10 m width on either side of the River Tywi in Wales also has altered the seasonal pattern of mean daily temperature. It has been revealed that the brown trout in the cleared stream attained 97% of the mass of trout in the moorland stream, compared to 78% in the unclear forest stream after one year [23]. The ongoing project for the improvement of river corridors under revised integrated action programme for Bridgend county borough has prepared a riparian habitat action plan for sustainable fisheries. The project together with Environment Agency Wales considers the merits of considering the designation of riparian buffer zones along river corridors [24]. The pearl mussel population has rapidly declined in England and Wales. In order to protect the pearl mussel the Environment Agency's Land Drainage powers has proposed the action of promoting river and riparian habitat management to achieve the objective of maintaining water quality in the appropriate stretches [25].

3.1.5 Protection

Conifer crops in streams banks in Wales had cleared to create 5 ~ 20 meter wide riparian buffer areas. The cleared streambeds have retained some of the hard features such as tree roots and rocks, with marginal vegetation of the forest streams. Even 7 years after the trees had been felled it still act as a buffer [23]. One of the main techniques being incorporated into the Afon Ogwen Project (1997-2000) on restoration of gravel Bed River in North Wales was a vegetation establishment on river banks as riparian woodland [26]. Environment Agency Wales [17] has advised Director of Planning Torfaen County Borough Council to preserve riparian trees and vegetation within 5 metres of the watercourse in order to promote conservation, preserve the watercourse and visual amenity. Farming Water pilot projects included with a riparian woodland pilot project under the Joint Agreement on Flooding (JAF) project assist in alleviating flooding by retaining more rainfall in the upper Parrett catchment and delaying the time it takes to reach the floodplain [27]. The England and Wales plan to link Flood Catchment Management Plans with River Basin Planning review flood policies to ensure that flood planning takes place at a catchment level. The directives recognize that the restoring and creating wetlands and riparian woodland can be a useful tool in achieving a whole variety of socio-economic benefits as well as helping to achieve good ecological status. It also advocates the use of riparian woodland buffer strips to effectively trap sediments and remove nitrates and other pollutants [28].

3.1.6 Urban riverine and recreation

The paths through riparian zones in urban and suburban areas make ideal commuter routes and popular with cyclists in Wales. With the establishment of National Cycle Network the pressure has increased for the use of these paths as linking routes [15]. Canolfan Tryweryn (Tryweryn White Water Centre) near Bala, North Wales is the Environment Agency's premier recreation asset near Bala, North Wales. This is the Environment Agency's premier recreation asset which attracts around 70,000 visitors each year. The Agency owns land around the River Tryweryn in the Snowdonia National Park used as a riverside trail rich in diverse riparian and woodland habitats. The Agency attempts to show this site how the conflicting needs of conservation and recreation can be accommodated at one site

[29]. The government had invited the Countryside Agency to provide the advice on the need to improve recreational access to the woodlands and watersides in Wales [15]. The permission is required from the riparian owner for fishing in remoter hill lakes in Wales. Further, visitors are requested to ensure that they leave no trace of their visit taking all litter home [30].

3.2 Management of Key Factors

3.2.1 Width

Stream banks in Wales had been cleared to create 5 ~ 20 meter wide riparian buffer areas to absorb surface run-off, fixing sediment deposits and protect stream banks from erosion [23]. Tir Gofal management, Wales is assessing buffer strips to be between 1 m and 10 m according to land use whether this is wide enough to elicit real benefits to the stream biota. It is believed that the current Tir Gofal recommendations are smaller than required for wildlife protection [31].

3.2.2 Structure

Geography Department [32], University of Cambridge has analysed the river basin management both water management and land use planning dimensions in four countries including England and Wales. They showed that the trees are able to adapt to some degree to changing water regime and riparian trees can adapt to differential water supply in ways that limit their water demands. They defined riparian plant community by its species richness and biomass production which are related to litter accumulation and decomposition and river hydrology and soil moisture. Countryside Survey 2000; Module 2: Freshwater studies report the strong significant relationships between riparian broad habitat type and indices of river corridor conditions and the biological condition in Wales [33]. The size of the alluvial forest depends on how confined the river valley is and the degree of human occupation of the floodplain and encroachment into riparian zones. Accordingly, nine alder woodland communities have been defined in wet woodlands in various stages of succession in north Wales under UK classification of Residual Alluvial Forests [34].

Forests and water guidelines in 2003 have recognized the need to improve water quality in order to prevent the decline in fish and invertebrate populations in some areas of Wales. Further the guideline propose the restructuring of riparian vegetation in promoting biological recovery in acidified systems by opening up stream sides to sunlight. The removal of the heavy shading cast by riparian conifers woodlands has been shown to improve freshwater and riparian habitats, and increase fish numbers where water quality is suitable [35]. The objective of all restocking design plans recommended by Forests and Water Guidelines in the UK is the opening up of streams in established conifer forests via the withdrawal of trees from riparian woodlands. Management of structure requires layout in planting schemes, avoiding dense stocking and the large-scale use of trees that cast heavy shade. Natural regeneration of Sitka spruce seedlings which quickly appear following the clear-felling of mature cone bearing stands in mid Wales needs careful management to achieve the desired design [23].

3.2.3 Species selection

Generally, the management of riparian woodland requires close attention to species choice. Wet woodlands occur with ash, oak, pine and sycamore on the drier riparian areas depending on the hydrological conditions and the treatment of the wood and its surrounding lands in Wales [21]. The input of terrestrial insects into the streams of the Upper Tywi in Wales is four times greater from riparian broadleaves compared to conifers [36]. The black poplar *Populus nigra* which is disappearing from the British landscape is still remaining as lone trees in hedgerows and on riparian woodlands of Wales [37]. A study of catchments in Wales found a close correlation between conifer afforestation and aluminum levels in run-off. The increased aluminum levels and acidification have severe impacts on a range of invertebrates, salmonoid fish, frogs and bird species [1]. Improving riparian woodlands by felling conifers and planting native broadleaves is considered as an eligible operation for species conservation [38]. Extensive woodlands surrounding Llyn Brenig in Wales are dominated by conifer mostly sitka spruce. The riparian zones are especially replanted with broadleaves considering network of paths at visitor centre and other areas [39]. A giant alien plant Hogweed is invading riverbanks on the lower River Usk, Wales damaging effect on the native habitat, suppressing the growth of native plants and leaving banks bare of vegetation. It reduces the recreational value of the land causing a growing problem for landowners, walkers and fishermen [40].

4 Environmental concerns

4.1 Preservation of Ecosystem

4.1.1 Habitat / food-chain improvement

River corridors and wet woodlands along with ancient hedgerows, ancient woodland, veteran trees and scrub are remnants of the natural habitat of Anglesey. River corridors and wet woodlands along rivers and streams have value for otter and water vole habitat [11]. A research reveals that the Barbastelle bat species which is widely distributed in Wales frequently travel more than 5 km to forage, using hedgerows and riparian corridors as flight lines [41]. The Tir Gofal encourages farmers to establish strips of woodland which are primarily designed to reduce pollution and enhance habitats for water vole, otter, freshwater white-clawed crayfish, great crested newt and three lobed water-crowfoot. The buffer zones or riparian corridors consisting of broadleaved woodlands, or other natural vegetation types, alongside water bodies are beneficial to a range of bird, mammal, invertebrate and fish species, and to the energy supply or nutrient cycling within the ecosystem. Although the Countryside Council for Wales' (CCW) Tir Cymen scheme have few considerations of impacts on or benefits the riparian environment, river habitat improvement would benefit macro-invertebrates, salmonids and river birds [31]. Terrestrial invertebrates in riparian woodlands form an important component of the diet of aquatic habitat. The input of terrestrial insects into the streams of the Upper Tywi in Wales is four times greater from riparian broadleaves compared to conifers [36]. Even five years after the streams banks were cleared the Tywi catchment in Wales were not colonised by the Cordulegaster dragonfly despite the water quality being suitable for their survival and lack of fish predation [23].

4.1.2 Aquatic Population

Riparian vegetation has an important influence on the invertebrate population. The presence of broadleaf trees and shrubs in riparian woodlands enhances aquatic biodiversity. The aquatic invertebrate biomass of streams in the catchment of the River Tywi in Wales reflects the quality of the input to the water in the order of broadleaf woodland, moorland and conifer forest [36]. The coniferous plantations in riparian woodlands in Wales can contribute to or exacerbate problems of soil and surface water acidification, and lead to detrimental effects on aquatic habitats and fisheries [42]. The presence of three distinct macro-invertebrate communities in the upper catchment of the River Tywi in Wales is related to the marginal habitat and substratum characteristics [23]. However, the macro-invertebrate population is absent in upland conifer forest streams with eroded banks across Wales [43].

4.2 Promotion of Biodiversity

Environment Agency Wales at its contribution to delivery of the woodlands for Wales strategy has addressed the issues related to enhancing biodiversity and landscape using riparian areas [44]. Local Biodiversity Action Plan has implemented species conservation, habitat enhancement and several riparian habitat projects including conservation of unique Biodiversity in the Snowdonia National Park in North West Wales [45]. River corridors and wet woodlands provide corridors along rivers and streams have particular value for biodiversity corridors of the natural habitat of Anglesey [11]. Radio-tracking in south Wales has revealed that lesser horseshoe bats are more active around riparian woodlands [46]. There are suitable resting sites include hollows in large riverside tree roots in riparian zones in Wales. Therefore, the removal of riparian trees reduces the number of sites that could potentially be used [47]. Daubenton's bat (*Myotis daubentonii*) is widespread in Wales but largely restricted to riparian habitats. It is dependant on water quality and quantity and riparian habitat structure. Inappropriate management of riparian woodlands particularly the removal of excessive branches of old trees would reduce the number of potential roost sites [48]. The kingfisher is identified by the UK Biodiversity Group as a species of conservation concern. The kingfisher population may have halved in Wales since 1992. The Kingfisher Species Action Plan encourages landowners to manage riparian habitats to benefit kingfishers since 2003. Further the action plan proposes to use the popularity of the kingfisher to promote the importance of biodiversity with regard to watercourses and riparian habitat [49].

4.3 Enrichment Soil Fertility and Water Storage

The riparian woodland traps sediments and nutrients from surface runoff and shallow groundwater, and reduce nutrient losses to streams in uplands. According to the Land Use Consultants [42] coniferous plantations in riparian buffer zones in Wales can contribute to or exacerbate problems of soil and surface water acidification. Memorandum submitted by the woodland Trust on climate change and water policy target riparian habitats considering the potential to develop ecologically functional landscapes ensuring biodiversity to cope, adapt and move in response to climate change. Talybont Research Station studying potential role of woodland in the flood plain to alleviate flood risk down stream have revealed that the soil water storage and infiltration capacity is significantly greater in the area planted with trees than in the adjacent agricultural land at Pontbren in Wales [50].

4.4 Mitigation of Hazards

The Environment Agency Wales has stress the importance of enhancing biodiversity in riparian areas in order to provide protection from runoff of pollutants and silt. Further, increasing areas of wetland attempts to increase the storage capacity of a catchment and hence reduce flooding further downstream [44]. It has been revealed that the natural habitat along rivers and streams of Anglesey have particular value for nutrient buffering from adjacent agricultural land [11]. The Forestry Commission is responsible for regulating forestry activities in Wales and incorporates its responsibilities into the programmes of the Water Framework Directive (WFD). WFD under its operational issues has considered strategically placed woodlands acting as riparian buffer zones help to reduce soil loss from arable cropping sites [51]. River corridors and wet woodlands which provide corridors along rivers and streams in Anglesey have particular value for erosion control and attenuation of flooding [11]. The broadleaf woodlands are beneficial to surface waters and can reduce the effects of soil erosion and protect areas from flooding in the riparian buffer zones. The clear felling of broadleaf woodlands in riparian buffer zones is recognized as a contributor to soil erosion in Wales [42].

5 Social participation

The land owners in riparian zone of River Dee in North Wales have the responsibility to pass on flow without obstruction, pollution or diversion affecting the rights of others. They are responsible for maintaining riparian woodlands including trees and shrubs growing on the banks, and also for cleaning any debris, litter and animal carcasses even it is not originate from their lands [52].

The government has run a various Job Creation Programmes via the Manpower Services Commission to employ graduates for research initiatives. The first inventories for mid-Wales of woodlands were one of the direct results of Job Creation projects. Governmental conservation and environmental bodies advocate two years river surveying of birds, fish, invertebrates, higher and lower plants and otters led to the development of several river and riparian survey techniques [53].

6 Institutional interventions

6.1 Institutional Setting

6.1.1 Forest / conservation services

The Director of Planning Torfaen County Borough Council has been advised by the Environment Agency Wales that the areas of higher conservation value including riparian woodlands in canal and streams corridors have to be preserved in situ. Further, the Environment Agency Wales seeks to preserve any riparian trees or vegetation within 5 metres of the watercourse and protect from any development in order to promote conservation [16].

6.1.2 Research and development

The Countryside Survey 2000 of Assessing Habitats in the UK Countryside conducted by Department for Environment, Food and Rural Affairs covered both terrestrial and freshwater habitats also found in Wales. The survey assessed the habitats including rivers and streams, canals, ponds and lakes, and the associated riparian zones [4]. The Llysdyman Field Centre in mid-Wales run by the School of Biosciences at Cardiff University conduct research and postgraduate studies on riparian and aquatic habitats, and non-fishery biodiversity effects of river habitat restoration in the area. Post-doctoral research investigated many aspects of riparian plants to evaluate the changes that might bring by the development [53]. It has been reported that the native trees in riparian woodlands in Wales suffer foliage loss due to variety of causes. The problem of Phytophthora disease and Crown Dieback has become serious within the last decade. Therefore, the Forestry Commission is currently conducting research into these diseases [54]. It is illustrated that the current Tir Gofal, Wales recommendations for the width of riparian buffer strips are smaller than the requirement for wildlife protection. Therefore, there is a need to assess whether this is wide enough to elicit real benefits to the stream biota [31]. Scrub is known to be an important habitat for a wide range of higher plants, herbivorous insects and birds. The scrub which is particularly characteristic of riparian woodlands in Wales is valued primarily for the species it supports. It has been recognized that the research on the successional dynamics of invertebrates, birds and small mammal communities within developing scrub is highly desirable in view of the conservation interest in riparian woodland [55].

6.1.3 Education and outreach program

A riparian woodland pilot project is a component of the Farming Water pilot projects in alleviating flooding and associated problems in the upper Parrett catchment. In addition to the technical water management projects the project has hosted a number of public events to increase awareness of the water and land management issues in the

catchment [27]. North Wales Riparian Mammals Group discuss their water vole and mink strategy at the mink training course conducted by UK Steering Group for the water vole at Snowdonia National Park for the representatives of various local groups and organisation [56]. Woodland Bats Species Action Plan of the Biodiversity Action Plan for the Isle of Wight has suggested a communication, awareness and promotion program for Wales to give advice to landowners in the vicinity of roosts on favourable habitat management of woodlands and riparian habitats [41].

6.2 Legislations and Legal Conditions

6.2.1 Critical area protection

Countryside Agency & Rural Development Service insist the need of special protection of some very sensitive riparian woodlands in Wales from any general right of access. In addition to the rare habitat, the protection of wildlife is also perceived as a reason to exclude access to many of the flood plains and meadows [15]. Although the land owners in riparian zone of River Dee in North Wales have riparian rights to own the land up to the centre of the watercourse, they cannot abstract water for spray irrigation from a watercourse at any point without license or prior consent from the Environment Agency [52]. Under the Land Drainage Byelaws, any tree planting within 7 metres of a main river requires a formal land drainage consent from the Environment Agency Wales [11]. Periodic access to some watercourses in Wales is required for maintenance and flood defence purposes. Advice and consent should be sought from the Environment Agency for the planting of trees within 9 m of these watercourses [35].

6.2.2 Environmental regulations

Although the Forests and Water Guidelines recognise the benefits of riparian woodland management in Wales, approval of forest plans, grant aid, felling licences and operations are subjected to the environmental impact assessment regulations. The Forestry Commission administers the environmental impact assessment regulations for all new planting, felling and certain other forestry operations [9]. Under the Tir Gofal AES the farmers have compulsory management prescriptions for riparian environment. The farmers have to improve the farm environment by a variety of conservation measures. All ponds, rivers and streams must be bounded by a 1 m wide strip of natural vegetation and broadleaved woodland should be managed when located on riparian zones. Use of pesticides, clearing ditches, vegetation cutting, supplementary feeding or burning requires project officer approval. A 7 meter wide buffer strip either side of watercourses have to be created voluntarily in order to control livestock grazing and physical damage to banks [31].

6.2.3 Riparian rights

The Countryside Agency has recommended government for the use of extensive, targeted rights of way creations to improve access to riparian zones in Wales but not a general statutory right [15]. According to the British Canoe Union only 2% of rivers in England and Wales have public access. The owners of the land along the river also have the property rights to the riverbed. According to the Environment Agency Wales [17], although the Local Authority has permissive powers to maintain watercourses, the responsibility for general maintenance of river banks rests with the riparian owner. The majority of land owners in catchment area of the River Dee in North Wales are keen to maintain and enhance the ecology of the rivers with the increased price of their land for its aesthetic, recreational and emotional value. They have the riparian rights presumed to own the land up to the centre of the watercourse unless it is known to be owned by others. They can protect the property from flooding and land from erosion, despite the requirement of prior consent from the Environment Agency for most works. However, they have the right to fish in their watercourse by legal methods only with an Environment Agency rod license [52].

6.3 Policy Issues

6.3.1 Stream buffer ordinance

Stream Buffer ordinance setting up conservation of riparian corridor woodlands that consist of streams, intermittent watercourses, lakes and wetlands. Ystrad (Rhondda) Magistrates' Court has sentenced a farmer and also ordered to pay costs to Environment Agency Wales who had pleaded guilty to allowing waste to be deposited on her land close to the river [57].

6.3.2 Livelihood orientation

Although the memorandum submitted by National Farmers' Union has identified the importance of recreating riparian woodlands on farmlands, they insist that the potentially significant benefit needs to be rigorously assessed as a policy option. Further, they have the opinion that the creation of riparian woodlands on farmland should be considered with the full participation of the farming community in order to ensure long term sustainability of the solution and the availability of adequate funding [10].

6.3.3 Forest stewardship

Public policies that encourage sound riparian woodland management require stewardship plans with the use of public funds. Environment Agency Wales at its contribution to delivery of the woodlands for Wales strategy has put forward the directives for significant change in environmental legislation covering the water environment. They are active at strategic level to influence policies and funding programmes to support agri-environment schemes. It has emphasised not only to replace the existing aquatic legislation, but also introducing the philosophy of river basin planning and management. It has implications for land use sectors to work closely with the farming sector to promote environmental best practice and sustainable land management practices (Merrett, undated). The removal of riparian trees has reduced the number of sites that could potentially be used as suitable resting sites for the Otters disappearing from Wales. Therefore, the Countryside Stewardship Scheme encourages riparian landowners to construct artificial otter holes and create habitat strips along riversides [58]. University of Brighton [59] in its report has identified the need for strategic planning for water-based sport and recreation in nearly 2,000 enclosed waters with a mean area of 27 hectares in England and Wales. The report insists the closer collaboration between local authorities, public agencies, riparian owners and waterway users for the sustainable management and development of the watercourses and riparian woodlands.

6.3.4 Conservation partnerships

Knighton Countryside Management Ltd [60] undertakes a wide range of projects throughout the South of England and Wales. They offer an extensive range of riparian works to ensure the health of the river and the highest levels of maintenance for the river bank or lakes. Hendurnpike Woods manage and care for 2.5 hectare of riparian woodland situated on the River Ogwen close to the Snowdonia National Park in North Wales in a sustainable manner encouraging biodiversity and a healthy environment. They have established broadleaf woodland and manage the land and its occupants such as birds and bugs as it has been dictated by the environmental history, topography and past land management [61]. In addition to the riparian owners on the Upper Wye River Wales, the Environment Agency has overall responsibility for the river, while the Countryside Council for Wales having a direct management input concerning the environmental protection, fisheries, ecology and recreation management, flood defense and water resources etc., [62]. The project carried out by the Pembrokeshire Rivers Trust together with Countryside Council for Wales & Environment Agency negotiated with landowners along the Cleddau Rivers in Pembrokeshire to protect and enhance the riparian habitats for wildlife interests [14].

6.3.5 Incentives and compensation

Environmentally Sensitive Areas and the Habitat Scheme in Wales provide incentives for woodland and wetland management. Wild Rivers Project, Highland Birchwoods, Coed Cymru, Cumbria Broadleaves, Tayside Native Woods also promote the expansion and management of these woods. However the agreement holders have to seek the management advices [63]. Under Single farm payment scheme in Wales, use of the entitlement may be possible where farmers are unable to access their farmland due to riparian erosion [64].

7 Conclusions and policy implications

Many strategies have already been implemented to management the riparian woodlands in Wales particularly for the purposes of protecting wildlife and environment in the riparian zone. Preservation of ecosystem and promotion of bio-diversity are the main ecological and environment concern of the management of riparian woodlands in Wales. There are many institutional interventions have been recoded as attempts to develop sustainable management of riparian woodlands. However, the social involvements and the economic benefits of riparian woodlands have yet to be quantified and promoted as prerequisites for the sustainable management of riparian woodlands in Wales.

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Ancient irrigation strategies: land use and hazard mitigation in Ma'rib, Yemen

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Ma'rib Oasis (Fig. 1), heartland of the Sabaean Kingdom is not only famous for its temples, but also for its technologies. One achievement of the ancient culture in Southern Arabia is the 'Great Dam of Marib', situated at the south eastern desert margin of the Rub Al-Khali. For reasons of land cultivation and hazard mitigation in this arid environment with heavy rainfalls and with strong fluctuations of precipitation, the Sabaean people built an earth dam with a length of 680 m.



Figure 1. Marib Oasis (A: recent well irrigation at ancient sedi-ments; B: Wadi Dhana; C: lava fields; D: Jurassic lime-stone; E: dunes; F: sluices; Source: Quickbird

The times of construction and reconstruction of the respective two sluices at the northern and southern tails of the ancient dam are dated between the 7th century BC and the 7th century AD. Within this period the dam bargaged the largest wadi had a maximum runoff of $5'000 \text{ m}^3 \text{ sec}^{-1}$. A runoff model at a scale of 1:100, built at the *Hochschule für Angewandte Wissenschaften in Hamburg*, gives detailed information about the capacity of the Great Dam. It demonstrates clearly the optimal function of the sluices and overflows to irrigate an area of 9'600 ha.

The know-how to handle the large water quantities was gained on forerunners of the dam. Comparable arrangements have been detected both in the same wadi and in a neighbouring smaller wadi. Hence the 'Great Dam' demonstrates the culmination of a long-term technical development of flood irrigation in this region.

An interdisciplinary project about land use change in Ma'rib gives special attention to soil development and land use suitability in the surrounding of the oasis, since both are directly related to climate conditions, and in particular controlled by runoff and infiltration.

The composition of silty and clayey flood irrigation deposits (Fig. 2) are compared with the composition of natural soils (Fig. 3) of lava fields, limestone escarpment and dunes, showing other properties and features than anthropogenic sediments.

Indeed, the organic matter content of natural soils is higher (1%), but in comparison to the irrigations sediments

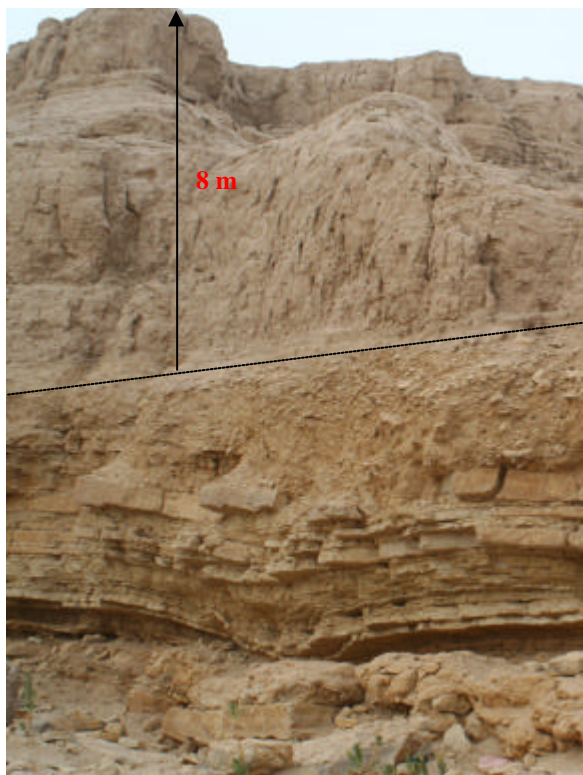


Figure 2. Irrigation sediments, here above Jurassic limestone and detritus cover; SOP2, southern Marib oasis,



Figure 3. Buried soil between 60 and 80 cm depth; LAS7, Hammad Misariyah, Yemen

their thickness is less: irrigation sediments are a few meters thick, buried soils both in the surrounding of the oasis and beneath irrigation sediments only 30 to 50 cm. The limited soil resources might have been one of the restrictions of rainfed cultivation, what made flood irrigation in the Sabaean time necessary.

The impact of land-use changes and river restoration on flood risk (water quantity) and sediment delivery (water quality) in a meso-scale catchment: A modelling approach

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Abstract

Large-scale flooding in Eastern Europe forms dramatic constraints for the future economic development of the region. Apart from the excess of water, the hinterland also delivers large quantities of sediment, which accumulates in downstream reservoirs or forms problems in fairways. To understand the processes of water and sediment generation in headwaters of major waterways it is important to look at these processes on a scale that is large enough to be representative of the processes involved, and small enough to be homogeneous and thus allow unambiguous results.

In south-western Poland the meso-scale catchment of Nysa Szalona (375 km²) an investigation is ongoing, involving the interaction between land use and sediment and water delivery. The aims are to assess the determining factors influencing sediment and water delivery. This catchment has multiple land uses and a reservoir, where the sedimentation history of the catchment can be linked to changes in land use.

Historical land-use maps, long hydrological records and the available sediment database in the downstream reservoir allow the development of an ArcGIS-based sediment delivery model with a strong hydrological and a snowmelt component. This (mostly) physically based model will be able to compute sediment delivery from a meso-scale catchment at any selected time-step.

A thorough geomorphologic and ecological survey of the riverine habitat will be the basis of several land-use scenarios to calculate possible ecologically friendly solutions to reduce the sediment delivery to the main channel and to retard the flood wave in the meso-scale headwater catchments.

Keywords : Meso-scale catchments, GIS-based sediment delivery model, flood risk reduction, sediment delivery reduction, nature conservation, Nysa Szalona, Poland

1 Introduction

Large-scale flooding in the major waterways of Eastern Europe forms dramatic constraints for the future economic development of the region (e.g. floods in 1997, 2001 and 2006; cf. [1][2]). Apart from the excess of water, which forms a direct threat to people, the hinterland delivers large quantities of sediment to the river system. The sediment either accumulates in reservoirs, reducing their life-expectancy or forms problems in the fairway. Both problems cause huge economical damages.

Most sediment and water provided to these large-scale rivers originates from meso-scale (50-400 km²) headwater catchments (up to 90% [3][4]). However, the processes in these meso-scale catchments regarding the generation of sediment and water have so far not received much scientific attention [5][6]. A few studies proved the importance of understanding the processes concerning discharge of water and sediment in meso-scale catchments (cf. [7][8]). When meso-scale river systems are understood and managed in a sustainable way, large-scale problems, like flood-risk and sediment-related problems in the main river, can be tackled [9]. Large-scale catchment heterogeneity (geology, land-use, catchment size, etc.) blur the observations, and make an unambiguous result impossible. Conversely, meso-scale catchments are large enough for reliable hydrological and sediment budget analysis, small enough for full field surveys and homogeneous enough to make reliable conclusions [10].

Study area and aims

To reduce water and sediment delivery to large-scale rivers, knowledge of meso-scale headwater catchments, such as the impact of river morphology, sediment production and sediment deposition is required. The Nysa Szalona catchment in southwestern Poland (Fig. 1) was selected, which is a third order tributary of the Oder River. The catchment has a reservoir near the outlet and the area of the catchment upstream from the reservoir is 375 km². The western part of the catchment has a pronounced relief and the eastern part consist of rolling hills. This difference is due to geological variations. The catchment is representative for meso-scale European catchments in terms of land use.

In this catchment a reforestation trend was observed due to abandonment of marginal agriculture in the region since the early 1990s. This trend is expected to continue due to the economic growth connected to the recent entry of Poland to the EU. The natural reforestation process was also observed in other countries where large-scale economic growth took place as well (e.g. Slovenia [7], Southern France [12], Italy [13]).

Several possible solutions for the retention of sediment and water will be assessed. And for this the following aims were formulated:

1. Assessing contributing factors for retarding peak flows (ultimately reducing flood risks in main river)
2. Assessment factors influencing sediment delivery to reduce sediment input (ultimately increasing reservoir life-expectancy).
3. Development of Arc-GIS based SDR model with larger hydrological input than existing models (user friendly!).
4. Development land-use scenarios with nature restoration plans in the riparian zone to reach aim 1 and 2, which will be tested with aim 3.

2 Approach

2.1 Collection of the available data

The available data of the Nysa Szalona catchment is provided by the Polish partners (from the University of Silesia). These data include: (i) hydrological data: precipitation, discharge and snow cover; (ii) sedimentological data: suspended sediment data and soil parameters; (iii) other geographical data: maps of the topography, geology, soil types, land use, historical land use and a digital elevation model (DEM). A general sedimentation history will be constructed from available bathymetric surface measurements conducted by the managers of the reservoir.

During field campaigns, additional data needed for the model input (e.g. soil parameters, land use) will be collected. The rivers morphological evolution will be mapped and linked to the sedimentation record in the downstream reservoir and to the historical discharge record (cf. [10]). The historical hydrological record, the river morphology and sedimentation rates in the downstream reservoir will provide the necessary input for the model calibration and validation. Furthermore, the riverine habitat in the meso-scale catchment will be ecologically mapped to collect data on the present situation. Both geomorphological and ecological characteristics will be used

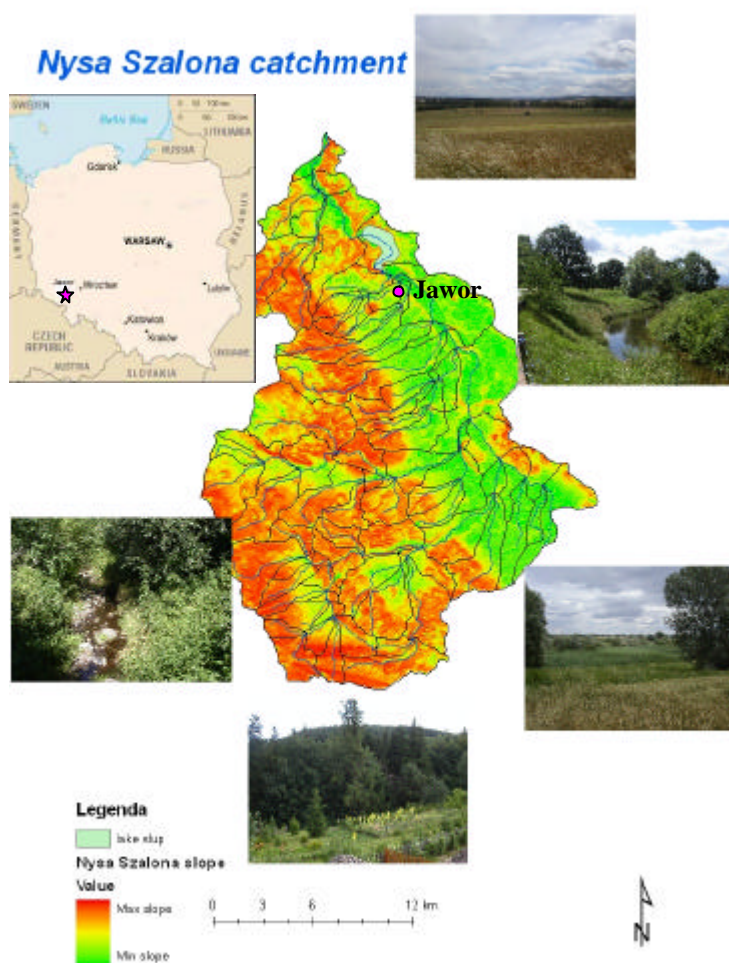


Figure 1. The slope of the Nysa Szalona catchment in SW Poland (375 km²) with impressions of the landscape. Star indicates catchment location(50°58'N 16°10'E)

to develop scenarios for future nature restoration that will be beneficial for biodiversity as well as for sediment and water retardation.

2.2 Model development

Sediment transport processes in meso-scale catchments have been largely neglected in science due to the large number of processes influencing the sediment dynamics and water balance in these catchments. Existing models usually incorporate only a selection of the active processes; and the model scale is either a hillslope or a macro-scale catchment. Moreover, they only focus on sediment delivery or the water balance of a catchment. The available meso-scale GIS-based models have no or very little hydrological components and are usually empirically calibrated and not physically based. Consequently, the models are scale-dependent in terms of pixel-size, which will largely be excluded by introducing a strong hydrological component.

The new model will be compiled from existing models for the calculation of hillslope erosion, sediment transport and discharge routing within the model. The Morgan Morgan Finney model [14] will be used to calculate gross erosion. Gross erosion will be linked to the approach of the Hillslope Sediment Delivery Ratio (HSDR) model [15]. HSDR combines a pixel-based sediment delivery ratio (SDR) with a physically based hydrologic routing model. In the case that this approach does not give satisfactory results, the TOPMODEL [16] will be applied for hydrological routing. Apart from the advantage that this model is physically based, it is also capable of predicting sediment delivery to the catchment outlet on any selected time step. For the snowmelt component the SRM (Snowmelt Runoff Model; [17]) will be used.

The model will also be user-friendly and ArcGIS-based, with which watershed managers can predict the benefits of biodiversity enhancement measures in terms of sediment and water retention.

2.3 Land-use scenario development

When the contributing factors for the retention of sediment and water are assessed, land-use scenarios will be developed to model the expected peak flows retardation and the reduction of sediment delivery to the river.

For reducing the sediment and water *input* to the rivers the scenarios comprise (i) afforestation of the most erosion-vulnerable areas; (ii) different tillage techniques and (iii) development of anti-erosion measures.

Secondly, for sediment and water *retention*, scenarios of different morphology and land use in the channel and the riparian zone will be developed. Providing space to rivers leads to spreading of sediment and water during floods. Peak-flows reach the main river more gradually and part of the sediment is temporarily stored in the headwater catchments [18][19][10]. Knowledge gained through Dutch river restoration projects as “Plan Ooievaar” [20] and ‘Ruimte voor de Rivier’ [21] will be used to develop the framework of the nature restoration. Nature conservation and preservation and enhancement of biodiversity are important topics on the agenda of the EU. However, to obtain sediment and water retention, and in the meantime enhance the biodiversity of the region, it is first necessary to increase our knowledge on catchment management.

To assess the effectiveness of the above-mentioned scenarios, they will be tested with the newly developed model.

3 Results

This project is currently in its starting phase. A reconnaissance trip was made in June 2007 and a general concept for the construction of the model was made. However, at this stage no firm results can be presented.

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Session 4

European planning strategies for catchment management

Legal Aspects of Preventive Flood Protection by Transnational Spatial Planning: The Example of the Project “ELLA”

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Abstract

This article gives an overview of the legal aspects of transboundary river catchment management with the focus on flood protection and spatial planning. It summarizes selected results of the INTERREG III B project “ELLA” in which five member states of the EC took part. The aim of this project was to develop preventive flood management measures by transnational spatial planning for the Elbe river catchment. Since by far the biggest part of the Elbe river basin is found in Germany and the Czech Republic, the focus is on the legal situation in these two states. The analysis of the transnational legal framework shows that there is already an extensive range of legal instruments for cross-border cooperation between the Czech Republic and Germany. At the level of the international law, this concerns the Agreement on the International Commission for the Protection of the Elbe as well as a whole series of Czech-German bilateral agreements. At the European level, the most important legal acts for flood protection and spatial planning are the European Spatial Development Perspective (ESDP), the SEA-Directive, the Water Framework Directive and the future Floods Directive. As far as the national level is concerned, both in Germany and in the Czech Republic, flood protection law consists of a complex legal cross section, which falls into different fields of law. From the planning point of view, sectoral water planning, comprehensive spatial planning and zone protection play a central part in flood protection. The analysis of these fields reveals, that in both states a lot of new legal instruments have been introduced in the last few years. However, the administrative implementation of these instruments is still in the early stages and needs further attention.

Keywords: Preventive flood protection, Transnational spatial planning, Elbe river catchment, Legal framework, Law comparison.

I Flood Protection by transnational spatial planning: The Project ELLA

The tremendous flood disasters in the recent years have caused huge damage in Europe, especially the Elbe flood in 2002. Such extreme events reveal the importance of land use management for preventive flood protection and the necessity of transboundary coordination. To improve the situation in these fields, the EC INTERREG III B project “ELLA” (**ELBE-LABE**, Preventive Flood Management Measures by Transnational Spatial Planning) was developed, which ended in December 2006 after a period of three years. 23 project partners from five EC Member States, under the leadership of the Saxon State Ministry of the Interior, took part in the project. The target was to develop a joint strategy for future spatial planning in the Elbe river catchment. To achieve this target, 5 working groups were set up. One of these working groups dealt with the specifics of the legal framework for transboundary cooperation and the flood protection and spatial planning law in the participating states. Legal instruments are essential for the implementation of transnational strategies. They allow the formulation of binding political and technical agreements and thus ensure the long-term validity of the decisions. Three legal studies have resulted from the activities of the working group. Since Germany and the Czech Republic own approximately 99 % of the Elbe river basin, the focus of the studies is on the legal situation in these states. While the first two – national – studies analyze the legal situation of flood protection and spatial planning in Germany [1] and in the Czech Republic [2], the third – transnational – study is focused on the legal framework of cross-border cooperation and contains a comparison of the national flood protection and spatial planning law [3]. The following article gives an overview of the most important results of these studies.

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II Transnational Legal Framework of cross border cooperation between Germany and the Czech Republic

The legal framework for cross-boarder cooperation between Germany and the Czech Republic can be separated into an international and a European level.

1 International Law

As far as the international level is concerned, there are a number of international agreements with relevance for cross-boarder cooperation between Germany and the Czech Republic. Such agreements have already existed for more than 15 years beginning in 1990 as a result of the political change in Europe. In detail, these documents are the following:

- Agreement on the International Commission for the Protection of the Elbe (1990),
- Convention on Environmental Impact Assessment in a Transboundary Context (Espoo-Convention 1991),
- Neighbourhood Agreement (1992),
- Frontier Waters Agreement (1995),
- Environmental Protection Agreement (1996),
- Bohemian-Saxon Working Group for Spatial Development (2005)
- German-Czech Working Group for Spatial Development (2006)

The most important agreement in the field of flood protection is on the International Commission for the Protection of the Elbe which has established its own working group "Flood protection". In 2003, the International Commission for the Protection of the Elbe adopted an action plan for flood protection of the Elbe river [4]. Due to its strong political authorization, this plan is of great practical importance for cross-border coordinated flood protection. As far as spatial planning is concerned, impulses for cross border cooperation could come from the recently founded Bohemian-Saxon Working Group for Spatial Development and the German-Czech Working Group for Spatial Development.

2 European Law

In the context of European law, four legal acts of the EC are of special importance for cross-boarder cooperation: the European Spatial Development Perspective (ESDP), the SEA -Directive, the Water Framework Directive (WFD) and finally the Floods Directive, which is expected to come into force by the end of 2007.

The **European Spatial Development Perspective (ESDP)** was adopted by the informal Council of Ministers responsible for spatial planning in 1999. It is a guidance framework for future EU policy in areas affecting spatial development and it is not legally binding [5]. The 3 fundamental goals pursued by the ESDP are economic and social cohesion, the maintenance of natural and of cultural heritage and balanced competition capabilities in the European territory. To implement transnational co-operation in these fields, the EU has set up the INTERREG initiative, which is a funding instrument of the EU. The condition for funding of projects by this initiative is their conformity with the guidelines of ESDP, so it has at least indirect legal implications. Management of water resources is a challenge especially for the spatial development, and transnational flood protection in particular (3.4.3. ESDP).

The **SEA-Directive** [6] includes the identification, description and evaluation of impacts of plans and programmes on certain issues such as human health, fauna, flora, biodiversity, soil, water, air etc. It stipulates transboundary consultations for plans or programmes which are likely to have significant environmental effects in another Member State (Art. 7). Consequently the SEA shall be carried out for instance for supra-local spatial plans, urban land-use plans, flood protection plans and water management plans (Art. 3 (2)). The Member States concerned shall ensure that the affected authorities and the public are informed and given an opportunity to forward their opinion (Art. 6 (2)). The results of these transboundary consultations shall be taken into account during the preparation of the plan or programme (Art. 8).

The target of the **Water Framework Directive (WFD)** [7] is to ensure a good status (high quality) of European water resources. Even though flood protection is not directly addressed [8], the WFD is nevertheless an important instrument for transnational cooperation in the fields of flood protection and spatial planning. This has two reasons: Firstly, it considers entire river basin districts (not only the water body), and secondly, it implies transboundary cooperation concerning the whole river basin (not only within the national territory). The legal basis for this cooperation is given by appropriate administrative arrangements, including the identification of appropriate competent authorities. For example, an international coordination group (ICG-WFD) was founded by Germany, the Czech Republic, Poland and Austria for the river basin of the Elbe.

Like the WFD, the future **Floods Directive** [9] prescribes the coordination of administrative arrangements within river basin districts (Art. 3) and makes use of the national and international arrangements made under WFD [10]. The directive contains 3 fundamental instruments for flood protection: a *preliminary flood risk assessment* (Art. 4, 5) to identify areas with significant flood risks, *flood maps* (Art. 6), which have to be set up for areas identified under Art. 5, and *flood risk management plans* (Art. 7, 8). Flood maps are divided into flood *hazard* maps identifying geographical areas which could be flooded according to scenarios with a low, medium or high probability and flood *risk* maps showing the potential adverse consequences associated with the flood scenarios. Flood risk plans contain objectives for the management of flood risks and measures for achieving these objectives (also taking into account relevant aspects such as spatial planning and land use).

III Law Comparison of the German and the Czech Flood Protection and Spatial Planning Law

For the transnational cooperation, it is necessary to know the legal situation in the corresponding states. Therefore, a comparison between the German and the Czech law was carried out within the framework of ELLA. In both states, flood protection law can be characterized as a complex legal cross-sectional area, which includes different fields of law (e.g. water law, spatial planning law, nature conservation law, soil protection law, agricultural law and forestry law). From the planning point of view, sectoral water plans with spatial impacts, as well as comprehensive spatial plans and protected zones play an important role.

1 Sectoral water planning

Sectoral water planning can be defined as systematic preparation and execution of measures of water management by the competent authority. Sectoral water plans are very important for flood protection, because they have significant spatial impacts. The legal basis for sectoral water planning in Germany is the Water Management Act (Wasserhaushaltsgesetz, WHG) [11] as well as the Water Acts of the “Länder”, and in the Czech Republic the Water Act (Vodní zákon, Vod. zák.) [12].

In Germany, there are separate plans relating to water quality on the one hand and flood protection on the other hand. Water quality is addressed in the programs of measures and river basin management plans according to the Water Framework Directive (Sec. 36 and 36b WHG), whereas flood protection is considered in the flood protection plans (Sec. 31d WHG). In contrast to this, in the Czech Republic, there are integrated river catchment management plans. Two types of such plans exist: The plan for main river basins is a strategic general plan for water management within the three main river basins of the Czech Republic Elbe, Morava and Odra (Sec. 24 (2) Vod. zák.). The river basin district plans are more detailed and regulate the water management in eight river basin districts (Sec. 25 (2) Vod. zák.). Both types of plans contain aspects of water quality as well as of flood protection.

2 Comprehensive spatial planning

The second relevant category for flood protection is comprehensive planning. This can be divided into supra-local spatial planning and urban land use planning. Within the transnational project ELLA, supra-local spatial planning represented a focal point. The function of this type of planning is the coordination and harmonisation of those elements of the various types of sectoral planning which have spatial impacts. The legal basis in Germany is the Spatial Planning Act (Raumordnungsgesetz, ROG) [13] as well as the Spatial Planning legislation of the “Länder” and in the Czech Republic the (new) Building Act No. 183/2006 Coll. (“Stavební zákon”, Stav. zák.) [14] which came into force in January 2007 and replaced the old Building Act No. 50/1976 Coll. In both states, one can distinguish two levels of supra-local spatial planning:

In Germany the highest level incorporates the spatial structure plan (Sec. 8 ROG) which is drawn up to cover the entire territory of a “Land” (Saxony: „Landesentwicklungsplan”). Below, regional plans (Sec. 9 ROG) are developed as plans for defined regions within a “Land” (Saxony: 5 regional plans). It is important to note that on the level of the whole territory of Germany, a binding spatial plan doesn’t exist. In the Czech Republic, with the new Building Act, such a general plan was introduced (“policy of regional development”, Sec. 31 Stav. zák.) [15]. This difference in the legal situation is an expression of the different state constitutions of Germany and the Czech Republic. While in Germany there is a federal state structure, the Czech Republic is subdivided into less independent districts. Each of these districts has its own regional plan, the so-called “Principles of regional development” (Sec. 36 Stav. zák.).

An important question for flood protection by spatial planning is how to integrate flood protection measures into the spatial plans. In Germany this is regulated by Sec. 7 ROG, which offers some instruments to achieve this aim. The first method is the implementation of the principles of comprehensive spatial planning (Sec. 7 para. 1 ROG), for instance the principle of preventive flood protection laid down in Sec. 2 ROG. A second option is to determine

open spaces for preventive flood protection (Sec. 7 para. 2 sent. 1 ROG) and to compensate for areas which can no longer be used for retention (Sec. 7 para. 2 sent. 2 ROG). Another instrument is the obligation to integrate water related sectoral plans into spatial plans (Sec. 7 para. 3 ROG). Finally it is possible to designate priority areas and reserved-function areas for preventive flood protection (Sec. 7 para. 4 ROG). In contrast to this, so called “land use limits” for flood protection areas in the spatial plans of the Czech Republic are defined, Sec. 26 (1) Stav. zák., Sec. 4 Decree 500/2006 Coll. [16]. These limits regulate the functional and spatial dispositions of an area, delimit protected zones and ensure the protection of these zones.

3 Zone Protection

The third category for flood protection is zone protection. From the planning point of view, protected zones are very important, because they have to be incorporated into the spatial plans (cf. Sec. 7 para. 3 ROG). One can distinguish three types of protected areas with relevance to flood protection: flood plains, areas endangered by floods and areas where floods originate.

Flood plains are regulated in both legal systems, even with a similar definition, cf. Sec. 31b (1) WHG, Sec. 66 (1) Vod. zák. However, there are differences in the specific legal implementation as well as in the resulting implications. In general, flood plains are all areas inundated by floods. In Germany, the ability to determine an area as such depends on a certain return period higher than once every 100 years, Sec. 31b (2) WHG. In Czech law, the return period is not fixed, but variable. However, an active zone is defined as one which carries the major amount of water flow, Sec. 66 (2), 67 Vod. zák. This zone normally only covers a part of the area inundated by floods with a return period once every 100 years. There are also differences in some allowed uses of flood plains, for instance in agriculture. Otherwise, the legal restrictions in the German flood plains are similar to the ones in the Czech active zones. This holds for instance for the permission of individual structures as well as for new built-use zones, cf. Sec. 31 (4) WHG, Sec. 67 (1) Vod. zák.

Another class of protected zones is the so-called **area endangered by floods**. This term is based on Sec. 31c WHG distinguishing two categories of such areas: Flood plains, which do not require determination according to Sec. 31b (2) sent. 3 and 4, because flood events have a return period higher than once every 100 years, and areas at risk of flooding in the case of failure of flood protection installations. For both categories, Sec. 31c WHG obliges to identify these areas and to implement appropriate protection measures. In the Czech Republic, such a class does not exist, however, this type of area is regulated in the Czech water law as well: Partly corresponding to the first category in Sec. 31c WHG is the area “outside the active zone” where the water authority may stipulate restrictions, Sec. 67 (3) Vod. zák. The second category mentioned above has its counterpart in the so-called territories exposed to a special flood danger, Sec. 69, 64 (1) Vod. zák. Such areas have to be determined in an emergency plan according to the Emergency Act No. 240/2000 Coll.

Areas where floods originate are a speciality in the legal regulation of Saxony. These areas are characterised by fast surface water flow in the case of heavy rains or melted snow, leading to a danger of flooding in rivers and in consequence to considerable danger for public safety (Sec. 100b Saxon Water Act) [17]. The aim of the determination of such areas is the obligation to maintain and improve the natural water retention potential. This implies restrictions for installations in the outer zone, construction of new streets, change of forest and grassland into farmland. Again, in the Czech law, such a category is not known. However, the function is given by the protected areas of natural water accumulation, which are declared by regulations of the government (Sec. 28 Vod. zák.). While the intention to define those areas is in the protection of the water resources in the areas, the practical realisation of this aim is comparable to the Saxon areas where floods originate (prohibition of reducing and draining of forest land). Finally “areas with accelerated flowing-off of precipitation and insufficient water retention” are addressed in the river basin district plans (part D 1.5, annex 2 decree No. 142/2005) [18].

IV Conclusions

The analysis of the legal situation in the fields of flood protection and spatial planning has shown that in both states a lot of new legal instruments have been introduced in the last few years. The comparison of these instruments reveals many common features, but also differences. However, transnational cooperation does not require “uniformity” of the legal regulations. It is sufficient if the contents of the instruments are “conform”, that means that they ensure certain standards and don’t include contradictions. In this sense, the German and Czech regulations of flood protection and spatial planning are conform in principle. However, the implementation of these instruments is still in its early stages. The transfer into practice is hampered by long implementation deadlines and immature methods. Consequently, special attention should be paid to the administrative implementation of the numerous new instruments in future. In this context, transnational cooperation has to be continued and further intensified. Moreover, new legal developments have to be considered, especially the coming into force of the Floods Directive,

which will make an important contribution to the harmonization of the instruments of preventive flood protection in all Member States in the EC.

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Preventive flood management measures in the Elbe river basin by transnational spatial planning - ELLA (INTERREG III B CADSES)

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Abstract

Preventive flood management in transnational river basins can only be handled in transboundary cooperation, either institutional or informal. In 2002 deficits in the Elbe river basin were identified especially regarding the integration of relevant regional spatial planning institutions. The INTERREG III B CADSES project ELLA aimed at working out flood hazard information and maps, implementing these into regional plans and pilot projects, disseminating the knowledge in awareness raising campaigns and working out a transnational strategy as agreement of the partners about a long term cooperation of spatial planning in the Elbe River Basin.

The ELLA results demonstrate clearly that the regional and national spatial planning and water management authorities are willing to work in close cooperation to fulfil the demands of land use management in risk areas. The implementations in the pilot projects demonstrate approaches for land use planning to respect the limits for secure developments as result of risk assessment. By this means a contribution is made to the planning strategies and policies in Germany, Czech Republic, Poland, Hungary and Austria to adjust to risk prevention throughout the river basins. This is the key issue of the joint ELLA strategy for spatial planning for preventive flood management in the Elbe river basin. The agreement about the implementation of a long-term cooperation was undersigned in Dresden, Dec 6th 2006.

Keywords: Preventive flood protection, Elbe river basin, transnational cooperation, spatial planning

1 Characteristics of the project

The ELLA project was developed in 2002/2003 after the disastrous Elbe flood. In this event once again the necessity of the transnational co-operation in terms of preventive flood protection became obvious. This project shows that the spatial planning authorities in the Elbe river basin are aware of their duty to contribute to risk management.

The project was supported on a wide base by nearly all regions in the Elbe river basin and national state authorities. Lead partner was the Saxon State Ministry of the Interior. The partnership covers the whole Elbe river basin and the relevant disciplines. In total, ten Czech and ten German partners as well as one partner each from Austria, Hungary and Poland participated in the project. The Partnership consists of spatially relevant authorities from 5 nations:

- 13 spatial planning authorities, 6 water management and environmental planning and 2 agriculture planning bodies as well as 1 national hydrological institute.
- 5 national, 14 regional and 2 local authorities as well as 1 national institute.
- External experts are involved in special activities like mapping and accompanying studies.

The project was supported by the European Union as part of the INTERREG III B programme with funds from the European Regional Development Fund (ERDF) and by the PHARE programme.

2 Transnational action programm for coordinated flood prevention

The action program, which was prepared by the transnational partnership and mutually agreed in a complex process, contribute in particular to the coordination of cross-border activities in spatial planning. Here, local activities are just as necessary as those at a regional or state level. The action program comprises:

- Legal basis and recommendations
- Transnational fields of activity

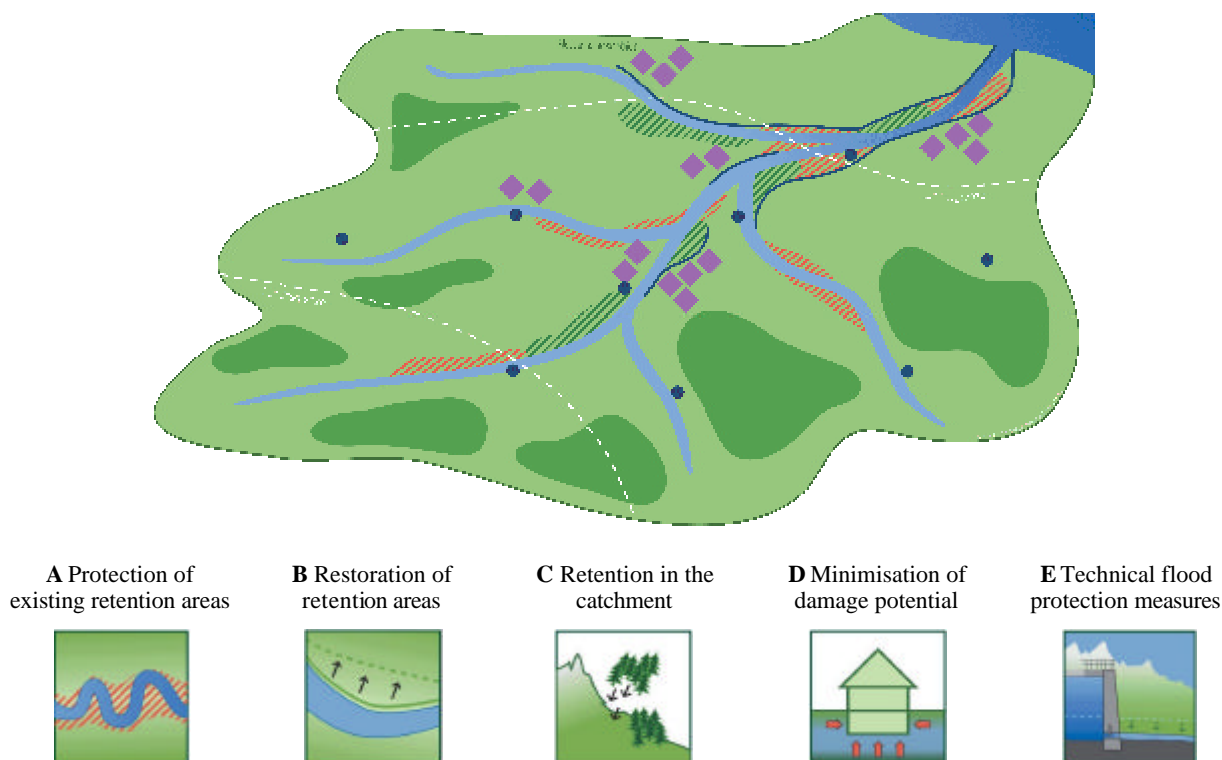
- Water management recommendations
- Recommendations for spatial planning in the regions
- Recommendations for an increased awareness of the flooding problem

The proposed actions are accompanied by maps, etc. indicating where the proposed measures are to be taken:

- Hazard information maps (Elbe Atlas)
- Diagrams and maps of the fields of activity

The frameworks of the action program are the national regulations and guidelines for action. The flood action plan of the ICPE was taken into account while developing the fields of activity for the ELLA recommendations. The measures for (transnational) planning in connection with defined fields of activity (see figure 1) are the basis of the action program and the defined recommendations. Integral part is the cooperation with and input by the water management sector.

Figure 1. The five transnational fields of activity of the ELLA strategy



Further results (see table 1), which were generated during the cooperation between 2004 and 2006 and which led to the action program, are e.g.:

- Flood hazard indication maps for almost all parts of the river basin (Elbe Atlas)
- Regional planning strategies for the pilot regions which shall be implemented
- The structure for the transnational strategy and general subjects
- Completed Simulations of measures of technical flood prevention throughout the river basin
- A new methodology for flood prone areas
- New local hazard maps for zoning and disaster management
- Flood management system in the pilot project Stendal (already used in the flood events 2006) as well as three other pilot actions completed (four others to be completed)
- A strategy for the awareness rising campaigns
- Negotiations with regional planning authorities about contents of spatial development plans.

Table 1. Overview of ELLA studies and reports (available for download on www.ella-interreg.org)

Language	English title
Proposed actions (Results brochure)	
DE, CZ, EN	Preventive flood management measures by spatial planning for the Elbe river basin - Results and proposed actions
DE, CZ, EN	10 theme flyers with results overviews
Legal and spatial planning studies	
DE	Flood protection and spatial planning law in the German catchment area of the Elbe
CZ, DE	Flood protection and spatial planning law in the Czech catchment area of the Elbe
DE	Legal environment of cross-border flood protection in the Elbe catchment area
DE	Integration of preventive flood protection into spatial planning using the example of transnational pilot projects in the Elbe catchment area
DE, CZ	Short and extensive reports of the nine pilot projects
Water management studies	
DE	Municipal flood hazard maps for Glauchau, Meißen, Torgau, Radebeul
DE, CZ, EN	Interactive flood hazard maps Glauchau, Meißen (INGE Software)
CZ	Determination of the spread of pollution from industrial plants along the Elbe during flooding events
DE, CZ, EN	Development of a methodology to identify runoff generation areas
DE	Model-supported evidence of the effects of planned retention measures in Saxony and Saxony-Anhalt on flooding along the Elbe
Other studies and reports	
DE	Report on the ELLA travelling exhibition, the regional conferences and expert workshops
DE	Summary of the on-going activities regarding flood protection relevant to spatial planning with reference to the ELLA project

3 The future perspective

Thanks to the EU support from the INTERREG III B CADSES program, it was possible to fulfil the wishes of the project partners in the Elbe catchment area for transnational cooperation. This funding gave the project partners the possibility to perform the transnational cooperation successfully. This support terminated at the end of December 2006.

It is especially remarkable that it was not only possible to meet the project target of working out a joint action concept, but also that this could be reviewed and agreed in a consultation process with the large number of project partners. Now, of course, the question arises as to what will happen in future to the work which has already begun and in particular to the transnational networks which have been created.

The project partners are unanimous in the opinion that long term cooperation is an important future target. In the three project years, much time had to be invested in building up the partnership in order to overcome language and administrative barriers and to understand the different working methods. The partners can now profit from the structure which has evolved and the high level of trust which has developed.

The partners have agreed that they will use EU-funding possibilities in the following years as well in order to be able to continue the cooperation. In detail, the partners envisage the following future tasks:

- Continuation / implementation of the joint transnational strategy and risk assessment and extension of the ELLA pilot results to the whole river basin
- Continuation of the implementation of the action plan for flood protection of ICPE, in particular the rapid realization of the flood protection measures requiring investment.

- The continuation and implementation of the agreed recommendations – here, in particular, an even stronger integration of water management concerns in regional planning. This includes the definition and safeguarding of hazard zones in regional planning on the basis of the flood hazard maps which have been produced. In Saxony, this process is on the road to completion but it must still be fully carried out for the whole Elbe catchment area.
- Further publicity raising activities, integration of communities (and industry)
- Adjustment with EU directives for flood risk management and river basin management (WFD)
- Realization of retention polders with instruments of water management and spatial planning
- Urban development in flood endangered areas.

According to the convictions of the project partners, the transnational cooperation in the field of spatial planning in the Elbe catchment area should, in future, also encompass further important spatial planning concerns of catchment area management, and thus provide a contribution to the solution of current land use conflicting interests in the river valley. The current subjects under discussion here are for example: the river as a transport route, tourism along the river valley and nature and landscape conservation in the Elbe valley.

In 2007, the concrete interests of the project partners for the future will be exactly defined and evaluated. On this basis, contacts are made with further potential associates. The German Federal Office for Building and Spatial Planning provided funds for this purpose. The application for follow-up projects is planned for the end of 2007.

For more information: www.ella-interreg.org

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The Project ELLA was initiated by the Saxon State Ministry of the Interior. On the national level it was supported by the German Federal Ministry of Transport, Building and Urban Development. The Czech Ministry for Regional Development coordinated the activities of the Czech project partners. In addition many formal and informal partners worked with high commitment in the working groups and working packages or in pilot projects. Especially a project designed as ELLA with a focus particularly on regional and local target groups depends on the active involvement of relevant regional authorities.

The authors at the company INFRASTRUKTUR & UMWELT, Professor Böhm und Partner took over on behalf of the project partners the external project- and financial management as well as the scientific coordination of the project ELLA. The scientific focus was primarily in the field of spatial planning and flood protection.

Flood hazard maps - Basis for risk mitigation

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Abstract

Floods that injure people and ruin property are striking more and more often as an increasing number of people is living in urban centres mostly along water ways. Climate change also seems to have an impact on the occurrence of flood events. Despite of defensive measures, floods will never be under absolute control. Therefore flood management has to be integrated into fields such as spatial planning, legislation and alert- and alarm planning. At the same time flood awareness of residents has to be strengthened. These points can successfully be tackled by having a solid and comprehensive basis to start from: flood hazard maps.

The clue information of flood hazard maps is the display of water depth and flood extent for several recurrence intervals. Generally spoken, the flood hazard maps significantly minimize the threat for lives and the risk of damage.

Due to the co-operation with relevant stakeholders and authorities as well as the exchange with other European partners, in the course of the Interreg IIIB project SAFER, the experience of Baden-Württemberg's mapping process can be taken as an example and transferred to other catchments easily.

Keywords: Flood hazard maps, damage mitigation, definition of floodplains, users of flood hazard maps, Interreg IIIB project SAFER.

1 Introduction

According to studies, floods are the most damaging of all natural disasters [6]. Civilization is increasingly vulnerable to this phenomenon due to the following reasons.

Last century the world's urban population increased five times as much as the population in rural areas. Lately, this movement brought the number of individuals in the world's urban centres up to half of the world's population [7]. Taking this trend to the regional level, Baden-Württemberg's population, increased in the last 100 years by 260 percent [2].

Space for development is a scarce resource and an especially precious item in urban areas. Most cities and towns are located along water ways. Thereof a considerable amount of buildings and infrastructure is situated in former floodplains. The influx of new residents is pushing cities to make more land available for housing, commerce and industry. This often results in built-up areas being close to rivers and at risk of flooding. Generally the soaring population is settling river valleys more and more intensively. An example thereof is the map comparing the situation of the 19th and the 20th century in the Neckar valley (see Figure 1).

Climate change is quite likely a new driver towards more severe flood events. Just lately researchers outlined that human activity, especially the raising output of greenhouse gases, is changing the distribution of rainfall across the globe. According to the climate models, there is a significant increase of precipitation in the northern Hemisphere [1].

Summarizing, these conditions are putting a dimbing pressure on water managers. Realizing the need for action, Baden-Württemberg's cabinet brought about the decision in 2003 to publish a guideline on "Flood Risk and Strategies for the Mitigation of Damage in Baden-Württemberg". Therein an urgent need for flood hazard maps that indicate water depths and extent with varying recurrence intervals is expressed.

Since then, the federal state of Baden-Württemberg is preparing flood hazard maps. The hazard maps of the Neckar catchment, being the state-wide pilot of the mapping approach, are part of the European funded Interreg IIIB project SAFER.



Figure 1. Comparison of the situation of settlements in the upper Neckar river valley in the 19th and 20th century [2]

2 The Interreg IIIB Project SAFER

SAFER (Strategies and Actions for Flood Emergency Risk Management) aims to develop innovative strategies and prevent and mitigate fluvial and coastal flood damage by working with organisations and agencies at different levels in various European countries. The five project partners are adopting a common approach in implementing these strategies. The project is approved under the Interreg IIIB north-west Europe (NWE) Programme and part-funded by the European Union (ERDF) [3].

Besides the flood hazard mapping, the SAFER partners work on two supplemental components to achieve the project goals: flood partnerships and flood emergency management. Flood hazard mapping is, however, the major part in the Neckar catchment being the German project region.

SAFER will come to an end in the middle of 2008 and will have received an EU-funding of more than €6 million. At this point in time the flood hazard maps for the Neckar catchment will be worked out. For more information about the project log on: www.eu-safer.de.

3 Flood hazard maps in Baden-Württemberg

The hazard mapping incentive actually was initiated by the Municipal Congress, the Council of Cities and Towns and the Association of the Districts of Baden-Württemberg; being a bottom-up approach. Finally the lead-management was assigned to the Regierungspräsidium Stuttgart (Regional District Authority) – this authority is also the lead partner of the SAFER project.

Since the very beginning the mapping is done in a very close co-operation with all stakeholders, regional governments and local communities. For the contents of the hazard maps water management authorities, special and regional planning institutions, fire brigade and disaster management have been queried of what kind of information would be useful. For instance, the fire brigade and the disaster management mentioned a certain grading of the water depth. By getting this specific information, adequate vehicles can be allocated and evacuation plans can be worked out etc. [5].

The flood hazard maps of Baden-Württemberg indicate where floods will occur and how deep the water will be; in each case for different recurrence intervals (10, 50 and 100 years as well as the extreme event). Figure 2 and 3 provide an example of the map type 1 (depth) and 2 (extent).

To date, the processing state of the flood hazard maps can be described as following: the demand analysis has been completed, the survey and digital terrain model are soon to be finished and the hydraulic computations are on the way. First hazard maps are published and can be accessed on the Internet. It's planned to publish the remaining maps for the federal state till 2010.

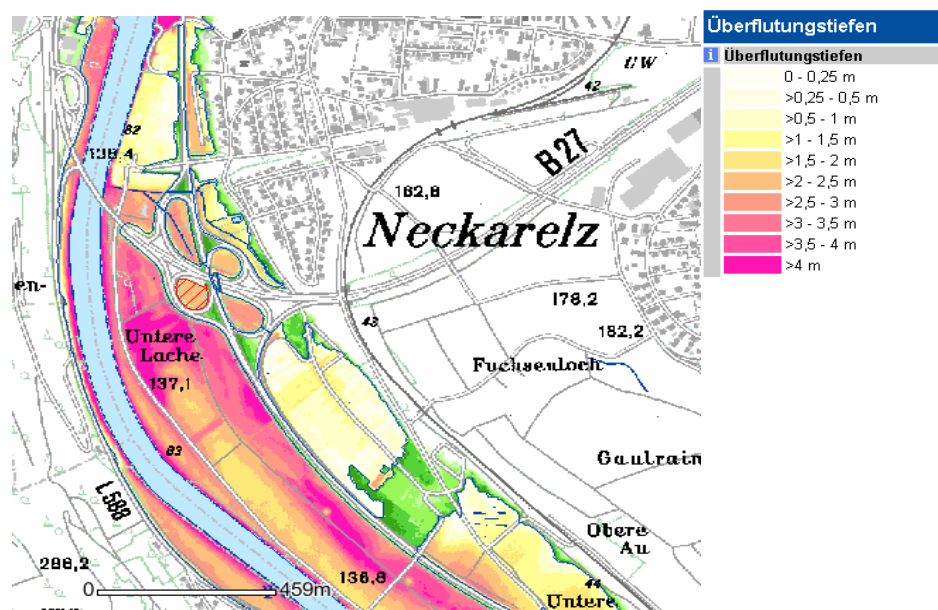


Figure 2. Example of a flood hazard map showing the inundation

3.1 Legal impact of the flood hazard maps

Embedded in the Water Act of the federal state of Baden-Württemberg the flood hazard maps have a very strong legal impact. The maps define floodplains and flood risk areas and have an instant effect on, among others, water management, spatial planning and agriculture. For instance, in the flood core area - land inundated by a 10 year event - the reversion of grassland is prohibited. The expansion of settlements in floodplains is only possible as an exception and in agreement with the water management authorities. Depending on the protection grade there are strict requirements that apply to the storage of substances hazardous to water.

In the future, regional plans will assign areas to one of the following two categories. Priority areas: intended as preventive flood protection and to avoid the risk of new damages, to conserve and activate natural floodplains as well as to maintain the possibilities of the development of water bodies and the restoration of floodplains. And reserve areas: intended as preventive flood protection and for the mitigation of damage risk [5].

4 Flood hazard maps for different target groups

Flood hazard maps are a product which is useful to a huge variety of individuals, institutions and organizations. In the following section, however, there is only focus on a few end users. At the same time water management, special planning and insurance companies do considerably profit from the mapping results.

The general public has several essential benefits. Firstly, people can use the information and superimpose recommendations of quick and inexpensive ways to prepare a house or apartment for flood events and thereby prevent major damage. Secondly, flood hazard maps display when, where and to what height water will rise. People can establish their own alert and action plans.

Flood risk maps are a useful tool to decide whether structural steps should be taken. In this way, buildings in risk areas can be protected using special building materials and, e.g. electronic and heating appliances can be moved out of the cellar and into the upper levels [4].

For local authorities and municipalities the flood hazard maps e.g. form the basis for alert and action plans. Each authority must evaluate and plan preventive measures that are required in relation to potential scenarios.

Equally, flood risk maps are likewise important for local authorities and municipalities in the regard of urban drainage. The maps indicate the effects of flooding on sewers, specialised structures and sewage plants. They also show which "low-lying areas", not directly impacted by flooding, might be subject to a flood risk through the sewer system. This makes it possible to determine design and operational measures to protect drainage facilities as well as residential areas [4].

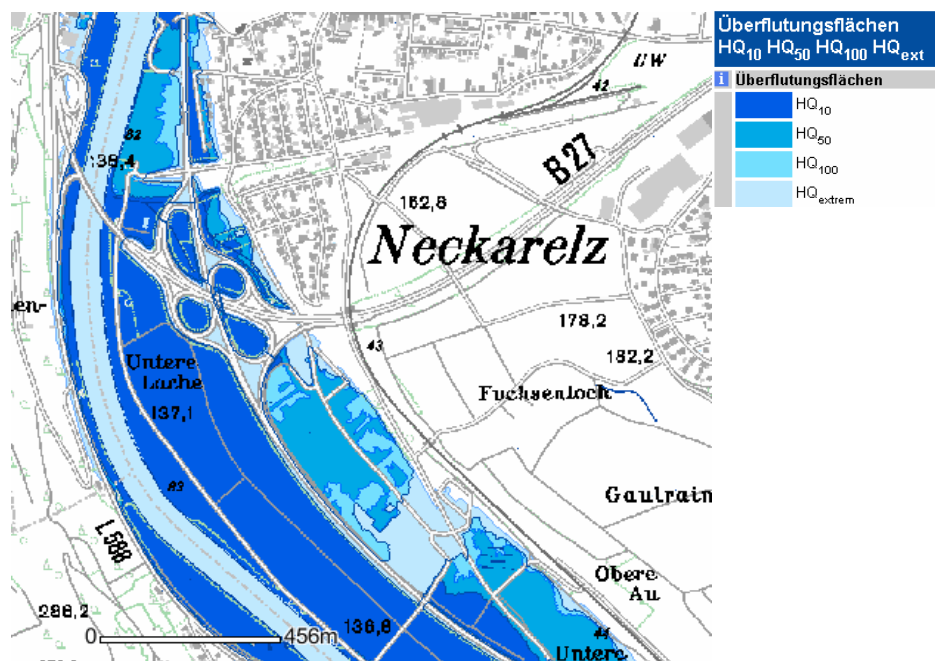


Figure 3. Example of a flood hazard map showing the water depth

Industry and commerce do have often to bear extreme flood damages. It is therefore particularly important to have a basis for the creation of alert and action or evacuation plans. The maps enable the companies to put up plans for flood defence and for the evacuation of production facilities.

Companies can also use the maps to check the level of risk to facilities that house water-hazardous substances and identify, where necessary, whether they need to be retrofitted. In addition to such advantages for industrial and commercial business, other companies – often those with multiregional interests – can also benefit, e.g. major energy providers and public transport providers, who can use comprehensive flood hazard maps to further adapt and safeguard their infrastructure [4].

5 Provision of flood hazard information

The general public can access the hazard maps via the Internet for free. The viewer provides both types of hazard maps to a scale of 1:5,000 (<http://www.hochwasser.baden-wuerttemberg.de/servlet/is/15783/>).

For local authorities and municipalities a new feature has been developed, the print-on-demand viewer. Therein the user can choose type, scale and location of interest according to its needs and send an order to receive all that as print out. The print-on-demand viewer allows a very flexible and user orientated way of providing the hazard maps that for instance is not settled on a fixed sheet line systems.

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GIS instruments and high resolution DTM to define risk flood areas

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Abstract

The Plan of Basin is the tool used by Italian Authority of Watershed to guarantee the hydraulic safety, the correct use of the water resource and the guardianship and management of Italian field. Particularly a detailed program for the flood defence contains the delineation of flooding risk areas and the actions to reduce the hazard to human life and the damages when a catastrophic flood event occurs. For these aim hydrodynamic studies has been carried out along the major rivers of Basilicata Region, in order to create flooded area maps. The present work shows GIS applications as instruments to support a more correct definition of flooding risk areas. The study area is Basento River in southern Italy and the software used for the hydrodynamic simulations are: Hec Ras (for mono dimensional studies) developed by the Hydrologic Engineering Centre; MIKE Flood developed from Danish Hydraulic Institute for bidimensional study in coastal plain. The river cross sections are obtained by grounded topographic relief in the first case, by laser scanned data in the second one. The GIS has been used either as input or as output of the hydraulic modelling. In the first case it has allowed to integrate the information about planimetric development of river and grounded cross sections through a detailed DTM (Digital Terrain Model). In the second one, the water surface elevation and top width achieved in riverbeds, for each hydrodynamic simulation, has been used with GIS software to draw the different flooded area maps. In particular differences between the results obtained using an automatic interpolation of cross sections with the HecRas tool and those obtained using river cross sections extracted by DEM are been evidenced. For the coastal plain, with the use of laser scanning techniques is possible apply bi-dimensional hydrodynamic model with accuracy data and more correct to describe the hydrodynamic motion on flat areas.

Keywords: Risk flood, hydrodynamic models, laser scanner data, DTM, GIS applications.

1 Introduction

Current Italian land protection legislation identifies the River Basin as the ideal territorial unit for research and action aimed at land protection and conservation of water resources. It is a complex environment where problems arise from the interaction of numerous factors including fluvial dynamics and slope stability as well as natural and anthropic phenomena. The location and delimitation of the hydraulic risk area constitute an important means for the application of planning programs of the hydraulic interventions. The Italian Basin authorities identify these areas in different ways, in relation to both flood risks as well as to possibilities of natural and environmental restoration. This paper presents studies aimed at the determination of areas of fluvial pertinence within the framework laid out in the Basilicata PAI; the flood propagation has been simulated with two models: Hec-Ras developed by Hydrologic Engineering Centre, of USACE for the mono dimensional solution and MIKE 21 (Danish Hydraulic Institute) for the bi-dimensional one.

2 Area of study

The area under study, Basento river basin, 157 km long, covers about 1500 km² and belong to the districts territory of the inter-regional watershed of Basilicata, figure 1. Basento River presents different morphologies: incisions in rock formations or strongly cohered terrain, steep/pools, flood plain, braided or bar braided, anastomosed, meandering et cetera [1]. Each morphology requires suitable hydrodynamic models in order to define the flooded areas.

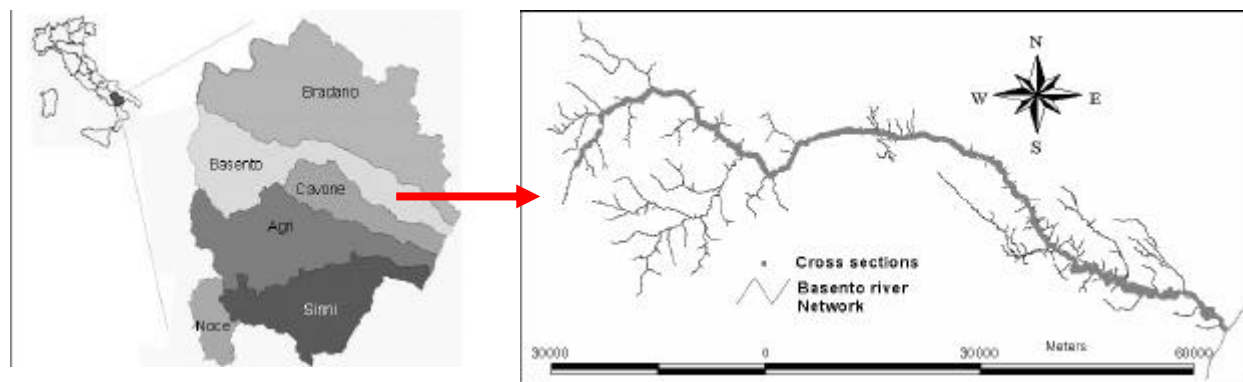


Figure 1. Districts territory of the inter-regional watershed of Basilicata with Basento river basin and river network

3 Methodology applied

Data collection – At first a protocol for a survey of river cross sections and their granulometric characteristics was defined. Surveys of about 560 cross sections were carried out along the main river course, fig.1. These included all the water works and all the river crossings and surveys were also carried out of the longitudinal profiles of the embankments. All the georeferenced and duly coded information was memorized in a geographic data base and superimposed on ortophotos with 1:5000 scale. In order to experiment new survey methods coupled with hydrodynamic simulation models, several surveys, in coastal plain, were carried out using laser scanner technology. The scanned area covers a fluvial strip which extends for about 3.5 km on both the hydraulic left and right. The functioning principle of laser scanning lies in the scansion of the territory from the aircraft platform using a telemetric laser, which measures the distance from the area in terms of the time taken by the laser beam travelling at the speed of light, to complete a return journey. Knowledge of the position and the condition of the aircraft at every moment which is usually assured by the integrated system GPS-INS facilitates the identification of the points in space which reflected the laser beam. The first product of the scansion laser is a cloud of points which constitute the DSM (Digital Surface Model). These points can be utilized directly or elaborated to calculate the value of a regular grid using interpolation filter techniques. Starting from a DSM it is possible to generate a Digital Elevation Model and a Model Keypoints (MKP) containing data considered to be key points of the digital surface. In the case under examination the utilization of MKP permitted the generation of bathymetry, useful for bidimensional simulation. The vertical accuracy of DTM is fundamental in the floodplain extend calculation, in very flat areas small differences in elevation values may extend over several meters.

Hydrologic model - The hydrologic study, utilized for the estimation of flood risk in any given section of the river network, is based on peaks methodology VAPI already carried out in the Basilicata region by Claps & Fiorentino [2]. This methodology makes reference to a probabilistic approach for the estimation of maximum annual peak flows. To reduce uncertainties related to the presence of very rare extreme events and to the spatial variability flood index, a methodology of regional analysis was adopted which also used conceptual models of the formation of stream flow caused by the heavy precipitations recorded in the basin. This approach allowed the use of all the hydrometric and pluviometric information of a given area. A two component extreme value (TCEV) [3], probabilistic model was adopted which interpreted maximum annual events as a result of a combination of two distinct populations of data: one producing ordinary more frequent but less intense maximum events, the other giving rise to less frequent but extraordinary and often catastrophic events. A number of river sections, largely corresponding to the principal affluent on the water courses under study, have been identified and their catchments areas calculated. In these river sections the mentioned method VAPI, has been applied and flood peaks have been computed for two different return periods: 30, 200 years.

Hydrodynamic models - The hydrodynamic data were calculated using two well known and consolidated hydrodynamic models: HEC-RAS (River Analysis System) developed by the Hydrologic Engineering Centre, of the United States Army Corps of Engineers, with HEC-GeoRAS ArcView extension, [4], and Mike Flood of the Danish Hydraulic Institute Water & Environment, DHI [5], [6],[7]. These models can be linked to GIS systems to preprocessing and post-processing modules. The first one has been used for monodimensional simulation in incise river branch (in rock formations or strongly cohered terrain), the second one in flood plain and in meandered

branch. The MIKE flood by DHI Water & Environment was utilized allowing the dynamic coupling of the bi-dimensional code MIKE 21 and the one-dimensional MIKE 11, under unsteady flow conditions.

4 Results and conclusions

Remembering the aim of study, the steps of elaboration can be resumed:

1. verify the hydraulic results obtained in sections automatically interpolated by software HEC-RAS starting from ground surveyed sections
2. comparison with same results obtained in sections extracted from Triangulated Irregular Network (TIN) generated by topographic map 1:5000;
3. comparison of results in flat areas obtained using TIN DTM data and Laser scanned data.

In the Hec-RAS model, it is possible to generate interpolated sections between two ground surveyed sections in order to reduce the spatial variable dx of numerical resolution. The interpolation algorithm traces cord between significant points of considered sections. The master cords joint extreme points of two considered sections and talweg, minor cord are automatically generated by software joining proportionally, between master cords, the remaining point of the considered sections. Here an interpolation dx equal to 20 m has been used.

In order to obtain river cross sections from DEM are necessary, in ArcView, some elaborations such as creation of TIN Model starting from available grid, 5m x 5m resolution (extracted by horto-photomap 1:5000), integrated with hard break lines representing: - the river talweg, - the cross sections ground surveyed and embankments; in fig3b is reported a sketch of TIN. With a suitable ArcView script numerous sections are extracted from TIN DTM, specifying the dx step, fixed equal to 20 m, fig 2a. In this manner has been obtained in the same position sections generated by Hec-Ras and sections extracted by TIN. For example in fig 2b is reported the comparison between sections extracted by TIN and interpolated by Hec-Ras, referred to fig. 2a.

Such types of differences are frequently when there are abrupt variations of river width, waterworks or the distance between the ground surveyed sections is too much. Hydrodynamic data obtained using the different sets of sections are reported automatically in ArcView through another suitable *script* and in fig 3 and fig 4 the differences in terms of hydraulic height and top width are reported.

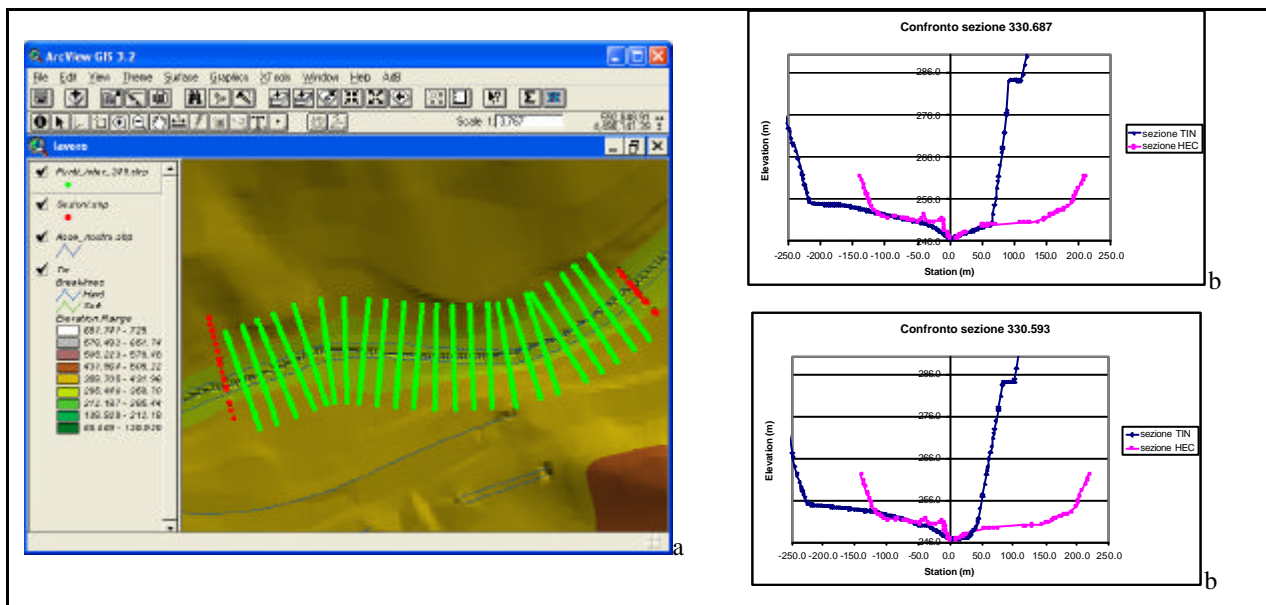


Figure 2. Sections comparison included between the ground surveyed BST_261 e BST_262 (red HEC, Blue TIN)

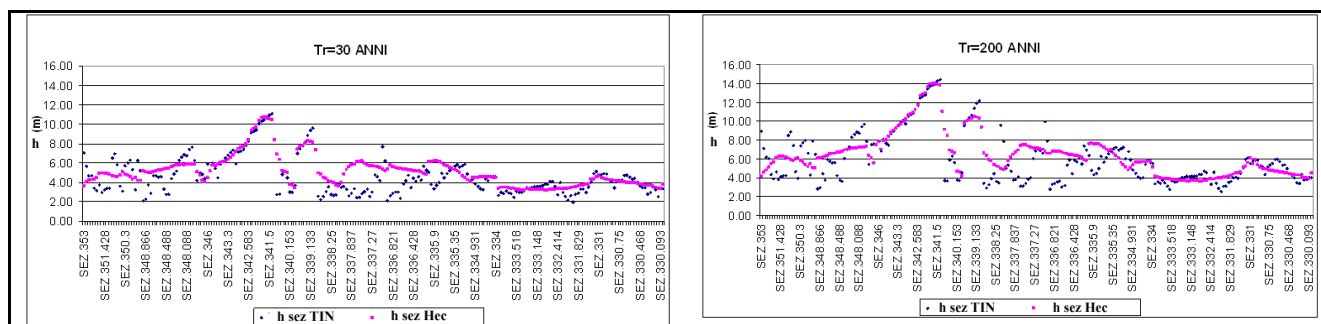


Figure 3. Comparison between hydraulic height in sections extracted by TIN and obtained by Hec interpolation for QT30 and QT200

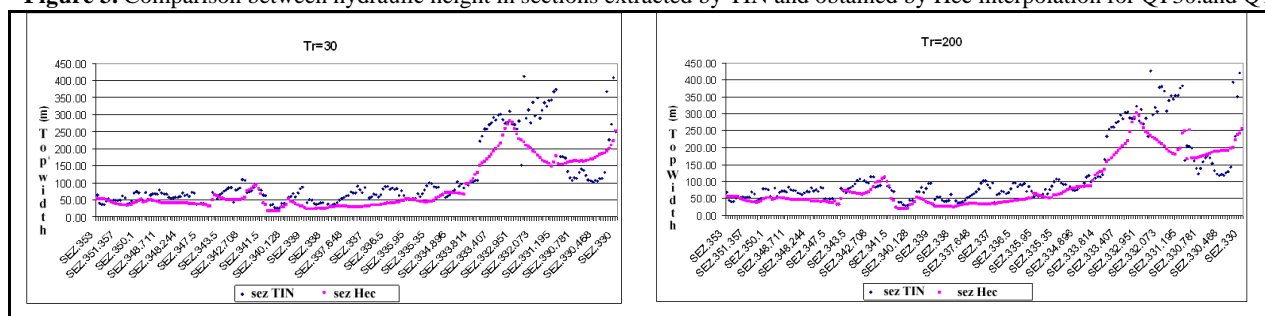


Figure 4. Comparison between top width in sections extracted by TIN and sections obtained by Hec interpolation for Q30 and Q200

For the very flat areas even data extracted by TIN (generated by 1:5000 topographic map), are inadequate to represent the flooded areas. In such cases are necessary more accurate surveys[8]. Laser scanner technology [9] is a very powerful system to represent the Digital Terrain Model and Digital Surface model in very accurate manner useful to describe topography, vegetation and antropic manufacture such as building or infrastructures, data necessary for a more correct hydrodynamic simulation. In fig. 5 is showed the differences between flooded areas evaluated by monodimensional model with above mentioned TIN data and those obtained by application of MIKE Flood with laser scanning data[8]. It can be noted that for QT=30 the mono and the bi-dimensional model have the same behaviour because the discharge is fully contained in the main channel. For QT=200 bi-dimensional model return values that correctly take into account the terrain morphology.

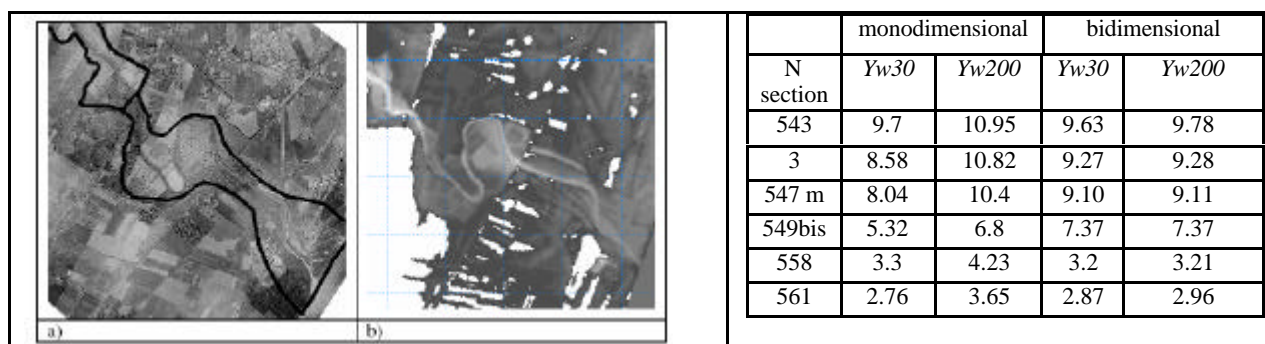


Figure 5. Flooded areas for QT30 a) monodimensional – b) bidimensional and relative hydraulic height differences

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Community Preparedness for Disaster Risk Reduction in Central and Eastern Nepal: A Case Study

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1 Introduction

DIPECHO_CPDRR¹ (Community Preparedness for Disaster Risk Reduction in central and eastern Nepal) is a project that enhances the capability of local communities to prepare, mitigate and cope with disasters. Supported by the European Commission through its Humanitarian Aid Department, the project focuses on establishing Disaster Management Teams at the lowest level (village). The Project support is directed towards securing lives and livelihoods of the poorest, which are disproportionately affected by, and vulnerable to disasters. The project worked in three Districts of Nepal. Kathmandu valley, where it focuses on earthquake preparedness and in Jhapa and Rauathat Districts where the focus was on flood preparedness

In the current program the local communities were the entry points, and need based skill training was given to enhance their knowledge of Disaster Preparedness. Thereby, the project strategy improved the local coping mechanisms through organization, training, mobilization, preparedness plans, small-scale mitigation schemes and linkages with local, regional and national institutions.

The project established 364 Task Forces to respond effectively before, during and after disasters; and 734 masons/ technicians are trained to apply earthquake safety construction skills.

Time Frame: February 15, 2006- July 15th 2007 : Country of Operation: Nepal

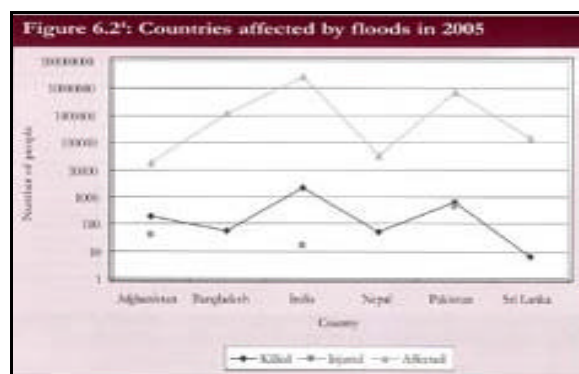


2 Background

Nepal is exposed to several types of natural disasters, such as floods, landslide, earthquake, fire, and droughts. The rugged and fragile geophysical structure, the very high angle of the slopes, complex geology, variable climatic conditions, unplanned settlement, the dense and increasing population, the poor economic condition and low literacy rate have made Nepal vulnerable to various types of disasters. The constant tectonic action of different degree along with the varied intensity of weather condition has had a diverse effect on the stability of the earth's surface and impacted on the flow of the rivers... The Himalayan region of Nepal is one of the severest flood prone zones. Beside heavy precipitation, high wetness and steepness of the watersheds and river channels contributes to flood magnitudes. Mainly, the middle hills are prone to landslides and the plains are prone to flood and fire. These disasters occur almost every year in one part of the country or the other causing loss of life and heavy damage of

¹ Paper presented at the WaReLa Conference on Integrated catchment Management for Hazard mitigation " September 24-26th, Trier, Germany

property. According to the statistics available 26,059 people have died due to natural disasters between 1997-2005, out of which 2,812 have been caused by floods. The present onslaught of heavy rains (July – August 2007 Nepal) is causing a national crisis with reported weather forecasts, showing no respite for the weeks to come.



2.1 Target population

The aftermath of disasters brought on by the onslaught of the monsoon, especially creates “vulnerable” peoples, effected populations, at risk due to the proximity to high flooding areas. In the case of Nepal, they are “doubly marginalized” due to the social discrimination they face as being groups categorized as ethnic minorities, Dalits¹, living on nutrient scarce lands, or landless tenant subsistence farmers. *For the poor, vulnerability is defined as a measurement of resilience to the shock, triggered through an event, in this case floods, landslides, earthquakes, cut off from basic facilities, loss of livelihoods and lands, resulting in the decline of their wellbeing.*

2.2 Project Focus

In an attempt to mitigate the damages caused by the flash floods/floods in the Terai² Districts DIPECHO – CPDRR attempted to include such peoples in the project initiatives through:

- selection of vulnerable areas/communities through Participatory Vulnerability Analysis and hazard mapping. Mobilization of communities through motivational training, with community volunteers acting as facilitators/negotiators with the community
- Formation of Task Forces and Disaster Management Teams. There are 52 DMTS, each consisting of 7-8 Task Forces, who were trained in skills like First Aid, Search and rescue training for flood situations, leadership and communication, PRA and Gender orientation, construction of bio engineering works,
- All DMTS were equipped with Emergency kits and trained on their maintenance and usage
- Initiation of Small scale Mitigation works like checkdams, tree plantations, rehabilitation and repair of river spurs, culverts, minor bio engineering works, etc
- The Project ended with mock drills conducted by each community DMT, along with the involvement of the local district authorities, and other community members.

3 Lessons learned³

Involvement of the communities in work that was of interest to them, which created community ownership for DIPECHO initiatives. Social inclusion of vulnerable groups was taken into consideration by communities. Community based approaches bridge the gap between local government and the communities

¹ Dalits: people belonging to the occupational castes, differentiated as being “untouchables” by the Hindu caste system

² Vulnerable perception of Disaster, paper presented at DPRIL IIASA, 3rd International Conference on Integrated Disaster Risk Management, July 3-5, 2005, Kyoto, Japan. Author: Komal Ray Aryal

³ Terai: Plains area of Nepal spanning the entire country from east to west, where most downstream populations are located.

Task Force Formation through communities mobilization in a country during a transitional peace process, was an uphill task, but achievable as people saw/understood the importance of preserving their resources, beyond partisan politics. Communities support and protect what they contributed to, and which strengthen their traditional coping mechanisms first.

Communication Use of simple language for community should be in a sensitive language / manner in line with traditions but mixed with new ideas and strategies. Messages should be closely related to the realities of target groups. Local and indigenous knowledge should be integrated in the development of awareness raising methods. Use of locally acceptable communication methods for information communication and awareness raising are important.

Small scale mitigation works are a good incentive for community mobilization and were discussed and planned with community and also cross-checked with technical experts. They were the biggest success in bringing about community cohesion, participation of men, women from socially marginalized groups. The visibility and success of the mitigation works also established credibility with warring groups in an area of armed conflict nevertheless contingency plans should address the limitation of small scale mitigation, capacities of communities for disaster preparedness, provide appropriate support systems and linkages to strengthen the same. In small mitigation works both downstream and upstream communities should be involved to avoid conflicts and one should consider conditions to replicate /upscale (cost effective, local technology)

Unplanned road and infrastructure construction in watersheds and upstream areas create hazards for downstream communities that are difficult /impossible to mitigate



4 Challenges

Any effort at hazard mitigation, disaster preparedness, capacity building of communities to respond cannot be a “quick – fix” method. Understanding the nature of the hazard, the communities it will impact upon and the nature of the donor perspectives is the biggest dichotomy in what one would wish to do. With due respect to the intention there were challenges that were particular to the context as stated under

- The short duration of the programme was not enough to be able to better monitor, upscale and link activities to government initiatives
- Political unrest and access to communities was restrained due to frequent calls for closure of roads, strikes, peoples movement, security threat to staff, flash floods.
- Early warning systems for flash floods were inadequate due to short lead time for this hazard; uneven playfield between different countries in skills to DRR
- How to incorporate DP into emergency response?
- DRR / DIPECHO targeted at the secondary priorities of communities. Livelihood was not number ONE priority
- Integration of women in operational issues was difficult due to the socio – cultural context, even though women were de facto heads of households
- Other donors do not prioritise DP / DRR as part of their development focus.

- Organizations involved at local level and at the coordination lack understanding of DP/DRR
- Lack of HR expertise, They was a definite lack of specialized services that would have strengthened the projects, like monitoring tools. Organizations were using methodologies that were difficult to standardize .
- Policy implementation at village level was difficult due to the large gap between Community Priorities and National strategies
- Remote areas which are hard to access due to the spatial spread of settlements in downstream areas
- Better coordination between donors and disaster preparedness projects in Nepal is needed and last but not the least

“Ensuring everybody knows how to react and what to do”

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Head of "Sections Forest Site" and "Soil Protection"

Project Manager

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Integrated River Basin Management and Flood Risk Management Planning in Germany

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Abstract

European water legislation demands from all Member States the establishment of river basin management plans (Art. 13 WFD) and flood risk management plans (Art. 7 FD). Coordination between both management strategies is intended (Art. 9 FD), but widely left to the Member States.

The analysis of intersections between river basin and flood risk management planning reveals numerous linkages and overlaps in the field of “naturogenic” and anthropogenic driving sources. The planning cycles offer both potential synergistic effects and conflicts concerning data requirements, objectives and the planning of measures. Hence, approaches for usage of synergetic effects and/or handling of conflicts between river basin and flood risk management planning are needed. Propositions for adjustment of both management approaches are made in this paper.

Keywords: European water policy, WFD, Floods Directive, river basin management, flood risk management, spatial planning, sectoral integration

1 Introduction: Planning instruments of European Water Policy

By adopting the Water Framework Directive (WFD, [1]) and releasing a proposal for a ‘European Directive on the assessment and management of floods’ (Floods Directive, FD, [2]) the European Commission is creating a common legislative framework for water policy in all Member States. Both directives use the instrument of plans as a strategy to achieve their objectives.

River basin management planning (RBMP, Art. 13 para. 7 WFD) aims at achieving a good ecological status of all water bodies by 2015. The flood risk management plans (FRMP, Art. 7 FD) are supposed to ensure appropriate levels of flood protection. Coordination between the two planning instruments on river basin level is intended (Art. 9 FD). The questions to be answered are at which planning steps of river basin and flood risk management coordination is required, and how it can be achieved.

2 Approach

Firstly, natural processes in river basins were analysed in order to reveal where relevant processes for RBMP and FRMP are redundant or linked. Using the DPSIR model (cf. [3], [4]) and the SPRC model (cf. [5], [6]) as theoretical background, starting points for RBM and FRM were ascertained and overlaps identified.

Secondly, river basin and flood risk management plans were screened for objectives, measures and planning procedures possessing possible synergies and conflicts. As no river basin and flood risk management plans fulfilling WFD and FD requirements are adopted yet, the directives, correspondent German law, model projects, older planning instruments, recommendations of research projects and public authorities were examined instead. Objectives and management targets were deduced from the theoretical background and directives regulation. In the following, the potential effects of measures and instruments regarding the achievement of management targets were assessed.

Once having identified the planning steps that exhibit possible synergies or conflicts, potential methods for adjustment are proposed.

3 Results: Requirements of coordination between river basin management and flood risk management

3.1 Overlap of natural processes of relevance for river basin and flood risk management

The instruments and objectives of the Water Framework Directive (WFD) and Floods Directive (FD) are concurring management approaches in the river basin. On the one hand, ecocentric river basin management (RBM) aims at reducing emission and immission of pollutants as well as at the protection and improvement of the state of aquatic ecosystems and their floodplain. On the other hand, the anthropocentric oriented flood risk management (FRM) tries to avoid flooding and to protect the society from floods.

However, both management approaches are compulsorily based on the same process factors, like landscape and water household processes and human influence (cf. [7]: 342). Examples for coupled components and processes are climate variability including climate change, characteristics of the river basin district (e. g. topography, soils, vegetation ...), and processes in the channel like run-off generation, groundwater recharge, transport of particulate matter and sedimentation, hydraulic discharge or exchange with the floodplain and wetlands. The anthropogenic intervention in the natural system (e. g. use of land or water) influences both the ecological and chemical status of water bodies and the flood risk.

3.2 Synergies and conflict potential of river basin and flood risk management

3.2.1 Objectives, targets, indicators

The objectives of WFD are characterised in Art. 4, Art. 9, Art. 10 WFD, while the FD commits the definition of "appropriate objectives" for flood risk management of the areas at risk widely to the Member States (Art. 7 para. 2 FD). Based on the directives and the theoretical background, management targets have been deduced from the more or less abstract objectives.

Synergies of targets appear particularly in relation to "improvement of ecological structure", "reduction of input from diffuse sources" or "limitation of anthropogenic changes of ground water" (RBM), and "creation of room for overflowing", "retention of water" and "adaptation of land use in the flood plain" (FRM). Conflict potential especially arises from targets involving hydromorphological structure in cases where enhancing flood protection implies the degradation of river morphology, physico-chemical characteristics and thus the biological quality of rivers.

Monitoring of ecological and chemical state partially uses the same indicators as the assessment of flood risk management strategies, e. g. discharge, number of pollutants in the flooding area, water quality during a flood event, groundwater level.

3.2.2 Instruments and measures

Possible interventions of river basin and flood risk management are numerous and are not restricted to water management but involve different fields of action. In the catchment river basin or flood risk management, actions are settled in the fields of agriculture, forestry, water supply, water distribution, and waste water management. They show predominantly synergic positive effects because they aim at the detention either of water or pollution which are coupled processes (cf. section 3.1).

Spatial and environmental planning instruments can be powerful tools for support and adjustment (see below) of both river basin and flood risk management measures in the catchment and along river stretches. By means of "mitigation measure banks" or (inter)communal "compensation area pools" connected passages along rivers may be saved for optimal ecological development as well as overtopping flood events. Several "non-structural" flood risk measures (cf. [8]) in the channel or floodplain may be used either for river basin or flood risk management. Often they are also in line with the objectives of nature protection.

Numerous conflicts become evident concerning construction measures and their maintenance. Longitudinal structures, lateral structures connected to quantitative and qualitative sediment management and regulated polder often oppose to the achievement of good ecological status. But their removal or the rehabilitation of water bodies may cause an augmenting flood risk for areas with high vulnerability. That's one reason why some pressures or impacts of the ecological state of water bodies will stay inevitable and/ or irreversible. Therefore, compensatory measures will play an important role in the implementation of the WFD.

3.3 Planning steps with necessity for reconciliation

The analysis of synergy and conflict potentials between river basin and flood risk management plans reveals thematic overlaps as well as the necessity for coordination in almost all planning steps (cf. figure 1).

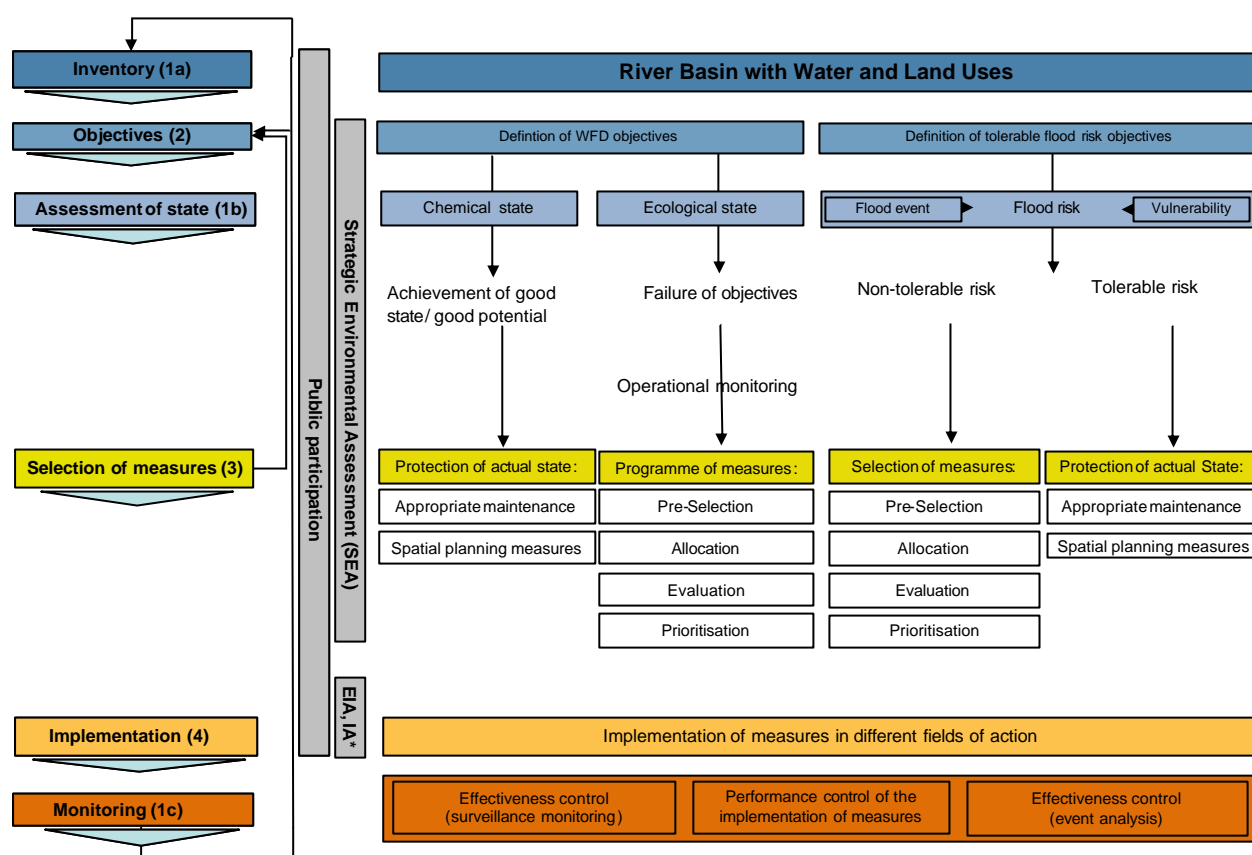


Figure 1. Demand for adjustment in different steps of river basin and flood risk management planning. **1a-c** Inventory, Monitoring of state of water bodies (WFD) and of flood risk assessment (FD) share data requirements. **2-3** Objectives and Selection of measures show strong synergies and conflict potentials that need to be adjusted (cf. Section 3.2). **4** Implementation of measures demands for adjustment of responsibilities, funding and priority setting. **Abbreviations:** **EIA** – Environmental Impact Assessment, **IA** – other impact assessments (e. g. impact regulation according to Sections 18 et seq. Nature Conservation Act, appropriate evaluation according to Art. 6 para. 3 Habitats Directive)

3.4 Approaches for the reconciliation of river basin and flood risk management

In every planning step showing a demand for reconciliation, agreements for the cooperation of river basin and flood risk management and procedures for reconciliation need to be developed. In table 1 instruments for the identification of potential synergies or conflicts are proposed.

Table 1. Instruments for the identification of possible synergies and conflicts of river basin and flood risk management

Planning step	Instruments for the identification of potential synergies and conflicts
A Definition of objectives	Identification of conflicts between RBM and FRM targets is integrated in <ul style="list-style-type: none"> - the review of environmental impacts of human activity and economic analysis of water use (Art. 5 WFD), - the definition of environmental objectives and verification of exemptions (Art. 4 WFD)
B Selection of measures	Pre-selection of potential measures: <ul style="list-style-type: none"> - A catalogue of all relevant measures for river basin and flood risk management and their positive and negative effects on targets of RBM, FRM and other management sectors (e. g. agriculture, nature protection, urban development ...) would be a useful tool Allocation and evaluation of measures: <ul style="list-style-type: none"> - The summary of measures in the FRMP (see annex A Floods Directive Number 4) include flood related measures taken under the Directives of Environmental Impact Assessment (EIA),

	<p>Seveso II, Strategic Environmental Assessment (SEA) and WFD. Thus, it is compulsory to demonstrate and use synergies.</p> <ul style="list-style-type: none"> - The analysis of cost-effective combination of measures should not only include the cost and effectiveness of the actions for RBM but as well the benefits and costs for FRM and other management targets. Thus, synergies and conflicts can be identified. Due to the effort, a traditional “quantitative” cost-benefit-analysis (CBA) is rarely applicable in practice. Instead the costs and benefits can be assessed by qualitative methods. - The Strategic Environmental Assessment (SEA) of WFD programmes of measures and of flood risk management plans includes the assessment of synergies and conflicts between FRM and WFD measures and targets - Instruments of spatial planning (regional plans, urban development schemes) can visualise overlapping zones e. g. priority areas/ areas of reservation for groundwater protection, flood retention, nature and landscape protection and thus help identify synergy potential and conflicts - A plan of conflicting zones and synergistic measures can be developed. Therefore instruments of landscape planning can be used if applicable.
C Implementation of measures	<p>Detailed planning of the implementation of measures is the last step where positive and negative effects of a measure on RBM, FRM and other environmental objectives are assessed. Therefore existing procedures can be used including</p> <ul style="list-style-type: none"> - the authorisation of measures according to the German Water Act, - the Environmental Impact Assessment (EIA), - the German impact regulation according to Sect. 18 et seq. German Nature Conservation Act, - the appropriate evaluation according to Art. 6 para. 3 Habitats Directive, - the German spatial impact assessment for spatially significant projects such as large reservoirs, dams and flood polders or transport projects
All planning steps	<p>The different responsible authorities need to identify common data requirements within the scope of inventory, surveillance or monitoring.</p> <p>All important stakeholders can be assembled in a river (sub-)basin commission which can be used to identify synergies and conflicts as well as to adjust different management targets</p>

Concerning conflicts between FRM and RBM objectives the WFD grants less stringent environmental objectives (Art. 4 para. 3 a iv, Art. 4 para. 7, Annex II para. 2.4 WFD) due to flood risk management.

As for the (pre-)selection of measures, authorities should clearly outline priority criteria. One criterion for the selection of measures could be that the actions accord to RBM targets and FRM targets and / or avoid conflicts between them. Those actions preferred should be promoted by regulatory instruments (laws or decrees), economic instruments (funds, pricing) and sectoral planning instruments.

The planning of measures needs to use and adapt existing water planning instruments and other sectoral plans e. g. agricultural or forestry development schemes, urban development schemes, management plans of protected areas as well as plans of sewage systems. For instance, local communities need to be incited to use community pre-emption or (inter)communal ‘compensation area pools“ in favour of the development of green corridors along rivers. Where executed, the SEA can be used for adjustment, the mitigation of conflicts and the support of positive synergistic effects. Also the integration of external costs and benefits into calculation of prices for hydropower, navigation, flood protection or their contribution to mitigation of impacts should be envisaged (cf. [9]).

The mentioned authorisation procedures for the implementation of measures (cf. table 1 line C) do generally integrate the denomination of avoidance, mitigation or compensatory measures. In this context a maintenance concept for quantitative and qualitative sediment management can be useful for adjustment of the interests of RBM, FRM, nature protection, navigation and mining.

Synergies referring to inventory, surveillance, or monitoring data can be capitalised on if the responsible authorities agree about standards for data acquisition, collection and recording. Where possible the same indicators should be applied. For instance, RBM indicators can serve as indicators for the achievement of the FRM target “limitation / reduction of ecological vulnerability of channel and flood plain”.

OUTLOOK

The author is developing a theoretical framework for an integrated river basin management plan in Germany. Within this work methods for reconciliation of river basin and flood risk management should systematically be reviewed. Finally, the concept will be discussed with concerned authorities.

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Eco-efficiency of Decentral Flood Mitigation Measures

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ABSTRACT

Previous flood protection management activities have predominantly been concentrated on central engineering protection measures. But there is a growing interest in the possibilities of flood protection through decentral preventive measures, namely by changing landuse throughout the entire river catchment. The aim of the Eco-efficiency Analysis (EEA) of Decentral Flood Mitigation Measures is to assess the ecological and economic consequences produced when implementing those measures. EEA was elaborated in the context of the Interreg III b project WaReLa (Water Retention by Landuse) and is the last step in a decision hierarchy within the decision support system (DSS) relating to spatial planning of flood prevention. The principle approach of EEA is to assess economic and ecological aspects, then combine them with water retention effectiveness of decentral flood mitigation measures within a timeframe of 80 years. By means of an Eco-efficiency Portfolio as a visualization-tool it is possible to compare, as well as choose between various measures, according to the preferences and normative background of decision makers.

Keywords: Eco-efficiency, economic assessment, ecological assessment, decision support, landuse management

1 Introduction

Experiences in flood disasters allow us to assume that existing engineering flood prevention measures are not sufficient to prevent flood disasters. In addition to flood disasters on major rivers, damage caused by the flooding of smaller and medium-sized tributaries is also of considerable significance.

To ensure that flood protection measures are effective, engineering flood prevention measures on the rivers must be supported by integrated catchment management. This includes preventive water retention measures implemented in the sectors of forestry, agriculture and in residential areas. These instruments and specific regional planning procedures can form the basis for co-operative international river basin management to ensure the permanent precaution of flood damage and, like the EU Water Framework Directive, promote high-quality and ecological international river basin management (<http://www.warela.eu>).

Within the EU INTERREG IIIB Projektes „WaReLa – Water Retention by Land Use regional steering elements for transnational river basin management and flood protection are developed. The EEA is part of WaReLa and contributes to the following modules:

- evaluation of the economic, ecological and water management efficiency within the scope of an Eco-efficiency Analysis.
- Elaboration of regional steering elements for transnational river basin management and flood protection.
- Development of an internationally-applicable spatial planning instrument - the “eco-efficient Decision Support System (DSS) for flood and retention potential in spatial planning”.

2 Objectives and Methods applied

The aim of the Eco-efficiency Analysis (EEA) of Decentral Flood Mitigation Measures is to assess the ecological and economic consequences produced when implementing those measures. In cooperation to the other parts of WaReLa the results of the assessment help to find out the most suitable flood protection management activity within a special area, and therefore represent the economic and ecological basis for further consideration processes. In order to achieve widespread applicability, the EEA is applicable in both forestry, agriculture and residential area.

Methodological requirements were both practicability, transparency and scientific validity. In order to address the problem of several levels of subjectivity, a methodological approach was chosen that was able to link both qualitative and quantitative analysis and assessments. Due to the characteristics of decentral flood mitigation measures, existing Eco-efficiency Analysis were modified by incorporating modified procedures of dynamic investment analysis and “interference assessments”.

3 Flood protection through decentral preventive measures

Due to Worreschk [2000], the height of flood depends besides the temporal and spatial distribution of precipitation on the capability of soil, vegetation and the water distribution network to store water. Besides, the shape of the watershed has an impact on floods. Decentral flood preventive measures are different to central flood preventive measures in the way, that decentral measures prevent floods in their development, but central measures try to “manage” the existing flood. Other distinctions can be drawn by looking at the size of the measures and technical or natural aspect of the measure.

4 Eco-efficiency Analysis

The definition of EEA used in the project is based on the simple assumption, that $EEA = \text{added value} / \text{“reduced” value}$. Added value represents mitigation effectiveness, ecological revaluation, financial income and avoided economic damage. Reduced value incorporates ecological vitiations and costs of the measures.

In order to classify the EEA, it is valuable to compare it with the Cost-Effectiveness-Analysis. Direct costs and income as well as economic advantages through the prevention of damage are correlated with the effectiveness of retention measures. Additionally ecological impacts are correlated. Their assessment can be compared with methods that are used in environmental impact assessments.

4.1 Assessment

4.1.1 Ecological Assessment

The ecological assessment serves to identify the measure with the least negative effects or the one which is most environmentally friendly. Guiding principles for finding the least negative impact are both environmental factors (in this case Sustainable Use of Landscape) and human welfare. The appraisal is based on the methodological approach of assessing the value of landscape on its suitability (Löffler & Steinhardt [2004]: 150) to fulfill certain functions (such as habitat functions, climate functions, or soil functions). Within the project, the micro- and lower meso scales (biotopes and biotope complex) has been tested. Despite, the concept is also applicable on the macro scale (landscape, watershed).

The ecological assessment is carried out similar to an ecological risk analysis. Unlike normal ecological risk analysis, the used methodology tries also to find positive impacts of measures. The fulfillment of particular landscape functions is classified in three classes for each point in time; the ecological development can be depicted with key-values, an Ecological Single Key Value is for the development of single functions, and a Cumulative Key Value is an aggregation of all classified functions within a timeframe of 80 years.

4.1.2 Economic Assessment

The economic assessment is based on Dynamic Investment Analysis. Due to the long timeframe considered Dynamic Investment Analysis proves as the best approach. Different points in time can be compared, as well as reinvestment costs considered. The main focus lies on the direct costs of the measure. They are divided in investment costs – which in general includes the cost of acquisition, construction as well as reinvestment – and operating cost with personal, material and energy cost. Indirect or opportunity costs, which are often caused by extrusion and loss of use, are more difficult to capture (Meyerhoff [1999]: 12). Indirect or opportunity costs are only considered when a significant effect may be expected (Interwies et al. [2004]: 55 pp). Indirect cost are not readily identifiable with a specific product or service, but are rather cost effects with no immediate relation to a measure, e.g. change of asset value. External or social costs may be considered within the benefit analysis when possible. This should be well founded and is part of the decision making process. They may be included within the examination of additional economic impacts on meso-scale. In order to compare the respective costs of measures, it is necessary to adjust them with discounted cash flow methods. It is common for investment projects, and also within the water management, to distinguish between two procedures used for cost assessment: the Net Present Value of project and the Annual Cost of project. Both are economic key values. The Net Present Value of project depicts the total cost of a measure – over the entire period – in reference to the initial date, which is the actual date of implementation. For this reason, costs prior to the initial date must be compounded and future costs are discounted.

4.1.3 Eco-efficiency Portfolio

Besides an assessment of the current state, the economic and ecological trends will be prognosticated for the points in time after 1, 5, 10, 30, 50 and 80 years. The Ecological Key Value, the Net Present Value and the mitigation effectiveness are combined as the eco-efficiency of measure. By means of an Eco-efficiency Portfolio as a

visualization-tool it is possible to compare, as well as choose between various measures located in the portfolio, according to the preferences and normative background of decision makers.

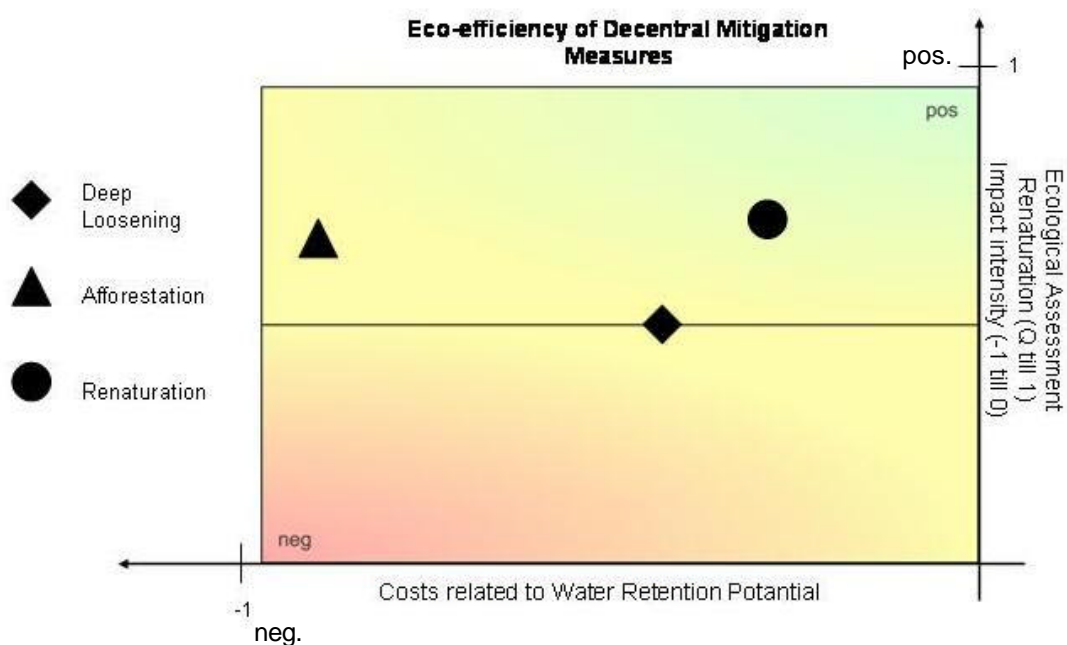


Figure 1. The portfolio shows a comparison between three measures

The compared measures are:

- Afforestation of runoff-sensible fallow land with site-specific forest and renaturation of an anthropogenic deformed source,
- Renaturation by stripwise felling of old spruces and repeated felling of young spruces. Succession to potential natural vegetation is encouraged by establishing moor-birches and closure of drainage channels .
- Mechanical deep loosening of an agronomic used area with compacted soils .

The areas within the portfolio can be regarded as decision areas, whereas the eco-efficiency is rising from the lower left corner to the upper right. Fast comparisons are possible by locating the different measures within the portfolio.

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Updating of land cover/land use for post-crisis analyses of flooded area using satellite images

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Abstract

Land cover/land use maps as well as stream system maps obtained from recent satellite data can be applied to periodical updating and comparing activities, and contribute to characterizing the elements of vulnerability, such as the assessment of floods impact.

The present paper refers to the land cover/land use updating (crops, forests, water bodies, evolution of populated areas etc.) for the Siret Hydrographical Basin floodable area (Lower Siret Plain).

LANDSAT satellite's ETM+ sensor provides satellite images used for obtaining detailed maps of the surface of the Earth. Images cover 170x183 km with a multispectral resolution of 30 m and a panchromatic one of 15 m.

The methodology involved gets through several stages including: computer-assisted photo-interpreting and quality control of results; database validation for the study area; getting the final documents under map, statistic, and table form.

After data geo-referencing, there have been applied supervised and unsupervised classification procedures resulting in updated land cover/land use maps.

The information obtained is integrated in the database organized in GIS environment, which allows getting thematic maps at various scales.

Keywords: floods, satellite images, GIS, land cover/land use, post-crisis.

1 Introduction

Floods are among the most devastating natural hazards in the world, affecting more people and causing more property damage than any other natural phenomena [4]. In the period of time between 1900 and 2006 a total of 415 major flood events occurred in Europe alone, with an average death toll of 22 and 35159 affected people [5]. In Romania as well as in many European countries, prevention and monitoring the floods are activities of national interest, taking into account the frequency of occurrence and the dimension of effects.

For planning any flood management measure, latest, reliable, accurate and timely information is required. The Earth observation satellites are able to provide comprehensive and multi temporal coverage of large areas. The real-time mapping of flood extent, which means rapid acquisition, processing and analysis of data fulfil the requirement of fast supply of data during floods. Availability within a few hours supports planning of emergency relief and helps to coordinate the response activities of various decision makers. Basically two different types of products by rapid mapping are claimed by users: overview maps of flooded areas and damage maps combined with additional information such as flood extent variation or land-use types of flooded area [1].

Remote sensing provides information that have proved useful for a wide range of application in disaster management. Usually, ground-based monitoring networks are inadequate to a low density of observation points; space-based platforms provide wide spatial coverage without access limitations. Satellite observation facilitates the regular monitoring of the extents of annual floods, and the mapping of flood risk zones [2].

Remote sensing data can easily allow for prevention (mapping of hazardous areas, drainage networks and land cover mapping, and precise basin modelling), or a-posteriori evaluation of damaged areas. On a case-to-case basis, one may need to provide cartographic products issued from available satellite data with the shortest delay.

Using land cover/land use maps represents one of the main sources involved in post-crisis analysis regarding floods. In this sense, updating this type of maps is the main goal of this study.

The present paper describes the methodology used to map the flood extend by using MODIS data and to estimate the affected land cover/ land use categories, affected by the July 2005 floods, in the lower Siret basin (Lower Siret Plain).

2 Study area

The Siret river is the main Danube tributary and has the highest mean flow in Romania (222 m³/s). From its total surface of 44,871 square km 42,890 square km are in Romania. The Siret river main watercourse is 647 km long, from its spring to its flow into the Danube, 559 km of this length being on the Romanian territory.

The Siret hydrographical basin is asymmetrical, its evolution having been mainly due to the right hand tributaries.

The main tributaries are: Barlad (207 km, 7720 square km) on the left hand and Suceava (173 km, 2298 square km), Moldova (213 km, 4299 square km), Bistrita (283 km, 7039 square km), Trotus (162 km, 4456 square km), Putna (153 km, 2480 square km), Ramnicu Sarat (137 km, 1063 square km) and Buzau (302 km, 5264 square km) on the right hand, [6].

Altitudes decrease over the whole length of the Siret hydrographical basin, from west to east. In the same direction, from west to east, the great, well outlined landforms succeed as follows: the Eastern Carpathians, the Moldavian and Curvature Sub-Carpathians, the Central Moldavian Plateau, and the Wallachian Plain (Lower Siret Plain). In figure 1 is shown the affected area by the flood occurred in July 2005.



Figure 1. Delimiting the study area

3 Data used

In order to update the land cover and stream system maps regarding the area of interest and to identify accordingly the types of their employment which have been affected by the July 2005 floods, there have been used:

- Topographic maps have been use to extract different types of info-layers:
 - administrative elements (national limits – border, administrative limits, localities);
 - natural elements (hydrographical network: rivers, dykes, channels, lakes etc);
 - communication network (roads and railways);
- Satellite images:
 - MODIS (Moderate Resolution Imaging Spectroradiometer). For our purpose a Level 1B, visible bands 1 and 2 (250 m resolution), calibrated reflectance data (format MOD02QKM) from 23.06.2005 has been used. The MODIS images offer daily global coverage and are provided by NASA free of charge. They can be ordered on the web site of the EOS data server [7];
 - LANDSAT TM and ETM+ satellite images from September 23, 1987 and October 4, 2000 respectively have been processed in order to update the map. The 30-meter-resolution TM image has been used as time series, while the 30-meter-resolution multispectral and 15-meter-resolution panchromatic ETM+ image has been processed so as to obtain the land cover/use map.

4 Methodology

The land cover/use methodology takes into account a series of technical criteria such as: the map-drawing and statistic feature of employed information, capacity to adjust to various scales in order to meet decision makers'

requests, possibility to update data fast and easy. The categories have been grouped into six classes: winter crops, summer crops, orchard and vineyard, pasture, forest and bare soil.

The involved methodology includes the following steps:

- Preliminary activities of organizing and selecting images, which include collecting and inventorying available cartographic documents and statistical data touching land cover: topographic maps, geological maps, forest cover, and other thematic maps on various scales. For getting a land cover map, the satellite images used should have a fine geometrical resolution and include multispectral information;
- Computer-assisted photo-interpreting and quality control of results, which result in delimiting homogeneous image areas, identifying and dividing them in classes of interest. Differentiating and identifying land cover/use classes is based on such image processing procedures as: adjusting the contrast-luminosity coefficient, equalization of the gray level histogram, calculation of vegetation indexes (normalized difference vegetation index, brightness index and normalized vegetation index) and of radiometric transformations (involving neighborhoods), statistic radiometric analyses, supervised and unsupervised classifications;
- Digitizing the obtained maps;
- Validation of the database covering the study area;
- Getting the final documents under map, statistic, and table form.

4.1 LANDSAT image processing methodology

In order to get a better LANDSAT image resolution, the merging of the two available images has been carried out, resulting in such an image that has the panchromatic image's 15-meter resolution and the richness of color belonging to the multispectral one.

Satellite image processing was accomplished with a view to:

- Identifying each land cover/use class according to the exogenous data and terrain data, establishing thus a catalogue of classes;
- Finding out those areas, which belong positively to a terrain cover/use class;
- Extending identification to the whole image.

According to the proposed methodology, following the steps mentioned below has made the land cover/use map:

- *Data geo-referencing*: Images are geo-corrected in UTM projection, datum WGS84, zone 35; same thing for the topographic maps of the area, to make easier the superposition and comparison with these;
- *Unsupervised classification*: In the case of unsupervised classification it is necessary to choose a proper number of a priori classes which should be found again on the original image. For the study area there have been made unsupervised classifications with 30, 50, and 90 classes and a specific number of iterations. Resulted classes have been regrouped in seven land cover/use units: forest, pasture, winter crops, summer crops, orchards, water, and bare soil;
- *Supervised classification*: It is grounded upon the use of test zones (the applying of ERDAS Imagine software's "area of interest" module). This classification requests to establish the desired number of land cover/use classes. It has been used the method of classification by parallelepiped limits. It was finally obtained the land cover/use map with seven classes (forest, pasture, winter crops, summer crops, orchards, water, and bare soil);
- *Manual corrections*: When classification has been over, manual corrections were carried out for removing the wrong classed pixels;
- *Validation of results*: Validation included local and regional verification methods with an emphasis on classification accuracy, number and extension of plotted areas, precision of geographic borders, and homogeneity of the covering structure.

The unsupervised classification for the study area has been initially performed in 30 classes (10 iterations), finally regrouped in 7 classes standing for the main land cover/use types. Figure 2 shows the land cover/use map of the analyzed area in raster format.

For identifying and delimiting the flooded areas there have been processed 10-20 TERRA/MODIS satellite images of the lower Siret basin.

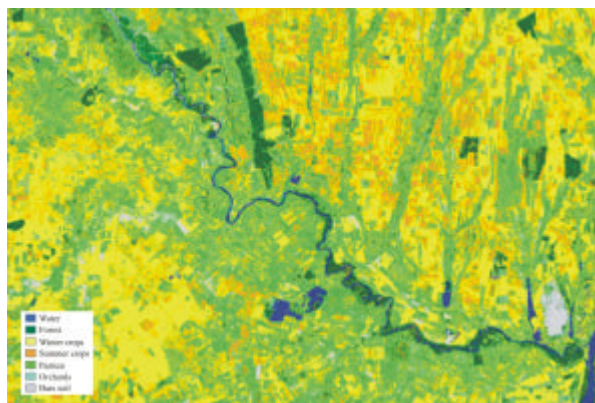


Figure 2. Land cover/use map updated by using LANDSAT (2000) images, lower Siret basin

4.2 TERRA/MODIS image processing methodology

The processing of MODIS images has been done by using the ENVI software. To obtain the water mask has been used the MOD02QKM (red and infrared bands). The methodology used to obtain the water mask includes the following steps:

- Perform the bowtie correction. The “bow-tie” effect distorts images at large looking angles. The “bow-tie” is a phenomena associated with sweeping instruments where the instantaneous field of view increases as the sensor sweeps away from nadir. As the instrument looks further out to the side it “sees” a larger area on the ground, the subsequent scans will have overlapping observations on the outer edges of a swath [8]. The ‘bow-tie’ correction of MODIS tool has been used to eliminate the effect. The “bow-tie” correction has to be done for each band, separately. If the “bow-tie” correction is performed together with the geo-reference the results are not satisfied and the distortion still exist;
- Geo-referencing the bowtie-corrected, 250 m, reflectance data, using the same UTM projection, datum WGS84, zone 35 the same as LANDSAT data and the topographic maps;
- Obtaining the water mask by using the NDVI;
- Saving the mask in .shp file, figure 3 [3].



Figure 3. The water mask of the flooded area resulted from MODIS image, lower Siret basin

5 Results

Drawing out information about lower Siret basin areas affected by the July 2005 floods goes through the following steps:

- getting the land cover/use map in raster and vector format;
- getting maximum flood extension mask in vector format;

- overlay the mask on the land cover/use map, figure 4;
- drawing out the flooded areas in vector format (figure 5) and table format (table 1).

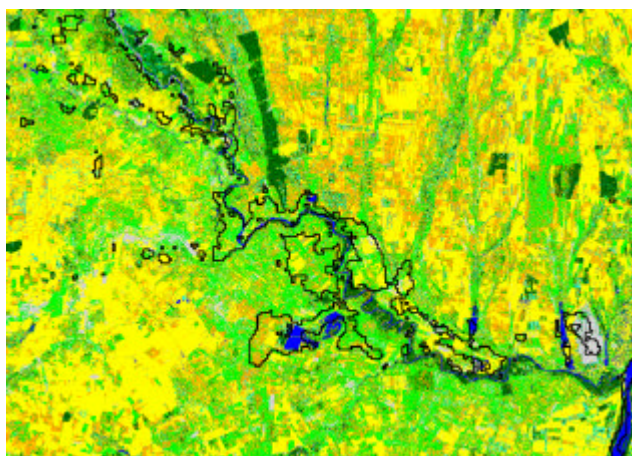


Figure 4. Water mask overlayed on the land cover/use map

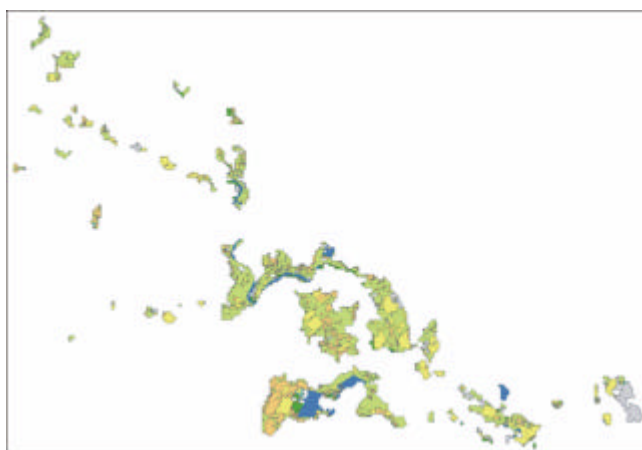


Figure 5. Lower Siret basin water-covered areas (July 23, 2005) during the July 2005 floods

Table 1. Flood-affected areas (July 23, 2005)

Range	Area (ha)	Rate %
Winter crops	3520.3	23.17
Summer crops	2392.5	16.02
Forest	477.0	3.12
Pasture	6899.6	44.42
Orchards	75.8	0.43
Bare soil	1060.6	7.00

5 Conclusions

For Romania as well as for many countries, floods produced in several areas of the country cause every year important damages over large areas and also the loss of human lives and economical consequences. The evaluation and management of floods constitute the indispensable first step and the rational basis of mitigation measures against flood damages.

The floods problem, much debated lately, is approached in this study from the angle of using data picked out from satellite images in order to get some products able to help decision makers in assessing faster the damages. These products, being numerical, can be easily handled and combined with data from other geographic sources through a GIS.

The products serve as valuable tools for future analysis and decisions concerning the efficiency and environmental impact of the structure works. The distribution of the graphic and cartographic products to the interested authorities, media and public is an important issue. These products contribute to preventive consideration of flooding in land development and special planning in the flood-prone areas, and for optimising the distribution of flood-related spatial information.

The remote sensing contribution brings to this application has two aspects: one, very important, regards the drawing out/delimiting of the flooded area; the second concerns the use of spatial information in updating land cover/use maps of affected areas, leading implicitly to a correct assessment of damages.

The method for satellite data processing and interpretation that is dedicated to the analysis of flooding are now used into the operational activities of the Romanian National Meteorological Administration.

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Rural mountain community of Rampur Village in east Nepal shares success story of catchment management

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Abstract

From centuries, indigenous techniques of catchment management are common among mountain communities in the Himalaya. These techniques include converting hill slope, first, into non-irrigated farm terraces (bari), then, gradually into irrigated farmland (khet), building ponds and slope stabilization activities like small check dams or diversion to prevent erosion, plantation of appropriate tree species like bamboo and other fast growing trees useful for fodder and wood. When cloudburst induced landslide and flood hits hard a remote and isolated mountain village, usually the entire community loose their sources of livelihoods along with hopes of recovery, thus, pushed into deeper poverty cycle. However there are few cases where affected communities show strong resilience power and use the post-disaster chaos into an opportunity to bring harmony while removing barriers such as disputes and conflicts among the villagers. This paper analyse focuses on Rampur community of Nepal mountain that was severely affected by a cloudburst induced disaster in July 1993 but reorganized itself and successfully coped with crisis that the community faced. The coping strategy includes conserving water, forest and land in an integrated approach. After 15 years of the worst disaster, the community finds itself in a better position while the village has earned reputation being one of the most preferred places for migration among neighbouring hill dwellers. Such a progress of the disaster affected community is a rare case in the isolated mountain village, therefore, deserves analysis of the approach behind this success. Study revealed that the villagers collectively worked for land, water and forest management, thus, enhanced access to water supply, electricity, effective erosion control on hillsides and enhanced forest cover and land productivity.

Key words : mountain village, cloudburst, disaster, community water management, success indicators

1 Introduction

Mountain communities of Nepal struggle hard to cope with extreme climatic events and water-hazards mainly floods, landslides and erosion during summer monsoon from June to September and long drought leading to severe water shortages from December to May in a cyclic fashion. Every year about three hundred people are killed; thousands of families are affected as they loose properties or precious farm lands on which they depend for living; and public infrastructures such as irrigation canal, trails, roads and bridges are damaged. Usually majority of affected families are socio-economically poor and pushed further into deeper poverty cycle by the recurrent natural hazards. Some of the affected communities, however, have been successful not only to recover from the shock of disaster and rebuild their capacity back to normal but also to improve their living standard employing technologies and adopting innovative management approaches collectively. They have been examples and sources of inspiration for others.

Suffered by the brunt of historic landslide and flood disaster in July 1993, the community of Rampur village of Okhaldhunga District in eastern Nepal has earned reputation for upbringing living standard faster than any other villages in the district. The widely disrupted life and livelihood sources of villagers did not stopped them to keep on working for better future with the remaining local capacity. The first change they brought into them after the event was creating a harmonious social environment among themselves that was completely missing before. The next step was the collective planning and decision making practices which helped them organizing rescue, relief and rehabilitation activities in a systematic way that went for years. This approach contributed for a conducive environment and a culture of cooperation, and brushing out disputes among themselves. This paved the way to start planning to manage water, land and forest resources. The study analyses community-led approach of mountain catchment management that can be useful to be followed or draw lesson particularly those affected by natural hazards like the one that hit Rampur. The cloudburst induced landslides and floods in July 1993 had devastating effects on local lives and livelihoods of Rampur but found it flourishing in 2007 mainly through local efforts and knowledge. In this context indicators of social and economic progress of the Rampur community are analysed. This

study used the baseline information of the earlier case study [1] and first hand information after a recent field survey of the study area.

2 Study contexts

The gentle slope and flat landscape features of Rampur have made it an attractive place for agriculture and settlement. This is one of the few attractive locations in the entire hilly region, which is characterised by deep gorges of rivers, valleys and rugged mountains. However, owing to the lack of irrigation, except in rainy season, the place remained less attractive to hill farmers compared to the productive soils of surrounding villages till 1990s. To make the situation worse, a powerful cloudburst of 6 July 1993 hit Rampur and had devastating impacts on lives and livelihoods of the villagers. Then half of the settlement this remote mountain village went under debris that killed 23 people; lost most productive farm lands and forced many families to leave village for alternative source of livelihoods [1]. Majority of the families continued making their livelihoods mainly out of subsistence farming practices and labour works as porters to carry loads from and to the nearest road heads at 150 km distance.

Rampur is the largest settlement in Baruneswor Village Development Committee (VDC) with 7000 population in Okhaldhunga District that consists of 56 VDCs. Rampur has 3,000 population and about five square kilometers in area, situated at a height of 1147 meters above sea level on a flat river terrace, which is locally called a tar. The tar is a plateau-like land form in mountain region. The village is surrounded by a rising hill to the north that has been sources of forest and spring water as well as a permanent threat of landslides particularly during monsoon when cloudbursts often trigger huge landslides debris flow from geologically fragile sections in steep slopes. To the east lies Jhagarpur River, a major source of irrigation water to the village, and, in the west lies a deep valley of snow-fed Molung River which is popular for its huge perennial flow and fertile floodplain. At three hours walking distance (about 15 kilometres) east from Rampur lies the district headquarters, which is recently connected by a fair weather road. In average Rampur receives 1500 mm rainfall in a year, out of which, 85% between monsoon months (June to September) and rest 15 % in 8 months. The climate is temperate with temperatures between 5 and 25 Celsius.

The mountains of Nepal experience torrential rainfall every monsoon, accounting for 80 per cent of the total annual rainfall. Soon after the monsoon rain influences the entire hilly region, the region becomes saturated and sensitive. Extreme climatic events such as cloudbursts can trigger big landslides, floods and mass movement in these conditions. A map of geologically hazardous areas of Nepal prepared by Dikshit [3] shows Okhaldhunga District to be in a 'high landslide hazard zone'. Of 75 districts in the country, seven districts including Okhaldhunga are categorised as 'very poor' in terms of watershed conditions. The three kilometre long hill to the north of Rampur tar is geo-physically fragile. The slope from the central to the eastern part of the hill was shaped by a major landslide in the past. Each of the landslides that have occurred in Rampur has had its origin at or near the top of the hill slope. During heavy rain, when a moderate landslide is triggered in a flood gully on the upstream mountain slope, the landslide and water current gradually increase and turn into a huge debris flow. Trees, boulders and loose rocks along the bed are washed down. The debris flow accelerates as it comes down. On the way downstream some of the landslides split into two or more branches. Finally, most of those from central and eastern parts end at the Jhagarpur River at the east and south-east of the village. Their vertical lengths range between one and three kilometres, and the maximum breadth is 500 metres.

3 Local approach to catchment management

In monsoon rains usually occur with high intensity. Farmers understand the importance of monsoon rains and conservation of land resources. They use several techniques to mitigate the effects of floods from the upstream mountains and at the same time they trap the runoff flow for irrigation and conserve water for next dry season. If there are no landslides, overland flow or minor floods are no major problem. Soil loss in the form of landslide and erosion is the major problem faced in the mountains. Water (in the form of rain, surface flow and underground flow) acts as the major agent in causing soil loss.

In Rampur, water is abundant only during the rainy days of the monsoon (June to September). At other times water shortage is evident. To address the problem of water shortage, a modern canal was built by the government but worked only seasonally. The canal passes through steep hill slope with active landslide zones, thus, very unstable in most of its 10 km kilometres length that links Pokting sub-watershed to Jhagarpur that comprises Rampur. It was completed in 1987 after 10 years of construction. The canal, which was one of largest projects then in eastern Nepal, collapsed within weeks of coming into operation. The government agencies then abandoned it for heavy cost of rehabilitation but later local people themselves brought it back into operation after several months of volunteer labour, using local construction materials (e.g. stone, brush-wood and mud). About one kilometre of the canal passes through the active landslide zone of the steep mountain slope. In monsoon, sections of the canal slide down the mountainside and the villagers rehabilitate the canal, with considerable effort, to bring water to the village

to cope with the acute shortage of water in the dry months. The major water and land management activities are summarised in the table 1.

Table 1. Water and land management practices in Rampur

Functions	Purpose	Actions	Impact
Runoff management	Erosion control, Draining runoff to ponds and irrigation canals, Rainwater collection	Identified hotspots for protection measures, built torrent control structures, diverted runoff water into canals and cultivated lands.	Reduced erosion, Natural regeneration of tree species including <i>uttis</i> for the first time, Improved drainage system
Ponds and canal restoration	Tapping water for livestock and irrigation	New arrangement to repair traditional canals, ponds routinely on the principle of 'users to pay'.	Improved access to water, Soil loss reduced
Landslide zone stabilization	Landscape improvement	Restriction to remove grass and plant species, Runoff control,	Growth of new and fast tree species, recharge of spring sources and
Plantation of fodder species	Feed livestock keeping in sheds	Fodder and grass species grown along sides of farmland, canals, erosion prone slopes.	Improved fodder stocks, time saved to fetch animal food.
Livestock farming	Grazing in forest prohibited	Selection of limited number and useful types of animals	Size of village livestock population decreased

In this context, villagers for decades take measures to conserve monsoon water by making a network of ponds so that water from different sources flow into them; water released from upstream passes to the next pond downstream. Small outlets in between allow the flow of water into the vegetable gardens of nearby households. These man-made ponds are useful for three different purposes: run-off management, water conservation and soil/nutrients/organic matter conservation. It is the general tendency of farmers to convert their slope land (bari) into level terraces (khet), which is not possible everywhere.

In each monsoon many scars of landslides appear on the surrounding hill slopes in the rainy season. Most of them disappear in one or two months under vegetation cover. The process is a normal phenomenon. Villagers partly believe the suggestion that a landslide can be controlled by vegetation or forest cover, but their experiences have taught them that landslides cannot be controlled by the forest alone. There are many examples of landslides in the forest area where numbers of trees were uprooted and swept away. This was the case in the landslide of 1993 when major landslides in the forest areas destroyed hundreds of trees, including big bar and peepal trees. However, for agricultural and economic reasons villagers grow bamboo and fodder trees where they find bare land, both on public land and at the edge of their private lands. They are usually grown on the steep slopes at the edge of farming terraces and in gullies where the chances of landslides are high; they are also grown on marginal and waste lands.

Slopes are stabilised by employing different measures, including stone-works. These types of measure are used mainly in canal protection and terrace walls. Stone-works are also built to make diversions and check gully erosion. In Rampur, stone is the principal construction material for buildings, trails, walls, etc., where bricks are not available. About 80 per cent of the roofs of house in the village are made of stone slabs. Diversions, canal walls and terrace repair works are usually made with stone and brushwood whereas mud and stone is used in house walls, and stone slabs (slates) are fixed to underlying wooden slabs in roof making.

Recently the management of water supply system has been given to local contractor for reliable supply water for which users pay the fee in accordance with agreement. This new arrangement has enhanced reliability of supply. Users have high level of willingness to pay the fee. These activities proved effective to bring back the greenery in the village and check excessive erosion in the monsoon. These works provided outlet for excess water without much damage. For example, in terraced rice fields in slope (khet), there are enough outlets to pass water to the next bench terrace.

4 Indicators of socio-economic progress

Household income levels have been doubled since last 15 years. The village has been electrified with a small micro-hydropower plant owned and built by an enthusiastic local entrepreneur. Regular water supply has been secured after maintenance of the government built canal that supplies water to the northern part of the village from Pokting River, another watershed to the north of Rampur. As a result farmers have been harvesting comfortably three to four crops in a year, a dramatic change from hardly one or two crops a decade ago. However, maintenance of canal is a huge task requiring labour intensive works and costs in rainy months. Because farmers have high level

of willingness to pay the price for secured water supply, generating funds for maintenance is no more a big problem. As the hydropower plant is run also by canal supply, the same entrepreneur has taken contractual responsibility of the canal maintenance. Trained local youth who have returned homes after completing various professional training courses in vocational schools have been playing important roles in introducing innovative tools and techniques in the field of catchment management, installing and running hydropower plants and value adding the local products through processing and packaging activities. Production of handmade wooden crafts for household uses, furniture and processing cum packaging of seasonal fruits and vegetables are some examples.

Abundant supply of fodder for livestock is another achievement of the villagers who organized plantation of fodder tree species about a decade ago. Otherwise villagers had to spend more than half of their daily working hours for collection of water, fodder and fuelwood. Regular supply of tapped water at door steps have eased live of women and children. Most of the households, nowadays, use improved cooking stove that emit less smoke and consume less fuel wood. As a consequence, people have started investing more in education of their children and stopped early marriage of girls till they complete at least secondary school level education. Collectively, these achievements have enhanced livelihoods of the villagers significantly. Recent practice of ensuring water supply for irrigation purposes by awarding annual or seasonal management contract to a competent individual through open bidding has been very successful. Introduction of water tariff provision and users' willingness to pay for tariff is the major reason behind this success. Users pay Rs 400 per ha per crop as water tariff. Those unable to pay the tariff provide equivalent labour.

Economic and social contexts have also been changed over time. Farming practiced has changed from a traditional non-cash economy to a market-oriented cash economy. These changed have mixed effects on the living standards of the villagers. Families having a good labour force are among the beneficiaries. The living standard of some socially and economically backward families has also been improved. Nevertheless, indigenous techniques of water management are still effective but not without limitations. Matching them with modern technologies is inevitable to meet growing aspirations of modern lifestyles. The observed changes are summarised in the table 1.

Table 2. Some indicators of socio-economic progress between 1993 and 2007

Indicators	In 1993	In 2007	Remarks
Area of canal irrigated land	60 % of total cultivated area	95% of total cultivated area	Converted nearly all non – irrigated area into into cultivated land
Area of high value marketable crops	30 % of total cultivated area	70% of total cultivated area	After canal irrigation facility
Paddy production per ha	3 ton	4 ton	Results of improved variety
Price of irrigated land	Rs. 0.2 million/ha	Rs 1.2 million/ha	Sharp increase in landvalue indicates soaring demand.
Labour rate	Rs 50/day	Rs 200/day	Due to demand of labour for land rehabilitation.
Household income	Just enough to meet basic needs	Surplus income	Ready to invest more for better living standard
Domestic water supply management	Community tap for every cluster of 10-15 hhs	Individual taps in parts of village, and 1 per tap for 5 hhs in rest.	Facility of piped water supply improved.
Livestock no per hh	5-10 heads Grazing in public land allowed.	2-5 heads. Grazing other than private land prohibited.	A compulsion after ban in animal grazing in forest and public lands.
Percentage of school enrolment	60%	99%	Awareness on and access to education enhanced.
Nearest road head	At 150 km or 4 day walking distance	At 36 km or at one day walking distance	Price to essential commodities reduced
Electricity	No. Several local attempts didn't materialize.	Yes. Two hydropower plants, one 1.5 kW and other of 5 kW are owned and operated by a local businessmen. About 100 households are electrified.	Local efforts materialized due to collective willingness to invest or pay for the new services.
Market	Weekly fair. More bartering, less cash flow	Weekly fair. Less bartering, more cash flow.	Expanding rapidly.

5. Social dimension

5.1 Can a natural disaster be an opportunity for restructuring socio-economic fabrication for better?

The disaster shook the hierarchic social order paving the way to restructure for new roles and positions. Few upper caste farmers used to control major portion of farmlands but suffered after the cloudburst triggered landslides converted most of those into useless debris land. Villagers have techniques to reclaim and manage the lands for productive use but required huge labour force often unaffordable to middle class farmers. However there was no other option than to invest for the same. It took years to bring back the lands into pre-disaster conditions but with huge costs. Poor families who belonged to lower caste and used to survive on income from daily wage labour were benefited from the contractual business of improving the damaged farmlands. Those families having more trained and adult members did better, those having more children or aged members lost and rest in status quo. In recent years, majority of lower caste families are in economically better positions and enjoying improved living conditions. Indeed, the gaps among traditionally rich and poor have narrowed down when the Rampur community is doing better in terms of income generation and natural resource management fronts.

5.2 Enhanced social harmony

The unity of villagers during the rescue and relief work after the 1993 disaster was exemplary. Their social, cultural and political differences, which were significant, did not reappear for a long time after the disaster. The backward (untouchable) community was greatly assisted by others in terms of materials, providing shelter and rehabilitating their lands. In contrast to the earlier practices when fellow villagers often engaged in disputes over resource use and management, nowadays such practices are rarely seen. For example number of households having registered legal disputes over resource sharing with neighbors reduced significantly. Rampur dwellers have gradually transformed into more cooperative and harmonious community. People realized the importance of collective and cooperative actions. Instead, formal and informal community based groups or organizations with the aim of mobilizing resources for better livelihood opportunities. Conflicts among villagers usually linked to sharing of resources, which have been solved through formulating rules and norms in participatory approach.

5.3 Youth in forefront

Majority of youths tend to leave villages in search of jobs in cities and towns. Those who get vocational trainings and university education in towns rarely return homes. However in recent years, a few of them have set trend of coming back to villages and working in their traditional farmlands rather differently. Major differences in their approaches include change of traditional cropping pattern with improved variety or high value crop, irrigation management and income diversification through marketing of the local products. Value additions to the local products such as vegetables without the use of chemical fertilizers and packaging of processed and dried vegetables were the other measures.

5.4 Importance of participatory planning understood

Though failure of government owned irrigation canal was a major setback to the Rampur dwellers, they learnt a great lesson that external experts could not be trusted fully for their formal education and high ranking government positions. Instead they realized that any plans for the villages should be questioned and discussed among villagers who often make their points based on their practical experiences. They mentioned the debate over canal intake and alignment on which villagers tried hard to convince the consultant that the design plan be revised to increase slope gradient but never heard. Consequence was the failure of the project. Again villagers successfully rehabilitated the canals but only after they could shift the intake site upstream and realigned the canal.

5.5 Others

Farming high value crops, mainly vegetables and fruits, is an emerging business. Growth of weekly market fair has contributed to promote the business. Local entrepreneurship in which educated youth are involved have been the major attractions. Other activities include promotion of biogas plants, solar photovoltaic for lighting and improved cooking stoves that replace traditional smoky firewood stove. Mandatory construction and use of hygienic toilets in all household is the another feature activity contributing to health. Change in livestock farming practice within walls led to conserve forest and fast regeneration of grassland. Also people speak about reasons behind the disaster of July 1993. There were mainly four perspectives. They include excessive use of blasting materials during canal constructions leading to destabilization of the slope, plantation of pine forest in deforested zones, disrespect to god and take the event as an inevitable natural cycle of the region.

Most spectacular change in Rampur in last 15 years is the conversion of all non-irrigable terraces (bari) into irrigable productive (khet). The change has a big implication in socio-economic conditions of the local. The three major factors that led to achieve the forest restoration include uses of improved cooking stoves that consume less firewood and emit less smoke, switching from firewood stove to biogas plant and increased supply from private forests. The value of land that was declined following the disaster not only bounced back to normal but also grew to a record high the region.

6 Conclusion

Recent survey finds hardly any scars of landslides left unrestored after the July 1993 event except in parts of northern mountain slopes. The seriously affected central and eastern part of the village including the dense forest and farmlands have been revived. For the difficult task of farmland restoration clearing huge boulders and debris deposits, villagers used traditional rural equipment and skills. They have addressed the key environmental challenges that they used to face, namely, reactivation of the once stabilised landslides, loss of nutrients and organic matter from the washing away of the topsoil, and the drying up of springs and wells (sources of drinking water), and utilizing of into a dry and waste land for productive use. A significant change noticed in the period is the development of positive or cooperative attitude among the locals. For example villagers could not reach an agreement before on constructing a new canal from other side of the hills even though there was severe shortage of drinking water for nearly half of a year. Later they not only agreed on this point but also contributed generously technically and financially. This type of change can also be seen in managing forest collectively, sharing benefits equitably and maintaining transparency in all decision making processes.

Thus the lost glory of the village following the event of July 1993 has been restored and strengthened. The debris -deposits have been rehabilitated as agricultural land. The fragile hill slope to the north has been developed into grassland and bushy forest. There are a number of check dams and erosion control measures. Livestock farming techniques have also been changed. The traditional way of feeding livestock was to free them in the jungle for the whole day. Now, they are kept and fed at home. Rows of fodder trees are grown around homes, farmlands and public land. This has been achieved through a range of factors that influenced villagers. Enhanced social harmony, provision of equitable benefit sharing and participatory approaches of decision makings for common interest activities are the key factors that Rampur community upholds for continuous progress in the future and shares the success story among other communities in the hills.

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Stakeholders involved in soil conservation and water retention in South Limburg, the Netherlands

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In the most south-eastern part of The Netherlands (South Limburg) there are slopes, mostly covered with loess. These soils have a rather weak structure and are susceptible to water erosion. As a result of the fertility and easy workability of the soil, this area was colonised in Roman times. The Roman farms or villas were surrounded by large plots, which were in turn surrounded by the small plots of smallholders and the farm labourers. From Medieval times onwards, villages were established along the watercourses in the valleys. Later, villages also appeared on the plateau and the area of arable land increased proportionally.

In the loess area of South Limburg soil erosion is responsible for damage in the agricultural area and subsequent runoff volumes cause damage by flooding urban areas with muddy water and block the infrastructure. Since the second half of last century erosion hazards have increased. With a general use of artificial fertilizers, the organic matter status of the soil dropped to critical levels. Up-scaling of agriculture in combination with land consolidation (enlargement of plots), the disappearance of landscape elements (natural terraces), a narrower crop rotation, mechanization, and activities outside agricultural areas, like the extension of built-up areas and infrastructure increased runoff volumes.

The public sector is responsible for general policies to control erosion. The basic principle is to tackle the erosion on the farmer's field by applying source measures. Municipalities have to solve small-scale problems with local flooding and sedimentation. They are supposed to prepare and guide local-level erosion plans, where (infra-structural) measures are taken to complement the on-farm erosion measures. To prevent flooding the Water Board has the task to develop the water infrastructure, to buffer water, and to discharge the runoff safely.

Partly because they feared drastic interventions from the authorities, the farmers took their responsibility to fight the erosion and to limit flooding. Other motives to invest in soil conservation were that the farmers wanted to reduce the damage they suffered and wanted to restore their public image. The farmer organisations were instrumental in the creation of an Erosion Ordinance (EO) which appeared in 1990 and has since been updated several times. Main (source) measures of the EO are: > 18% grassland; tillage in autumn or a cover crop in winter; elimination of wheel tracks in root crops; maximum slope length < 5% slope 400m, >5% 300m.

In 2000 authorities involved (Province, Water Board, Land Consolidation Committee, farmer's organisation, 20 local authorities) in erosion and flood control signed a covenant in which generic and specific interventions were agreed upon to be realised within a period of four years. Main interventions of the covenant are: to embed erosion policy in legislation; to adapt regulations for ploughing up grassland; execution of grass strips and grassed waterways (discharge > 500 l s⁻¹); to solve the problems of 250 bottlenecks in drainage systems; implementation of rainwater buffers. After four years of regular meetings, planning of interventions and execution of measures, the outcome is encouraging. Grassland has been established in critical zones (though, unfortunately, some has already been ploughed up). Half of the bottlenecks have been tackled and action plans have been made for the remainder. In the last decade the Water Board, mostly in collaboration with the Land Consolidation Committees, has created about 250 rainwater buffers, to temporarily store runoff water and to collect sediment. In the early years, reservoirs with a capacity of 1,000-15,000 m³ were designed, to prevent villages from flooding ("end-of-pipe measures"). More recently, reservoirs with a capacity of < 1,000 m³ have been built in fields where overland flow starts ("source measures"). In total, there are about 100 more buffers to be constructed. Though the agreed measures of the covenant are only partly realised, the intentions of the covenant are still valid. The plans will be implemented in the coming years. However, interventions, that influence the field layout (grass strips, grassed waterways), are meeting in recent years more and more farmer resistance.

In 2003 the farmers' organisation introduced a new instrument in the EO: the Farm Erosion Management Plan (FEMP). With an FEMP a farmer can assume the responsibility for keeping the risk of erosion on his land at an accepted level, to organising his own farm strategy and to get dispensation of several measures otherwise due to the EO. The effectiveness of measures in an FEMP is assessed on the basis of land management scores. The minimum average scores have to be 40 pts/ha and 75 pts/ha in the 100 m zone uphill of buildings and infrastructure. Some

management examples and scores (pts ha⁻¹) are: grassland 100; winter cereals 40; cover crop and mulch 50, including direct drill 75; contour tillage 25; minimum tillage 35. Additional scores can be obtained by maintaining and reinforcing the landscape infrastructure, like field boundary management, execution and maintenance of grass strips, grassed waterways and reservoirs. The monitoring period for an FEMP is from harvest to harvest.

Farmers can rely on EU-subsidies when applying erosion measures (cross-compliance). Both the EO and the FEMP are part of the 'Good Agricultural Practice' of the EU General Agricultural Policy.

In spite of legislation, accepted responsibilities at different levels and financial support, erosion interventions do not cover the whole area and not all actors are equally motivated. In practice, monitoring of the fulfilment of the EO and the FEMP is quite complicated, because of scattered property, the complexity of the instruments and lack of controllers. At municipality level several plans to solve problems are ready, but lack of money will postpone execution of some of them.

Decentralised rainwater management in urban areas – recommendations concerning planning, construction and operating stage.

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Abstract

In comparison to sewage systems decentralised rainwater management in urban areas is a rather new way of rainwater treatment. In Germany it is regulated by law since the 1990s. Consulting engineers gained experience in designing retention measures since the 1980s but today there is still a lack of acceptance towards its enforcement among the population and the stakeholders as well. This paper is based on the investigation of factors influencing people's acceptance towards retention measures. According to several interviews in the region of Trier successful acceptance of near to nature management measures for rainwater runoff depends mainly on the early stages of planning and actual construction work. It is important to involve the property owners right from the start and to give detailed information to them. The present report introduces recommendations and several information media.

Keywords: decentralised rainwater management, urban areas, retention measures, acceptance, recommendations.

1 Introduction

According to the German Federal Water Act everyone is bound to avoid pollution and detrimental alterations of water, to use it economically, to preserve the water balance's capacity and to avoid the increase and acceleration of run off. This can be seen as an express rejection to discharging rainwater into the sewage system. The Water Law of Rhineland-Palatinate stipulates the immediate use of rainwater (if possible) or else to have it trickled away since 1995.

First projects concerning retention measures in Germany had been realised in the 1980s, as for example the Documenta Urbana in Kassel (1982), the building area Hamburg Neugraben-Fischbek (1983) and the Internationale Bauausstellung in Berlin (1987) [1].

Even a quarter century later accompanied by technical progress there is still a lack of acceptance towards its enforcement among the population and the stakeholders as well.

2 Question and Method

Near to nature management measures for rainwater runoff are based on the following components: retention, usage, slow infiltration, evaporation and throttled discharge. In comparison to conventional sewage systems these measures provide several benefits such as:

- the existing sewage system is subject to less loading if rainwater is not added
- sewage works are conserved
- no wastewater is discharged into receiving waters after intense rainfalls
- the natural groundwater renewal rate can either be retained or re-established at its natural condition before commencement of building
- small decentralised units may also be additionally useful for flood protection.

An important aspect for or against the implementation of retention measures are the costs involved. In comparison to a sewage system decentralised retention measures can actually afford savings as some studies show ([2], [3], [4], q. v. [5], [6], [7]). Additionally they are characterised by several advantages which can not be judged monetarily ([8], [9], [10]). Hence the reasons for the hesitant implementing of retention measures in urban areas have to be different ones.

As per Kleeberg & Willems [11] and Sieker [12] the rejections are psychological based, intensified by a lack of knowledge and inaccurate constructions. To find out more about factors influencing the acceptance of such measures private owners living in districts with decentralised retention measures in the region of Trier had been

asked several questions. Based on these interviews Michalski [13] identified the most important factors influencing the acceptance of retention measures and differentiated them as follows:

- factors with a direct and strong influence on the acceptance
- factors with an indirect influence on the acceptance
- factors with no detectable influence on the acceptance.

3 Results

The strongest influencing factor is a successful working retention measure. Hence the main objectives are a professional implementation and a frictionless functioning of the retention system. According to the identified factors Kronewirth & Wintrich [14] (q. v. [15]) compiled the following recommendations concerning the planning, the construction and the operating stage of such measures which shall help to avoid mistakes and to reach these aims.

3.1 Planning Stage

The retention concept has to be adapted to the soil properties. Therefore comprehensive and detailed soil analyses are necessary. Infiltration capacity can be measured using the following methods: Open-End-Test, Doppelring-Infiltrrometer, Beetinfiltrrometer whereas the significance increases in the order of their listing [16]. All tests should be conducted at the ground depth at which rainwater runoff shall infiltrate after construction.

If retention measures have to be implemented on private estate the real owners should be involved into the planning process right from the start, e. g. by civil participation. Very often people do not know what decentralised retention measures are good for and the interviews showed that people wish to be informed at an early stage. Concerning people's attitude towards retention measures it is helpful if they know about the several systems, their functionality and maintenance.

Public relations and the involvement of any third parties can lead to more transparent and creative solutions based on the knowledge and opinion of many people. It can help to avoid conflicts, leads to a more effective realisation and hence increases the chance of a long-term and general acceptance [17].

Information should be well visualized, site-related and practical. Several information media can be used, such as: brochures, display walls, exhibitions, special promotion days, demonstration plants, pilot projects as well as discussions with a panel of experts and a sequence of articles in the daily press. However information should be compact and people should be given the possibility of co-determination.

As the interviews showed financial incentives do not seem to have a strong influence on the acceptance but they may help to stimulate a positive attitude in the run-up.

3.2 Construction Stage

In the forefront of and during the construction stage soil compaction should be avoided or else the soil has to be prepared by deep loosening. To guarantee a proper functioning retention basin the following actions have to be avoided (q. v. [18]):

- driving on the retention site with construction equipment
- dumping of construction waste and excavated material
- improper use of retention basins
- no discharge of rainwater runoff before the basin is covered with grass
- underdimensioning.

Hence only well-trained specialists should be commissioned.

A further factor influencing the acceptance in a strong and direct way is the retention basin's exterior. Most interviewed persons wanted their retention basin not to attract attention and to be free concerning their landscape gardening. About 35 % of the interviewed persons wished consultation and 30 % wished to know more about the maintenance of retention measures. As good maintenance obtains long-life functionality people should be informed about possible consultation.

3.3 Operating Stage

Control is an important factor which some of the interviewed people even asked for. Only controls can assure the right construction and the functioning of retention systems in the long run.

Decentralised retention measures on private estate can be replaced by public semi-decentralised retention areas. The compliance with formalities will be more likely, the needed retention volume will be guaranteed, control and maintenance will be easier. The acceptance of the residents will increase as they do not have to pay much attention to this topic and the residential area becomes more attractive due to additional green space.

With regard to private retention measures as well as public semi-decentralised retention areas it is important to maintain the retention areas. Shabby lawns cause negative feelings and can decrease the acceptance. Furthermore the infiltration capacity can be reduced by 30 % if the grass is not cut regularly and the autumn foliage is not removed [18].

4 Conclusion

The present abstract shows good acceptance to be the result especially of flawless function and appealing looks. Purposeful means of actual usage from the residents' points of view as well as financial incentives and detailed, well visualized information can create a stable, positive basic opinion and will help to maintain long-term public acceptance.

Generally the success of projects concerning near to nature rainwater management relies on a good cooperation between all participants and the involvement of the public.

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