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Country reports

Albania

Flood Risk Management in Albania

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Floods are a natural phenomenon in Albania. They frequently occur in the valleys of northern, central and southern Albania, affecting cities, road networks and inundating agricultural land. They are caused by torrential rains, characteristic of the Mediterranean climate. The mountainous character of the rivers, hence the large slopes and the same direction of the flow from east to west, make that peak discharge occur almost simultaneously across the country. In most rivers we have flash floods crossing the river network over an 8 - 10 hour period.

During big floods, which have a return period of 50 to 100 years, the waters inundate the embankments, flooding mainly the Western Plains.

The Western Plains and the Drini and Vjosa river basins are particularly prone to flooding due to deforestation and the lack of riverbed management (World Bank, 2003). Flooding has a direct influence on the life of local communities, by damaging their houses and weakening their economic position. By causing significant damage to agricultural lands and disrupting drinking water supply services, floods increase human health risks and can seriously damage various infrastructures. Most floods take place along the Buna, Drini, Vjosa, and Semani river basins, potentially affecting 24,000 buildings and up to 840,000 people. According to internal reports from the MARDWA, the flooding from the River Vjosa in January 2016 was the worst since 1954. Floods in other river basins potentially affect 8,000 buildings and up to 50,000 people.

According to data from the Ministry of Agriculture (A. Muka 2015) there is a total of 860 km of flood protection embankments in Albania. Every year, efforts are made to repair and reconstruct some of these embankments. The measures undertaken have decreased the risk of inundations from these floods. Nevertheless, during periods of intensive rainfall, and particularly because of the lack of maintenance of urban drainage, these floods still present a certain risk of inundation.

Policy and institutional framework

The National Water Council (NWC) is the main inter-institutional body responsible for drafting policies and plans for integrated water resource management, acting under the Law 111/2012. It is chaired by the Prime Minister of Albania and composed of seven main stakeholder ministries.

The Water Resources Management Agency (WRMA) is the responsible executive institution responsible for the implementation of policies and strategies related to water resources as approved by the National Water Council. The WRMA thus is also responsible for implementing flood risk management policies (according to law 111/2012 for integrated water resources management).

The EU Directive 2007/60/EC on Floods is transposed into Albanian policy as part of the policy "The Content, Development and Implementation of National Water Strategies, of River Basin District Management Plans and of Flood Risk Management Plans", approved by National Water Council decision no. 1 dated 17.2.2015. The policy includes a package of sub laws prepared with support of EU on transposition of EU legislation, like the Directive 2006/118/EC, Directive 2007/60/EC and Directive 2009/90/EC.

The WRMA contributes, in collaboration with the Ministry of Interior, to prevent civil emergencies (according to Article 70 of the Law 111/2012 - Flood risk management Plans). This includes the coordinated implementation of policies for river basin management and flood risk management in compliance with the legislation in force for civil emergencies and the National Management Plan for Civil Emergency.

Practically WRMA is in charge of preparing the flood risk management plans and to coordinate the process with different institutions.

MARD (Ministry of agriculture and rural development) is responsible to prepare and implement the investments for the protection of agriculture land and drainage pumping stations based on the FRM-plans. The municipalities are responsible to protect urban areas from flood risk, also based on the FRM-plan. The General directorate for civil emergencies prepares and implements the national plan for civil emergencies which shall be coordinated with the flood risk management plans.

According to the law 111/2012, the WRMA coordinates all the activities in this area. In detail the following institutions are part of the FRM implementation strategy. Responsible institutions for planning and policies:

- WRMA responsible for policy and planning on central level;
- River Basin Council is responsible for approval of Flood risk management plan;
- General Directorate for civil emergencies is responsible for preparation and approval of Management plan for civil emergencies. Responsible institutions for flood protection investments and risk reduction measures:
- Ministry of Agriculture and Rural Development is responsible for flood protection infrastructure on Agriculture land;
- Municipalities are responsible for investments on flood protection of urban areas and risk reduction measures. Responsible institutions for flood emergencies situations:
- Ministry of Defence and General Directorate of Civil Protection is responsible for coordination of actions and intervention to protect human life and property;
- Prefecture is responsible to coordinate the local institutions during the emergency events on Qark level;
- Municipalities are responsible to coordinate their structures on protection of human life and property.

Besides others some important FRM-projects have been implemented or are ongoing with relevance for the Albanian Drin/Drim-Buna/Bojana River Basin: with GIZ-support the project "FRM-plan for the Skhodra Region" was implemented according to the EU standards from 2012-2015 within the GIZ-programme "Climate Change Adaptation for the Western Balkans" as one of the first FRM plans in the Western Balkan region. The ongoing project PRONEWS, financed by EU, is contributing to the Preliminary Flood Risk Assessment (PFRA) and flood risk maps (FRM) for Albania.

Flood risk management plan

A preliminary flood risk assessment is not developed in Albania, however there are some ongoing activities and projects that are relevant for preliminary risk assessment. Specifically, data on floods and their associated losses are systematically collected by the General Directorate of Civil Emergency / Ministry of Internal Affairs by using the methodology and tools DesInventar (see www.desinventar.net). Furthermore, the flood prones area have been mapped for the lower part of the Rivers Buna and Drini. A Post-Disaster Comprehensive Flood Risk Assessment & Management Study, a Risk Analysis of Flood Hazard & Impact (March 2012) supported by the General Directorate of Civil Emergency / Ministry of Internal Affairs, and implemented by Mott MacDonald (https://www.mottmac.com/) has been developed. These actions represent a starting point for conducting a PRA at national level.

Though the development of a Flood Risk Management Plan (FRMP) is included into Law 11/2012, only few pilot attempts are currently present in Albania and there is not a systematic elaboration of a FRMP for each Unit of Management. A FRMP has been developed for the lower part of the Rivers Buna and Drini in the framework of a project (Author, 2015) implemented by the German Agency for International Cooperation GIZ GmbH in collaboration with key national institutions such as the Ministry of Environment, Ministry of Agriculture, Rural Development and Water Administration, Ministry of Internal Affairs – General Directorate of Civil Emergencies, and the local government of the Shkodër Region.

Flood Hazard and Flood Risk Mapping

The state of flood hazard and risk mapping is at an early stage in Albania and no substantial activities are present in the country. Flood Hazard and Risk Mapping have been produced on a project base for the lower part of the Rivers Drini and Buna by three different initiatives: 1) IncREO project "Increasing Resilience through Earth Observation" (http://www.increo-fp7.eu/project-overview/project-structure/flooding-use-case-albania/), supported by EU–FP7; 2) "Climate Change Adaptation in Western Balkans" programme, implemented by Germany Agency for International Cooperation (GIZ - https://www.giz.de/en/worldwide/294.html); 3) "Drini and Buna risk assessment - A Post-Disaster Comprehensive Flood Risk Assessment & Management Study, Risk Analysis of Flood Hazard & Impact", March 2012, implemented by the General Directorate of Civil Emergency – Ministry of Internal Affairs with the financial support of the World Bank.

Forest contribution to flood protection

Forests represent one of the major natural resources of the country (37% of the territory of Albania). Due to their natural and diverse structure, as well as extensive natural regeneration, they represent crucial resources for the further development of Albania.

Broadleaf forests dominate over coniferous, with a large proportion of oak forests that are mainly used for fodder and firewood production. There is a large portion of degraded or open forest areas in the country (36% of all forest area is covered by shrubs, barren land and/or other forest area).

The majority (78%) of forest areas in Albania are classified as economic forests, i.e., forests which are actually managed for economic purposes. Protected forests represent the 20% of the forest and serve primarily for the protection of land, waters, biodiversity and landscape; including national parks, natural parks, and nature preserves, forests intended for leisure activities, sports, recreation, teaching, and scientific research.

Special purpose forests (2%) are those forests that are especially rare in nature or have a special cultural, religious, or historic importance; as well forests managed for the protection of important water bodies or other important infrastructures.

Table 1: Structure of forest area and forest land by vegetation form, purpose of use and availability[1]

Vegetation form	Available surface (ha)			Total (ha)
	Economic forests	**Protected forests**	**Special purpose forests**	
1. High Forests	323.406	118.113	10.721	**452.240**
2. Coppice forest	279.289	55.220	2.306	**336.815**
1+2 All forests	**602.695**	**173.333**	**13.027**	**789.055**
3. Shrubbery	224.961	26.909	466	**252.336**
4. Barren land	138.588	29.025		**167.613**
3+4 Shrub and barren	**363.549**	**55.934**	**466**	**419.949**
5. Other forest area	12.664	16.737		**29.401**
1+2+3+5 FAO forests	**840.320**	**216.979**	**13.493**	**1.070.792**
6. All forest and forest land	**978.908**	**246.004**	**13.493**	**1.238.405**

Source: Ministry of Environment

There are limited or no data about forest health and damages, particularly of forest diseases. Even reported data on some of the damages (forest fires, illegal logging) are not reliable and accurate since different sources report different data.

The overall productivity of Albanian forests is low (52 m3/ha)2, and the area of good productive high forest is reducing. This is the result of various factors including but not limited to:

- Large proportion of shrubs and coppice forest.
- Overuse of forest resources over the last 50 years.
- Overgrazing of forests areas.
- Lack of management measures for the last 30 years.
- Mediterranean climate/vegetation.

The support of the forestry sector to the economy is therefore very limited. The contribution of forestry sector to the GDP cannot be calculated since it is aggregated to the contribution of the agriculture sector. The trade balance is negative and the employment rate very low.

Illegal and/or unregulated logging are continuing despite government efforts to control them. The government has set a ban on forest commercial activities with the aim to better control and eventually stop illegal logging. Similarly, in order to stop poaching, there is also a ban on hunting for a five-year period. Both these decisions have heavily influenced the level of income generated by the forest sector.

The key actors in the forestry sector include government institutions (Ministry of Tourism and Environment, National Forest Agency, National Agency for Protected Areas), Municipalities, Forests and Pastures Users Associations and private businesses and individuals implementing forestry related activities.

Since 2016, the management of forest resources has been transferred to local government units (municipalities). Most of the municipalities do not have the adequate human and financial resources to provide for a proper management of forest resources.

[1] Source: Ministry of Environment, 2016
[2] INSTAT 2019

The Directorate of Forest at the Ministry of Environment plays a limited role within forest management and cannot guide the sector development since there is little or no connection with the municipalities and their forest management departments. Hopefully the recently established National Forest Agency will complete this gap. The management of forests within protected areas is under the National Agency for Protected Areas. These forests are mainly managed for their environmental function and biodiversity protection.

Investments are mostly provided by international donors. The Environment Services Project has supported the forestry sector by strengthening institutional capacities, supporting IPARD-like grants to improve land management, and introducing Payment for Environmental Services Schemes. The IPARD II program for Albania has included no forestry related measures.

Public investments in the forestry sector during 2019 were focused mainly on afforestation, preparation of management plans and thinning operations. Clearly there is no investment in other forestry activities such as: forest tending, nurseries, water point construction, pasture improvement and soil erosion control measures.

The Forest Policy Document in Albania for the period 2019-2030[3], defines four strategic directions for the future development of the forestry sector in Albania:

- Good governance: Positioning forests as a government priority as one of the most important and vital resources, and raising awareness on the importance of forests.
- Functional organization: Establishing and strengthening an efficient organizational system from the centre to the most remote villages based on best standards and practices.
- Sustainable harvesting: Using forest resources on a sustainable basis by balancing their multipurpose use and potential.
- Quality services: Providing quality services for the forests, aiming at better protection, quality, and use of fast-growing species.

In April 2020, the Parliament approved the new law 57/2020 "For Forests", providing a legal framework for the implementation of the Forest Policy of 2018.

[3] Developed by MOG and CNVP with the financial support of SIDA, approved through DCM no. 814 of 31.12.2018 .

Austria

Integral approach to the flood protection effect of the forest with special consideration of water and sediment retention

Austrian country report in the scope of the 33rd session of the Working Party on the Management of Mountain Watersheds (WPMMW)

Contributions by

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1) Who are the responsible organizations or institutions for flood protection in mountainous regions in your country?

Austria has a long tradition of prevention against natural hazards such as floods or avalanches in alpine catchment areas. Until modern times, natural hazards were considered as devil's work or punishment of supernatural power. Around 1880 - after severe weather catastrophes - the government started to provide protection against natural hazards with France as a reference. In 1882, on the basis of two - at that time still - royal decrees, governmental support could now be granted for disaster areas. Legally, this was attempted for the entire Austrian region at that time. In 1884, the torrent control and melioration acts were the starting impulse for today's federal institution "Forsttechnischer Dienst für Wildbach- und Lawinenverbauung" (Forestry Service for Torrent and Avalanche Control), or WLV for short.

As a federal agency of the Republic of Austria, the Torrent and Avalanche Control is responsible for the protection against natural hazards, such as floods and mudflows, but there is a clear competence depending on whether it is a torrent or a river. According to § 99 para. 1 Forest Act 1975, a torrent is a *"permanently or intermittently flowing watercourse which, by means of rapidly occurring swellings lasting only a short time, removes solids from its catchment area or from its streambed to a dangerous extent, carries them along with it and deposits them inside or outside its bed or feeds them to another watercourse."*

In the upper catchment area, the Torrent and Avalanche Control is responsible for harmful discharges and generally for obstruction; in larger rivers in the lower catchment areas and in the main valley drainages in alpine regions, the Federal Water Engineering Administration is responsible. In addition, there is a third administrative unit, the Federal Waterways Administration, which is in charge of Austria's only stream - the Danube - as well as parts of the rivers Thaya and March.

In alpine regions, however, the Torrent and Avalanche Control is the first point of contact for protection against natural hazards and, as a subordinate agency of the federal government, is organized on a decentralized basis throughout Austria. It is divided into 7 Provincial Headquarters and 21 Regional Headquarters. In addition, there are 4 Expert Teams and a Central Payroll Accounting Unit. The following figure shows the locations.

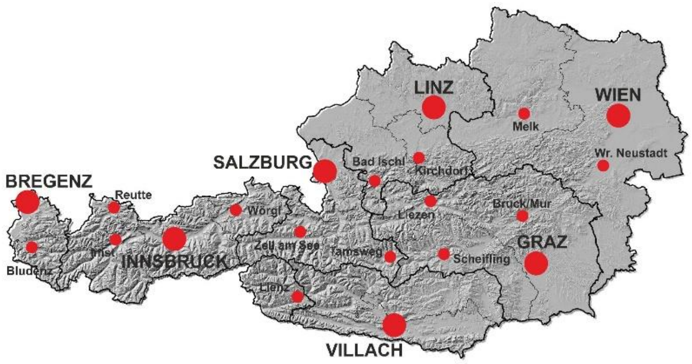

Figure 1: The large red circles symbolize the locations of the Provincial Headquarters , the small ones the Regional Headquarters. At some locations, such as Bregenz, Villach, Innsbruck, Salzburg and Linz, both are located. ©WLV

The services of the WLV include, besides of planning the measures and construction works, expert activities, information on natural hazards, hazard zone mapping and investment management.

In addition to the active management of floods and natural hazards, research, teaching and training play a particularly important role in Austria. The Institute of Alpine Natural Hazards at the University of Natural Resources and Applied Life Sciences Vienna (BOKU) as well as the Institute of Natural Hazards of the Federal Forest Research Center (BFW) have great expertise in topics such as forest effects against floods (retention effect), natural hazard processes or studies on the origin, development and impact of alpine natural hazards. Along with practice-oriented methods to secure human settlements and economic spaces, recommendations for action are published, for example, for the optimization of forest cover for near-surface precipitation storage. The master program Alpine Natural hazards/ Torrent and Avalanche Control at BOKU prepares future engineers for the challenges in practice.

Furthermore, other universities or research institutions are dealing with the topic of flood protection and retention effects. To mention are (excerpt) the Vienna University of Technology (Institute of Hydraulic Engineering and Engineering Hydrology) or other universities in Graz, Salzburg or Innsbruck.

2) What is the legal basis for flood protection and the protection function of forests?

The Torrent and Avalanche Control has its legal basis in the **Forest Act 1975** as amended (§102.) and in the Torrent Control Act for the harmless discharge of mountain waters of 1884 (still valid). The field of work, materials or compensation are additionally regulated.

The Forestry Act 1975 as amended also regulates (VII. section - protection against torrents and avalanches):

- Forest management in catchment areas (§ 100): Should it appear necessary to avert torrent and avalanche hazards, the authority has several options for prescribing special forest management requirements. For example, the use of suitable forest reproductive material or special tree species can be decreed; in addition, felling in the tree line area and in the immediate working area of the WLV can be tied to a permit.
- In addition, if the condition of a torrent catchment area deteriorates, the authorities (§ 100) may prescribe preventive measures such as reforestation or a restriction on the type of logging or limit forest pasture. Furthermore, every municipality through whose territory a torrent flows is obliged to survey these sections at least once a year and to remove any debris found, such as wood or objects obstructing the watercourse.
- Irrespective of the special regulations on forest management in torrent catchment areas, the use of forests is strictly regulated in Section VI of the Forest Act 1975. For example, § 82 regulates the prohibition of clear-cutting. Clear-cutting is prohibited if the productive power of the forest soil is permanently reduced, the water balance is impaired, a run-off of the forest soil is favored or the effect of protective forests is endangered. A distinction is also made between large clearcuts, which comprise a clearcut area with a width of up to 50 m over a length of 600 m or a width of 50 m with an extent of 2 ha. For such a large clearcut, a permit from the forestry authorities is required. Smaller felling operations - as long as they do not involve immature stands (not reaching 60 years of age) - are to be supervised by the authority. These felling operations do not require an official permit, however, if the area used exceeds half a hectare, the forest owner must notify the authority one week before the start of the felling operation.

- If a given forest requires a particular treatment due to its initial site situation or an object-protecting function, this forest is considered a protective forest (§ 21 ff Forest Act). Protective forests include, for example, forests on sites at risk of erosion, rocky rugged sites or growth close to the treeline. Here, according to the Forest Act, the owner is obliged to reinvest the proceeds back into the protective forest - for example, for maintenance measures. If a forest protects an object, however, public funds or payments from beneficiaries are necessary for the reinvestment measures. If the forest serves the direct defense against dangers, here also flood is mentioned, then it can be put into protective forest by declaratory decree at the request of the landowner or by the authority (§ 27 Forest Act 1975 - Bannwald). The management and all interventions in this forest stand are then regulated by the authorities by means of decrees and regulations.

Further legal provisions on precautions against flooding for areas with potential flood risk are regulated by the **Water Rights Act 1959 (WRG)**. The 4th section regulates the defense and maintenance of water bodies:

- § 39 WRG says that the landowner may not arbitrarily change the natural drainage of the waters accumulating on it or flowing over it to the detriment of the lower land.
- According to Article 41 WRG, regulatory and hydraulic structures require a permit under water rights act.
- Hazard zone maps needs to be drawn for areas with a potential significant flood risk in accordance to § 42a. In detail, areas that are particularly at risk are to be kept free of buildings.
- Furthermore, the Water Rights Act includes provisions for precautions against recurrent flooding, obligations for maintenance, the preparation of National Water Management Plans, and flood risk management plans.

Another law that promotes flood protection and the retention effect in a broader sense is the **Water Structures Promotion Act 1985 (WBFG).** The law regulates the objectives for which federal financial resources or funds can be granted. One of these objectives is the protection against water devastation and mudflows. In this way, protection and regulation measures to prevent the formation of bedload in torrents, to improve the water balance and to ensure the harmless discharge of water and bedload, as well as for the care and maintenance of catchment areas, can be funded.

3) What is the major impact of forests on flood protection in mountainous areas?

Depending on tree species, tree species combination and stand structure, forest vegetation reduces the precipitation reaching the soil surface by 4-6 mm per event through canopy retention. With annual precipitation amounts around 1000 mm, the interception loss of conifers can amount to 300 mm and more. The interception loss of tree vegetation, but also of alpine dwarf shrub heath (alpine rose, blueberry, etc.) is significantly higher compared to open land (low-growing vegetation).

Surface runoff on forest sites is usually lower than on the surrounding open land. Furthermore, the roughness of the forest surface is usually higher. The kinetic energy of the precipitation is significantly reduced by the storey-like structure of the stands (canopy, forest floor vegetation and dead material, humus layer...), the flow velocity at the soil surface is significantly reduced. Thus a dosed infiltration into the mineral soil is made possible.

Spruce stands - for example - evaporate up to 90 % at annual precipitation values below 700 mm. At annual precipitation values of around 2000 mm, this value drops to just over 20 %. Thus, the free water storage capacity is higher in forest soils. The retention capacity of non-compacted forest soils and their saturated conductivity are usually significantly higher during heavy precipitation. As an order of magnitude: a 1% increase in moisture may result in a 5% increase in runoff.

In some cases the combination of high long-term precipitation, high pre-humidity, low free soil storage and high interflow rates can also lead to an "overload situation" for some forest sites, e.g. on cohesive soils or on very shallow soils above hard substrate. In such cases the runoff behaviour can successively approach that of the open land.

Deep seepage in the regeneration phase (up to approx. 20 years) is significantly higher - regardless of the tree species - due to the lower evaporation and interception capacity. Therefore, the disposition to landslides is higher in open areas and in young stands. Especially under future climate conditions (e.g., increased liquid precipitation in late autumn and late winter), a proportion of conifers in protection forests at lower altitudes is necessary to ensure sufficient free soil pore space in these periods.

A large number of rain simulation experiments by the BFW (Austrian Research Centre for Forests) and the LfU (Bavarian Environmental Agency) prove a generally lower surface runoff disposition of forest sites compared to open land with low-growing vegetation (alpine grasslands, pastures, etc.). Irrigation experiments of the LfU Bavaria on clear-cuts showed surface runoff values between 10 and 80 %, in spruce regrowth areas between 10 and only 50 %.

In forest soils with macropores near the surface (root channels, fissures, shrinkage cracks...), mean flow velocities of 500 m d-1 and higher can be expected. Macropores in the soil (cavities in the mm to dm range) allow rapid deep percolation, but under certain circumstances also rapid lateral interflow to the receiving water course. However, a minimum amount of precipitation is necessary for a corresponding reaction (continuous rainfall events).

4) In which way an integral (multifunctional) approach for the management of mountain watersheds influences the flood protection effect of the forest?

Forest management and land use can massively change the timing and the amount of water discharged into the receiving water course along the different runoff pathways (surface runoff, interflow, deep percolation), and especially the flow pathways themselves. For example, clear-cutting leads to an increase in runoff, especially on runoff-sensitive sites. Additional stresses on the forest soil, e.g. long-term grazing, driving with heavy machinery, etc., significantly worsen the runoff behaviour and infiltration characteristics of forest soils.

Peak flows in forested catchments (< 10 km^2) occur with a significant delay and are generally lower compared to unforested areas. In this context in small mountain catchments significant reduction and delay of runoff in torrential rain events can be achieved in runoff prone catchments e.g. by a significant reduction of the grazed areas, abandonment of pasturing in forests, installing of extensive afforestation in the subalpine zone, improvement of exploited forests or the closure of gaps in forests by afforestation. The forest effect depends on i) percentage and location of the area covered by forests and ii) the extent and duration of the precipitation event. According to numerous studies, the retentive or runoff-reducing effect of forest vegetation is only small during continuous rainfall events and during prolonged convective events in large catchments (>> 100 km^2). However, the literature consistently suggests that flood peaks in small, forested catchments (< 10 km^2 area) are significantly delayed and generally lower. Field observations after the catastrophic rainfall events of 22nd/23rd August 2005 in the Bregenzerwald showed that appropriately managed protective forests have a runoff-reducing and slope-stabilising effect even during continuous rainfall or longer convective rain events. They have a slope-stabilising effect, reduce the input of solids into torrents and thus can reduce the potential for debris flows.

According to the results of the ITAT4041 project BLÖSSEN, even in catchments with a low proportion of forest there is a clear runoff-reducing effect of the forest belt, at least at sub-catchment level and at the slope scale. However, forest improvement measures implemented over decades are often neutralised by short-term technical interventions (e.g. construction of roads, tourism infrastructure, etc.).

Forested areas are only capable of buffering slope water (surface and also interflow) from higher (forest-free) areas to a limited extent. Such run-offs are quickly channelled linearly to the receiving watercourse. In order to compensate for 1 ha of converted forest area (levelled, disturbed forest soil), or to at least partially compensate for this deterioration mathematically, the runoff coefficient would have to be reduced from a surface runoff coefficient of 0.2 to a value below 0.1 on a forest area of at least 5 ha directly below. In fact, compensation is much more complex, as the runoff on these (partially) sealed areas or from the drainage systems or culverts immediately becomes linear (concentration in the depth contours) and cuts through the underlying areas linearly.

5) What challenges do you see in the management of forests with special consideration of flood protection?

Climate change poses problems for the stability of protective forests. Drought will be more important for tree growth and species distribution in climate change than increased temperatures. In addition, the tree species spectrum in the protective forests is limited due to the altitude. Drought severely limits the growth of beech, ash, fir and spruce. Pine and spruce have good water-saving strategies, but the susceptibility of spruce to pests and damage has increased considerably in many locations in recent years. Larch restricts its water consumption only insignificantly during dry periods, so increased future dry periods may pose a problem for larch too. In this context, forest fires are also highly crucial. Although, overall, these account for only a small proportion of disturbances in the forest ecosystem, an increase is expected in Austria. If such fires occur in important object protective forests, immediate measures and, in many cases, technical obstructions are necessary in order to be able to guarantee the protection of the living space in the long term. Foresters will have to face an increase of disturbances (damages to forest stands by storms, wet snow, diseases…). Adaptation of the management strategies is necessary.

Driftwood management is a major problem. Forests can also form a danger due to the entry of tree trunks into water bodies. For this reason, the slopes alongside the streams - depending on the inclination - deserve adequate management over a width of two to several tree lengths. Current regulations require a general removal of trees to a spread of 1.5 tree lengths and more along the stream. This is counterproductive in terms of surface runoff prevention and slope stability, since the slopes lose their natural reinforcement 10-20 years after the removal of the old stand due to the decomposition of the roots. The goal should be mixed stands managed like permanent forests, in which the stronger individuals are removed within shorter intervals (no one-time clearing during the rotation period, but interventions at shorter intervals).

Delayed reforestation after timber harvesting is a strongly increasing problem. Foresters report increases of open areas in protective forests due to high browsing pressure by game. Game is being pushed into regeneration areas due to increasing tourism and local recreation activities. This leads to reduced slope stability because of the lack of reinforcement by tree roots, and higher (surface) runoff during heavy rainfall. Timely reforestation is therefore linked to optimised game management. However, this also requires a reduction of anthropogenic stress factors, such as avoidance of permanent disturbance of game animals by humans.

6) Which kind of calculation and simulation approaches are used for flood protection issues?

In Austria different kinds of calculation and simulation approaches are used. An up-to-date overview in German is provided by ÖWAV Regelblatt 220: Precipitation-Runoff Modeling (ÖWAV, 2019). Quite common for calculation of (recurrent) design events in ungauged micro-scale (<=10 km²) and meso-scale (10-100 km²) catchments are event-based precipitation/runoff (p/r) models. Event models like HEC-HMS, MODRAT, ZEMOKOST, HYDR²AC only represent a single runoff event occurring over a period of time, ranging from an hour or less to several days. Before running the model, the prevalent system conditions must be defined. A major advantage of such models is that usually only a small number of parameters is required. In addition, parameterization of the models is easy, the necessary data can be collected with reasonable effort at a highly accurate level. So, the p/r-model ZEMOKOST (Kohl 2011) which is widely used in Austria by the Torrent and Avalanche Control (WLV), civil engineers and technical offices, uses surface runoff coefficients and surface roughness coefficients which can be easily derived using the "Code of Practice for assessment of Surface Runoff Coefficients". The code of Practice has been tested for Austria, South Tyrol, Bavaria and Switzerland. Subsurface flow in ZEMOKOST is rooted in a similar way to surface runoff. Therefore, information about contributing areas in the underground and potential flow velocity is needed. In the Federal Province of Tyrol area-wide information on surface runoff coefficients and surface roughness coefficients has newly been developed in the frame of the Projects PSINOT and PSIOT at BFW on behalf of the WLV, Section Tyrol. In the frame of PSINOT also the hydrogeological information from the HYGENOT project (Hydro-Geology North-Tyrol) and a precursor hydrogeological project edited by Pirkl (2011) for East Tyrol was processed in such a manner that contributing areas in the subsurface and bandwidths of flow velocities are also available for the Tyrol. The project HYGENOT was developed at the Institute of Applied Geology at BOKU (Vienna) on behalf of WLV, Section Tyrol, too.

HEC-1 and HEC-HMS derivatives or further developments of these approaches are also in use. HEC-1, developed by the Hydrologic Engineering Centre in Davis, USA, is based on so called curve numbers, which have been developed for the US soils. Thus, there is a lack of suitable curve-numbers e.g., for the alpine soils in Austria.

Other event-based approaches used in Austria are e.g. IHW, WMS, PROMAB GIS or HYDR²AC. However, some of these models are only used by the developers or a few authorised companies and some are subject to a distribution restriction.

Until the turn of the millennium, in many cases so-called “rules of thumb” were primarily used to estimate p/r- and design runoff. These formulas were mostly developed by experienced experts of the WLV, often over decades of observation. As a rule, they are simple empirical relationships with which the mean discharge, the discharge head or their extreme values are calculated from area characteristics such as catchment area size, river length, mean gradient or precipitation height. One problem is comprehensibility. Often these approaches only have regional validity. Therefore, these approaches are used less and less, e.g., sometimes for cross-checking model results.

For the estimation of sediment transport in mountain rivers and torrents, the simulation software TomSed is often used. TomSed is a one-dimensional model, gravity and resistance are considered in the equation of motion (kinematic wave). Backwater effects cannot be represented because local and convective accelerations as well as pressure terms are not integrated in the numerical solution.

There are a number of approaches for runoff modelling and forecasting in gauged large river basins in Austria. For the Tyrolean River Inn, for example, the HQsim model is used as a forecasting model, an approach originally based on the BROOK model, with significantly more detailed temporal resolution and improved routines for winter water turnover. Furthermore, the Hydrographic Service of Tyrol also uses the LARSIM model (Large Area Runoff Simulation Model) developed by HYDROTEC for runoff forecasting in the larger river basins of the Lech and the Großache (North Tyrol) and the Isel (East Tyrol). The flood forecast models for the rivers Mur, Enns and Raab in Styria were developed by JOANNEUM RESEARCH in cooperation with the Danish Hydraulic Institute (DHI) on behalf of the province of Styria. They serve to provide the respective flood warning services in the countries of Austria, Slovenia, Hungary and Croatia with a tool that makes it possible to estimate developments in the runoff pattern for a certain advance warning period on the basis of constantly updated data on precipitation, water level and predicted precipitation data. A multitude of other models could be mentioned here (COSERO, TUW-HBV, KAMPUS...).

7) Are there best practices of watershed management measures that have a positive impact on the runoff capacity of mountainous torrents and streams and subsequently in the settlement area?

In order to control the water balance, for example, but also to prevent avalanches and rockfall or to reduce the potential for landslides, area management projects ("Flächenwirtschaftliche Projekte") are implemented in "forests with object protective effect". As a rule, these projects include afforestation, forest maintenance and forest management measures as well as the construction of the necessary access roads and supporting technical measures. Such land management measures have been very successful and have contributed to the reduction of runoff potential in many catchments.

One of the best examples of the hydrological effectiveness of land management measures in alpine catchments is the "Integral amelioration in the Ziller valley" (a right-bank tributary valley of the river Inn). In the front and the middle part of the valley extensive measures have been taken since the 1950s by the WLV to reduce runoff in heavy rainfall. These measures included a significant reduction in pastures, extensive afforestation of high-altitude areas, afforestation of non-forested areas in the forest belt, optimisation of existing forest stands, e.g., by releasing pastures, and others. Comprehensive studies by the BFW prove the high effectiveness of the measures implemented by the WLV (e.g., Kohl et al. 2004, Kohl et al. 2007).

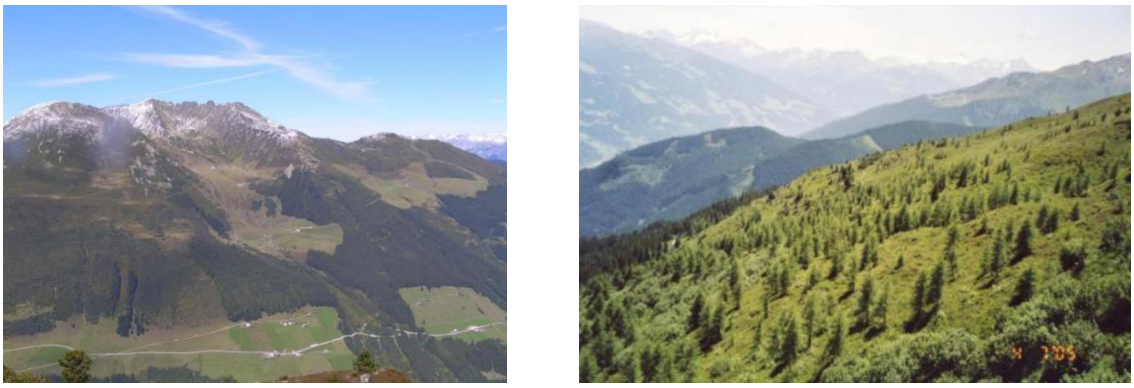

Figure 2: One of the main measures was the reforestation after destructive events such as avalanches and the reforestation of high altitudes with forest plants as well as with dwarf shrub heaths (alpine roses, blueberries,..).©WLV

In order to improve the reproducibility of hydrological modelling results, efforts have been made at the federal state level to create standardised input data bases. On behalf of the province of Lower Austria and the Lower Austrian section of the WLV, standardised data bases (soil hydrological parameters, runoff coefficient maps, etc.) were created by the BFW and the Federal Office for Water Management in the HYDROBOD_NÖ project, which can serve as input parameters for common hydrological models (ZEMOKOST, HEC-HMS, etc.). For Upper Austria, such a project (HYDROBOD_OÖ) is in progress on behalf of the province of Upper Austria and WLV. A map of the subsoil runoff processes (by H. Pirkl) and a runoff coefficient map developed by the BFW for East Tyrol are available. Such maps developed by BOKU and BFW respectively on behalf of the WLV, Tyrol Section, will be available by the end of 2021.

The draft of the second national flood risk management plan RMP2021 is available (https://info.bmlrt.gv.at/themen/wasser/wisa/hochwasserrisiko/oeffentlichkeitsbeteiligung-risikomanagementplan2021.html). It was prepared in accordance with the requirements of Directive 2007/60/EC of the European Parliament and of the Council on the assessment and management of flood risks (EU Flood Directive). The Directive was implemented in the Water Rights Act (WRG 1959) and provides for three working steps:

- Carrying out a preliminary flood risk assessment.
- Preparation of flood hazard maps and flood risk maps
- Preparation of a flood risk management plan

The third step, the flood risk management plan and the action programme for the individual risk areas contained therein, must - according to the WRG - contain measures to achieve the appropriate objectives for flood risk management. The measures include both structural measures, such as flood protection dams and retention basins, but in many areas also non-structural planning measures (spatial planning, building regulations, disaster control), management measures (agriculture and forestry) and awareness raising. The flood risk management plan describes these measures, explains the process of implementation, and gives recommendations for action.

Within the framework of the ITAT4041 project BLÖSSEN, in coordination with the Tyrolean and South Tyrolean Forestry Service, the WLV and other stakeholders the BFW developed a code of practice for the optimisation of the hydrological effect of protection forests, based on extensive literature research and field studies as well as the experiences of responsible foresters and forest rangers. (https://www.bfw.gv.at/wp-content/uploads/BFW_Handlungsanleitung_Optimierung_hydrologischer_Wirkung_Schutzwaeldern_2020.pdf)

In the Danube-Transnational-Project CAMARO-D (Cooperating towards advanced management routines for land use impacts on the water regime in the Danube river basin) a guide for sustainable land use planning has been developed (GUIDR - Guidance for the Danube Region for sustainable land use planning). (http://www.interreg-danube.eu/uploads/media/approved_project_output/0001/37/5b8d5a835624b6a9538ab8bc7e4f92cc625eb3c8.pdf)

References

Kohl B., Sauermoser S., Frey D., Stepanek L., Markart G. (2004): Steuerung des Abflusses in Wildbacheinzugsgebieten über flächenwirtschaftliche Maßnahmen. Internationales Symposion INTERPRAEVENT 2004 – RIVA / TRIENT, Tagungspublikation, Band 1, Thema III, 2004, p. 159-169.

Forstgesetz 1975. Bundesgesetz vom 3. Juli 1975 mit dem das Forstwesen geregelt wird. StF: BGBl. Nr. 440/1975

Kohl, B., B. Sotier, K, Klebinder, A. Jochem und G. Markart (2007): Hydrologie Finsing – Szenarienanalyse. Bericht an den Forsttechnischen Dienst für Wildbach- und Lawinenverbauung, Sektion Tirol, 40 Seiten.

Kohl B. (2011): ZEMOKOST – Entwicklung eines praktikablen Niederschlag-/Abflussmodells zur Modellierung von Hochwasserabflüssen in Wildbacheinzugsgebieten unter Einbeziehung verbesserter Felddaten. Dissertation, Fakultät für Geo- und Atmosphärenwissenschaften, Institut für Geographie, Universität Innsbruck, 2011.

ÖWAV (2019): ÖWAV Regelblatt 220: Niederschlag-Abfluss-Modellierung, Österreichischer Wasser- und Abfallwirtschaftsverband, Wien.

Wasserrechtsgesetz 1959. WRG. Gesamte Rechtsvorschrift für Wasserrechtsgesetz 1959. StF: BGBl. Nr. 215/1959 (WV)

Wasserbautenförderungsgesetz 1985. WBFG. Bundesgesetz über die Förderung des Wasserbaues aus Bundesmitteln. StF: BGBl. Nr. 148/1985 (WV)

Wildbachverbauungsgesetz 1884. Gesetz vom 30. Juni 1884 betreffend Vorkehrungen zur unschädlichen Ableitung von Gebirgswässern. StF: RGBl. Nr. 117/1884

Bulgaria

33rd Session of the EFC Working Party on the Management of Mountain Watersheds (WPMMW) with focus on this year's topic:

Integral approach to the flood protection effect of the forest with special consideration of water and sediment retention, 13th – 15th of October 2021

Traunkirchen, Austria or online via stream

Country report, Bulgaria

1. Who are the responsible organizations or institutions for flood protection in mountainous regions in your country?

The main executive disaster management organization is General directorate „Fire safety and civil protection /FSCP/ by Ministry of interior. Each region in the country has a local FSCP directorate.
Responsible structures for disaster risk reduction are all ministries and departments, district administrations, municipalities, centers for emergency medical care, other medical and health facilities that have obligations to perform the preventive activity under Art. 6 of Disaster Protection Act and the implementation of disaster protection plans, including legal entities and sole traders, voluntary formations and formations of the armed forces. Forest services at the Ministry of agriculture, food and forests and River basin directorates at the Ministry of environment and water, esp. on regional level are working in cooperation with Ministry of interior in case of disaster. On national level the Ministry of Environment and Waters is responsible for water management and on regional - River basin directorates.

At national level:

The Council of Ministers determines the policy for disaster protection. The Council of Ministers is assisted by the Disaster Risk Reduction Council, which acts as the national DRR platform. The Council includes relevant ministries, the Bulgarian Academy of Science, universities, the municipalities association, the Bulgarian Red Cross and other organizations working on DRR.
The executive power authorities assist the drafting of national planning documents and implement them; control the implementation; take DRR measures; provide the response capacities of the relevant authority and implement the activities of the national strategy for DRR.

At regional level:

The Regional Governors organize and manage the disaster management in the region, assisted by Regional Disaster Risk Reduction Councils.

At municipal level:

The mayors organize and manage the disaster protection within the municipalities, assisted by Municipal Disaster Risk Reduction Council.
Voluntary formations, established at municipal level are under the direct authority of the mayor. They are an integral part of the unified rescue system.[4]

2. What is the legal basis for flood protection and the protection function of forests?

The main legal act regulating flood protection is the Disaster Protection Act and according to it the Minister of Interior shall draw up the National Disaster Protection Plan jointly with representatives of the ministries, The Bulgarian Red Cross and the local government authorities. It is adopted by the

[4] https://ec.europa.eu/echo/what/civil-protection/disaster-management/bulgaria_en

Council of Ministers. The district governor organizes the drawing up of a district disaster protection plan in coordination with the territorial units of the central executive power and the mayors of municipalities. The mayor of the municipality draw up a municipal disaster protection plan jointly with representatives of departments and legal entities related to disaster protection carrying out their activity within the territory of the municipality. The "Flood" part from the disaster protection plans shall be drawn up taking into account the Flood risk management plans, developed under the terms and following the procedure of the Water Act. In accordance with the Water act, flood risk management plans have been developed for each of the four basin management areas for the period 2016-2021.[5] Flood risk management plan with program of measures according to the implementation of the EU Floods Directive are elaborated by River Basin Directorates and Ministry of environment and waters. River basin management plans, Hazard and flood risks maps, Municipal plans for disaster protection are conducted on regional level.

The main legal act for the protection functions of forests is the Forest Act. According to it:
Art. 5 "Forest territories, depending on their major functions shall be divided in 3 categories:
1. Protective
2. Special
3. Economic
Protective shall be the forest territories for protection of soils, waters, urban territories, buildings and sites of the technical infrastructure; the upper forest limit; the protective belts, as well as forests for erosion control.
"Forest territories shall fulfill the following basic functions:

- 1. protection of soils, water resources and cleanness of the air;
- 2. maintaining the biological diversity of the forest ecosystems;
- 3.providing social, educational scientific, landscape and recreation uses for society;
- 4. protection of the natural and cultural inheritance;
- 5. production of timber and non-timber forest products;
- 6. regulation of climate and absorption of carbon[6]

Art. 90. (1) The protection of the forest territories against erosion and floods shall cover the activities, related to protection from taking away fine fractions from the threatened soil for maintaining the soil fruitfulness by limiting or decreasing the surface water flow, protection of the upper layer from wind erosion and providing opportunities for development of vegetation, including by technical equipment

- (2) The protection of the forest territories against erosion and floods, as well as the structure of the supporting equipment shall be done under the terms and conditions of the ordinance under Art. 95, Para. 2, p. 4.

A Chapter on forest ecosystem services is included in the Forest Act, Public Ecosystem benefits from the Forest Territories.
Art. 248. (1) Public eco-system benefits from the forest territories shall be the results from the specialized activities of its management.
(2) Public ecosystem benefits from the forest territories shall be
1. Protection against erosion of soil from avalanches and floods;
2. Guaranteeing the quantity and quality of water;
3. Maintaining biological diversity;
4. Scanning, noise contaminators take over and maintaining micro-climate;
5. Providing conditions for recreation and tourism;
6. Maintaining the traditional landscape;

[5] file:///D:/User/Downloads/ON_PROTECTION_IN_CASE_OF_DISASTERSDISASTER_PROTECTION_ACT.pdf

[6] https://www.lex.bg/laws/ldoc/2135721295

7. Protection of the natural and cultural heritage;
8. Protection of infrastructure sites and equipment;
9. Slowing down and regulation of impacts from the climate changes.
Art. 249. (1) The public ecosystem benefits under Art. 248, Para. 2, where they are in favour of performing economic activity shall be paid.

The issue for protective forests is included as a special chapter in the National strategy for the development of the forest sector in the Republic of Bulgaria 2013-2020, and in the Strategic Plan for the Development of the Forest Sector 2014-2023 (SPDFS).
Two of the four identified priorities are
i) Sustaining vital, productive and multifunctional forest ecosystems, contributing to the mitigation of the effects of the climate changes;
ii) Protection, restoration and maintenance of the biological and landscape diversity in forest territories
The Strategic Plan for the Development of the Forest Sector, 2014-2023 also identifies to develop a concept for ecosystem services and their sustainable and socially acceptable management.
The Forest Act and the Ordinance on forest inventory have special chapters for protective forests, describing their functions and management.
The Executive Forest Agency and its regional structures, the Regional Forest Directorates, are responsible for the regulation and control of forests. The Executive Forest Agency cooperates with the Ministry of environment and water and with the Executive Environment Agency in order to protect and manage the protective forests in a sustainable way.
There is cooperation on regional level between regional and local forest services and River basin directorates related to water protective forests. State Forest Enterprises are responsible for the management of the protective forests. The municipalities manages the municipal forests according to the forest management plans.

3. What is the major impact of forests on flood protection in mountainous areas?

Forest ecosystems with high-level water protection functionality provide (1) good infiltration conditions for precipitation water, (2) storage capacity for the water infiltrated in the soils and also on plant surfaces, (3) snow storage capacity, (4) prevention or mitigation of erosion processes like mudslides, rock-fall or snow-avalanches, (5) stabilization of soil and humus layers and (6) filtration of precipitation water.
Good practices for erosion and torrent control in the country exist for more than 100 years. Best practice for decreasing erosion and flood risk are avoiding soil degradation especially on steep slopes, afforestation of eroded or bare land, and establishment of forest shelter belts. Afforestation activities for erosion, flood and torrent control are main instrument on steep slopes and are closely related with water and forest management. The organized erosion control activities combine forestation and construction of fortification facilities, not only for protection of soil, but also for its long-term recovery.

Fig. 1 Technical erosion control measures

Fig. 2 Lukov dol - 1937

Lukov dol - recently

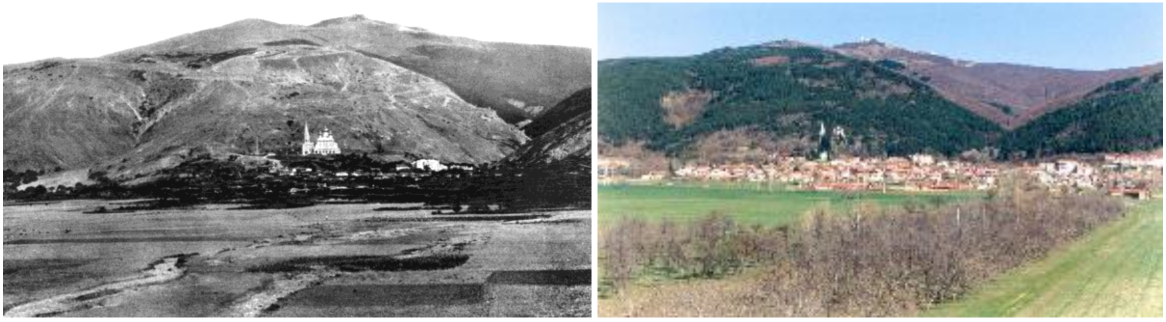

Fig. 3 Southern slopes of Balкan mountain, close to village Shipka in the beginning and at the end of XX century[7]

Buffer Strips along streams, dolines and sinkholes limit erosion processes and are a very effective way to prevent the entrance of various substances into the water body. Forested buffer strips close to streams and lakes are established and maintained in order to protect the open water bodies from direct infiltration of nutrients or sediments, which can be caused by strong precipitation events, erosion processes or logging activities.

The tree line (upper forest limit) is a special ecological system, expressing a sharp change in the vertical zonation. Part of the water protective forests in the country form the upper tree line (upper forest limit) in high mountains, regulating surface water runoff and avalanches. The upper forest limit maintains the water flow of rivers, reduces the spring floods, and protects roads and settlements. The forests in the alpine zone retain in their crowns parts of the rainfall (interception), reduce evaporation and increase soil retention capacity. Thus the preservation of upper forest limit is of great importance for the improvement of water-protective and water-regulative functions of forests.

4. In which way an integral (multifunctional) approach for the management of mountain watersheds influences the flood protection effect of the forest?

Watershed management is a dynamic and continually readjusting process. Considering the variety of the interactions between the different land use types, the implementation of the land use plan is the core for sustainable management within the catchment. The multidisciplinary and flexible approach of managing land use types includes best management practices, implemented in order to solve existing conflicts between land uses and the protection of water resources as well as flood prevention. The sustainable management practices for protection of water resources and flood risk prevention

[7] Panov P., 2000, Control of torrents in Bulgaria, MAF, National Forestry Board

differ according to the land use types. They are directed to restriction of management activities on vulnerable lands, erosion and torrent control, reduction of fertilizers, pesticides and herbicides, special management regimes and proper spatial planning in drinking water protection areas, furthermore regulating timber harvest regime and maintenance of river banks and cleaning the riverside vegetation.

In forests, avoidance or prohibition of clear cuttings, especially on steep slopes is a practice to prevent erosion processes and reducing flood risk. According to Art. 104 of the Forest Act it shall be prohibited:
"1. Conducting clear cuttings in all forests with the exception of the poplar, willow and low-stem forests;
2. Conducting clear cuttings in linden forests in an area larger than 2 ha
3. Merging clear, non-restorable timber –cutting area, larger than 2 ha in low-stem forests with the exception of acacia forests;
4. Felling dwarf pines and Bosnian pine (Pinus heldreichii) forests with the exception of the sanitary one;"

Restoration and enrichment of eroded grassland (meadows, pastures) and afforestation on eroded and torrential slopes in order to achieve land stabilization and erosion and flood risk minimization is of great importance. Practices for erosion and flood control are the avoidance of housing, commercial and infrastructure development in river flood plains, restoration and enrichment of eroded natural vegetation /grassland/forest in the mountain regions and maintenance of buffer green belts around settlements and water bodies. There are efforts to support sustainable land use management in protected and/or wetland areas in order to contribute to biodiversity preservation and improve landscape quality. Other efforts are related to limiting bark beetle infestation and spreading of invasive species to ensure growth, regeneration and distribution of native species.
"The Bulgarian Forest Act contains a variety of provisions related to protecting and increasing the forest area, maintaining and improving forest conditions, guaranteeing and maintaining ecosystems, the social and economic functions of the forest territories, protection of forest territories against erosion and flood control and regulate sylvicultural measures including afforestation, reforestation and natural regeneration of forests. It includes specific objectives to convert hardwood coppice stands into high-stem forests (Art. 88 of the Forest Act), as a sylvicultural measure to improve economic, social and environmental outputs of forests. To maintain landscape diversity, there is a general principle to convert even-aged, homogeneous forest into unevenaged, heterogeneous stands through close-to-nature sylvicultural measures. The forest management plans contain a chapter about erosion control and anti-erosion measures. Forest planning in river basins takes fully into account the need for water protection zones around drinking water supplies".[8] Within the Camaro-D project (EU INTERREG, Danube transnational programme 2014-2020), where the Executive Forest Agency participated, a concept of a land-use development plan was elaborated on the transnational level. The concept comprises a number of interdependencies between land-use practices and water resources. Within the land-use development planning (LUDP) concept, the issue of good governance for the effective coordination of policies between different sectors and policy levels are described. Horizontal coordination of sector administrations and policies, vertical coordination of different levels of responsibilities and the active involvement of all relevant stakeholders are essential. "It represents the starting point for transnational catchment-based cooperation, to include common measures that could be integrated into existing River Basin Management Plans and Flood risk management. Its main goal was to develop guidelines to steer stakeholders and their activities towards long-term water resource protection and flood risk mitigation." [9]

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[8] **Forest Landscape Restoration** in Eastern and South-East Europe, *Background study for the Ministerial Roundtable on Forest Landscape Restoration and the Bonn Challenge, GENEVA TIMBER AND FOREST DISCUSSION PAPER 87, UN, FAO/UN, 2021*
[9] The same as ref. 5

Policy measures guaranteeing an environmentally friendly and sustainable management of land use types and ensuring the coordination of all sectors concerned (forestry, agriculture, water management, grassland management) are recommended. Prerequisite for successful policy development is active stakeholder involvement in decision making process which should be ensured throughout different instruments /knowledge transfer, workshops, filed trips, mobile expert groups on the spot, etc/. For mitigation of flood risks the integration of flood hazard information and protection of open spaces in regional and local land use planning are one of the most important issues, whereby the coordination of flood risk management at catchment scale has to be considered.

5. What challenges do you see in the management of forests with special consideration of flood protection?

In the past, the over-exploitation of the forest resources caused the main torrential activities. In the beginning of the 18th century, the main reasons for the destruction of the Bulgarian forest were the intensive mining to supply the military shipbuilding of the Ottoman Empire, the extraction of charcoal for the iron industry, the establishment of arable lands and pastures on the slopes. Nowadays, components of the negative anthropogenic influence are forest fires, uncontrolled grazing, illegal logging, and the extraction of inert and mineral materials.
Up to 1944 about 170,000 ha of eroded land in torrential watersheds are afforested. The combat against erosion has a new development after 1952. This period is characterized by the biggest afforestation -1 900 000 ha, 40% of which was with anti-erosion purposes. Up to 2004, 159 000 ha have been afforested, i.e. 10 600 ha per year. Less than 10% were anti-erosion forestation. The reasons for this decrease is mainly related to economic and organizational instability of forest sector.[10] Coniferous species are used at more than 80% of total afforestation. Big part of them were forested out of their natural distribution. Coniferous plantations, afforested 40-50 years ago out of their natural areal with the main aim to control the erosion in the country reached their utmost growth limit. As a result they are very susceptible to bark beetle or other forest pests. Recently on the territory of the country about 30 000 ha coniferous plantations are affected. There are legislative measures for ecological reconstruction of damaged forests, e.g. cutting of the affected forests and encouragement of natural regeneration of the broadleaf species in their natural areal. In mountain watershed plantations, *Pinus nigra* and *Pinus sylvestris* are attacked by bark beetle, which leads to deforestation of certain areas and risk of erosion and torrents.
The vulnerability of water resources depends on climate change at different degrees. Climate change (trends and extreme events) and land use changes (erosion, land degradation, soil compaction, forest fires, etc.) decline water retention capacity and increase flood and drought risk. Extreme events will become more frequent and more flash floods and fluvial floods can be expected. Climate change can alter the growth conditions for forest ecosystems significantly. Within “Programme of measures for adaptation of the forests in Bulgaria and mitigation the negative effect of climate change on them”, adopted by the Minister of agriculture and food, a determination of the main vulnerability zones of the forest ecosystems in terms of climate changes was elaborated. The measures for adaptation are specified according to every vulnerability zone.[11] The challenge will be to secure funding for the implementation of adaptation measures.

[10] Panov P., 2000, Control of torrents in Bulgaria, MAF, National Forestry Board

[11] Programme of measures for adaptation of the forests in Bulgaria and mitigation the negative effect of climate change on them”, 2011, INTERREG IVC, FUTUREforest project publication

6. Which kind of calculation and simulation approaches are used for flood protection issues?

The National Institute of Meteorology and Hydrology (NIMH) at BAS (Bulgarian Academy of Science) is the main body carrying out scientific research and operational activities in the field of meteorology and agrometeorology. The guiding principles of these activities, especially the operational ones, are the Technical Regulations of the World Meteorological Organization, where NIMH is the official representative of Bulgaria. In 2005 NIMH started to receive the European Flood Alert System (EFAS) bulletins with indicative hydrological forecasts. The operational issues of flood monitoring, forecasting and warning are based on operational observations of river levels and provisional rating curves for real time conversion of levels into discharges; operational synoptic meteorological forecasts of precipitation and air temperature; operational forecasts of precipitation and air temperature coming from the High Resolution Limited Area meteorological forecasting model (ALADIN).[12]

Early warning system including a real time hydrological data processing, graphical representation of intense precipitation forecast and hydrological forecasts, flood forecasting/warning system (at different Bulgarian river basins) is set up by NIMH (Fig…, Fig…). According to their scope and organization the early warning systems are on national level (www.hydro.bg), on basin level (plovdiv.meteo.bg), on local level (www.targo.org). [13]

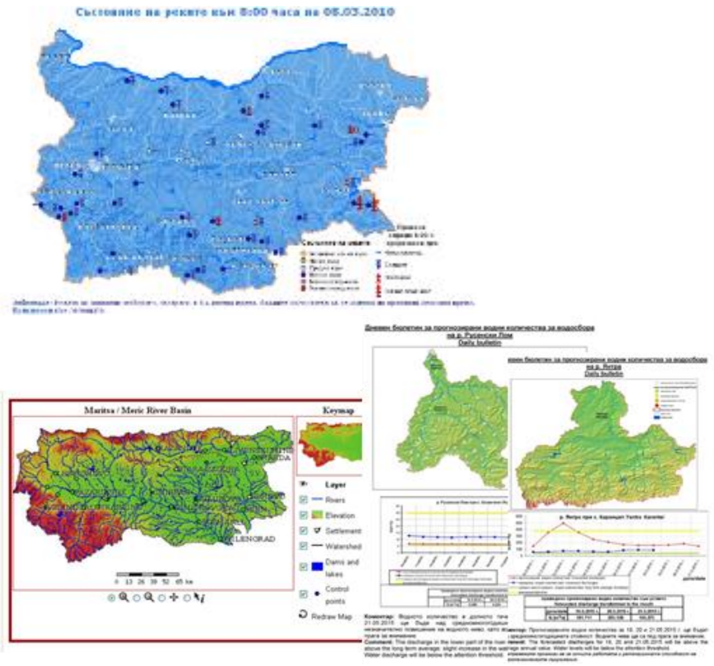

Fig. 4 Real time hydrological data processing and flood forecasting systems, NIMH (www.hydro.bg)

[12] https://www.icpdr.org/main/sites/default/files/FAP15_Lower_Danube_Corridor.pdf

[13] Artinyan, Er., D. Dimitrov, Hydrological Information System, Basic Tool in Water Management and Decision Making, http://plovdiv.meteo.bg/docs/bulgaria_presentation.doc

Fig. 5 Flood Warning - simulated scenarios (D. Dimitrov, 2015)

168 simulation models of floods in the country, as well as subject maps of potentially flooded areas of some pilot municipalities and river basins (Fig. 6) are developed.[14]

Fig. 6 Areas with developed simulation models in Bulgaria

7. Are there best practices of watershed management measures that have a positive impact on the runoff capacity of mountainous torrents and streams and subsequently in the settlement area?

Buffer zones around settlements are created to protect the environment and protect residential and commercial areas from industrial and natural disasters. They are forests of natural or artificial origin where sylvicultural activities can be carried out to improve the condition and increase the effectiveness of the anti-erosion effect. They have a significant anti-erosion effect both against water and wind erosion by affecting the adjoining sites and improving the microclimate and living conditions in the protected settlements. The aim of afforestation was to protect the neighboring houses from landslides and floods. To protect the road infrastructure, additional rocky bracket walls were build.

[14] Dimitrov, D., Early warning and forecasting systems, NIMH – BAS, 2015

Years	Erosion control afforestation, ha			
	Total	state	municipal	private
2011	519,7	519,7	0	0
2012	356	356	0	0
2013	433,6	364,1	69,5	0
2014	542,1	521,6	20,5	0
2015	454,4	445,7	8,7	0
2016	579,8	523,8	56	0
2017	520.8	520.8	0	0
2018	487.4	480.5	6.9	0
2019	452.3	444	8.3	0
2020	531.2	531.2	0	0

Table 1 Erosion control activities on forest territories carried out in the period 2011-2020 depending on ownership[15]

The water protective forests in the country preserve gullies, shorelines, etc. and protect from landslides, torrents, floods, etc. Part of them form the upper tree line (upper forest limit) in high mountains, regulating surface water runoff and avalanches. The upper forest limit maintains the water flow of rivers, reduces the spring floods, and protects roads and settlements. Due to the fact that this type of forests have a solely water protective function, forestry practices are not recommended. If necessary, the activities should imitate the natural dynamics and restoration processes of the ecosystems. These forests are marked as High Conservation Value Forests (HCVF)[16]. Most of them are coniferous forests, esp. mountain (dwarf) pine stands /*Pinus mugo*/. The total area of the forests at the tree line in subalpine forest belt in Bulgaria is 40,356 ha, from which mountain pine is 23 879 ha. [17]

The upper forest limit of some Bulgarian mountains, such as Belasitsa, Malashevska, Vlachina, Stara Planina, Rhodopi, have been often artificially created as a result of grazing or forest fires /in most cases human induced/. For Bulgarian mountains Rila and Pirin the upper forest limit is from 1900 to 2300 m and for Stara planina 1700 -1800 m. Vegetation here is low-growing and often dies due to extreme temperatures and soil freezing. Such habitats have mainly ecological functions and roles. They play an important role for water regime in subalpine ecosystems by retaining a large amount of snow during the winter season and controlling erosion processes and avalanches. The most important tree species at the tree line in Bulgaria are: Macedonian pine (*Pinus peuce* Griseb.), Norway spruce (*Picea abies* Karst.), White pine (*Pinus sylvestris* L.), Bosnian Pine (*Pinus heldreichii* Christ.), European beech (*Fagus sylvatica* L.), and less often – European Silver fir (*Abies alba* Mill.) and silver birch (*Betula pendula* Roth.)[18], mountain pine (*Pinus mugo* Turra.) and common juniper (*Juniperus sibirica* Burgsd.)[19]. The

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[15] EFA Information system

[16] A practical guide for Identifying, Managing, and Monitoring of High Conservation Value Forests in Bulgaria, 2016, WWF and the working group for development for national FSC Standard for Bulgaria within a partnership of WWF and IKEA

[17] EFA Information system

[18] Dakov, M., I. Dobrinov, A. Iliev, V. Donov, S. Dimitrov. 1980. Upword of the tree line. Zemizdat. 220 p. (In Bulgarian)

[19] Yurukov, S. 1992.Investigations of the Mugo pine (Pinus mugo Turra) taxonomy affiliations in Rila mountain, Scientific works of the ForestryUniversity. , XXXV, Issue/Vol. Forest management. P. 7 -15

mountain pine stands accumulate about 43.4 % more water content in the snow areas in comparison to the open areas. The better water protection and water regulating role /the reduction of surface runoff/ of the coniferous forests at the tree line is due to reduction in precipitation, because of the interception and better water and physical properties of the forest soils /higher porosity, lower density etc./. At the tree line, the processes of plant residuals decomposition are limited. As a result a humus cover is formed. It has higher capacity to retain moisture and, thus to maintain the ecosystem functions. All this ensures an equable water regime in the mountain water currents, which form their waters from the territories of these altitudes.[20]

Fig. 7 Forest at the tree line /mountain pine (Pinus mugo), Rusakova V. 2011[21]

Pinus mugo was entered in the Red Book of Endangered Species in Bulgaria as a species of high conservation value, mainly for water-preserving purposes.

Coniferous plantations, which have been afforested 40-50 years ago out of their natural areal with the main aim of controlling the erosion in the country reached their utmost growth limit. As a result, they are very susceptible to bark beetle or other forest pests. About 30,000 ha of coniferous plantations are affected throughout the country. Another objective is to transform conifer stands planted beyond their natural range, to indigenous broadleaved stands. In this regards at the national level, an expert working group was created in order to observe and to take decisions for fast utilization of affected timber and to recommend measures to fight bark beetle infestations. In 2017, “Special instructions for the management of pine plantations depending on their health condition” were elaborated in order to limit further bark beetle infestations and to support the natural transformation of those plantations. To achieve better results, the “Rules for restoration of forests damaged by pest, diseases and natural disturbances” were introduced by EFA experts and spread at the regional level for implementation. Further recommendations for future afforestation with coniferous species were elaborated. The main afforestation requirements include lower density of the plants and new afforestation schemes and avoiding single species plantations.

Regeneration of forests in the process of erosion and torrent control is assessed as a cheap and effective measure. The regeneration processes need to be managed and directed to ensure future adaptation and sustainability. The natural transformation and succession processes have to be observed and maintained according to the long-term forest management goals. Vital and stable regeneration of all tree species within forest ecosystems is important for their sustainability and for their adaptation under climate change conditions, which increases their role for protection of water resources.

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[20] Raev, Iv. 1989. Investigation of the hydrological role of the coniferous forests in Bulgaria. Thesis for doctoral degree. Forest research institute. BAS, 232p. (In Bulgarian)

[21] Red book of Endangered Species in Bulgaria, Volume III - Natural habitats, 2011, Joint edition of Bulgarian academy of science and Ministry of environment and water, V. Rusakova photography

The most important and mostly used best management practices in the country are described below:

1. Limitation of Clear-Cuts - according to the Forest Act clear cut in Bulgaria is forbidden except in some short-rotation species plantations /poplar, willow/ and coppice forests.
2. Defined canopy cover percentage of forest stands - crown cover percentage should range between 70 % and 90 % and within subalpine conifer forest communities, crown cover percentage should range between 60 % and 80 %. According to Bulgarian legislation crown cover percentage should be minimum 60%.
3. Limitation of the Percentage of Timber Extraction
4. Buffer strips along streams, rivers, dolines and sinkholes – preservation of water bodies and karst landscape from direct infiltration of mineral deposits and sediments
5. Supporting natural regeneration
6. Forest Fire Prevention - There are traditions of common process of planning and cooperation between forest and fire prevention services in the country. Common Fire Fighting Plans are elaborated annually and adopted on a regional level. They include common forest fire prevention activities. An early automatic warning system is developed, which covers more than 10% of the country. The responsible institutions continue their effort to expand the system.
7. Adequate Timber Yield Techniques - use of livestock power for harvesting and soil-conserving timber harvest – to prevent the disturbance of the soil- and humus layers. The use of livestock power for harvesting is popular and common practice, especially in mountainous regions, which is proper technique for soil conservation.
8. Preservation of the Forests at the Tree Line and Timber Line (Subalpine Forest Belt in Mountainous Regions)
9. Policy and legislation initiatives There is a number of legislative obligations in Forest Act and its' Regulations, especially related with activities in torrential watersheds and restrictions in order to use resources in ecologically fragile areas
10. Special management regime for protective forest

There are special management regimes for protective forests and protected areas. This is of a great importance because Natura 2000 areas cover 34% of the country territory and 57% of forests. Most of the torrential watersheds are situated in mountain regions and in Natura 2000 zones, which guarantees implementation of close to nature management of the forest stands.

11. Stabilization of riverside lands

The measure "Stabilization of riverside lands" is part of the national "Programme of measures for adaptation of the forests in Bulgaria and mitigation the negative effect of climate change on them", adopted by the Minister of agriculture and food.

12. Maintaining of the register for torrential watersheds

The torrential watersheds are registered with an Order of the Executive director of Executive Forest Agency on 30.07.2015, updated every year. The special measures for those watersheds are part of forest management plans. Most of the torrential watersheds are situated in mountain regions and in Natura 2000 zones, which guarantees implementation of close to nature management of the forest stands. Registering torrential watershed is of importance for future planning of erosion control activities and monitoring.

Number of watersheds	Area, ha		Ownership, ha			
	Total	Incl. in forest territories	state	municipal	private	other
330	191 541	175 080	161 127	7 459	5 510	984

Table 2 Register of torrential watersheds in the country[22]

According to the assessments, erosion in the country is under control, but there are still territories with active erosion processes, creating potential flood risk. All of the erosion control activities are monitored annually by forest services. At present, their condition is assessed as good, but there are some facilities that need major or routine repairs. The construction and maintenance of erosion control facilities is responsibility of the owners. Insufficient financial resources and inappropriate maintenance can cause potential risk for the population. There are also check dams on lands with unidentified owner.

13. Establishment of protective forests
14. Afforestation of eroded lands
15. Establishment of mixed forests

According to Forest legislation /Ordinance 8 for forest logging/ one of the main principals of forest logging is to maintain the mixed structure of the forest stands and to maintain also individuals from valuable tree species. All activities during the logging are directed to maintain the structural diversity of the forest.

16. Improve the structural diversity of the forest stands - ensuring tree species diversity as well as uneven-aged and multi-layered forest stands
17. Ecological reconstruction of coniferous stands from outside the areal
18. Technical measures for erosion control in forest territories
19. Ecological reconstruction of forests damaged by biotic and abiotic factors[23]

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[22] EFA Information system
[23] National review of Best management practices-Forest; Cooperating towards Advanced MAnagement ROutines for land use impacts on the water regime in the Danube river basin, Camaro-D project under Danube transnational programme 2014-2020

Czech Republic

Flood protection by managing mountain forests in the Czech Republic

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Introduction

Floods (overflows of stream water beyond normal limits) are among the most important natural hazards (Hickey and Salas, 1995). Therefore, flood protection belongs to important environmental services based on the link between flows of values to human societies as the result of the state and quantity of natural capital (MEA, 2005). Particularly, floods originating in mountain areas are a crucial agent damaging lowland infrastructure and life, as well as providing geomorphic changes in mountain valleys and watercourses (Stoffel *et al*., 2016). Mountain watersheds in the Czech Republic are predominantly covered by forests (Fig. 1); therefore, forestry practices including forest protection strategies are among the key aspects of their beneficial functions to be considered in collaborative watershed management (FAO, 2006). However, the present estimates of hydrological characteristics (design flows and probability of extreme events) in mountain catchments are affected by serious uncertainties (Foy *et al*., 2015).

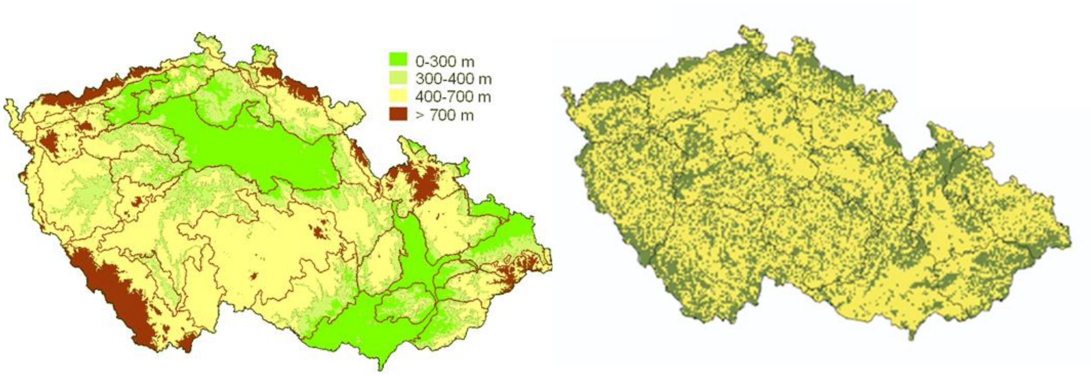

Fig. 1. Elevation (left) and forests – green colour (right) in the Czech Republic (www.casopis.ochranaprirody.cz/res/archive).

According to the mountain delineation criteria of Gløersen et al. (2004), the local elevation range above 300 m within a 7 km radius, mountain forests in the Czech Republic represent 70 percent of the national woodland area (18,600 square kilometres). The most important owner of mountain forests is the state, represented by the "Forests of the Czech Republic, State

Enterprise" (LCR). The state is responsible for forestry practices controlling almost 80 percent of national water resources, including 38,600 square kilometres of small headwater torrents and 887 small water reservoirs.

Flood protection strategy

In the Czech Republic, flood protection is based on the Czech National Flood Protection Strategy, approved by the Government Resolution no. 382 of 19 April 2000 (Ministry of the Environment of the Czech Republic, MoE, 2021). Thus, the flood protection management is assured by flood protection authorities, following flood-event management plans. Flood Committees are the flood protection authorities during floods; they co-operate with the units of the Integrated Rescue System (Fire Rescue Service, Medical Rescue Service, Czech Police, etc.). According to the Water Act 138/1973 and 254/2001 Coll. (Tureček, 2002), flood protection measures include 1) Preventive measures (organisation of flood forecasting, activity degrees, protection plans and inspections, etc.), 2) Measures taken during floods (flood rescue activities, etc.), 3) Flood documentation and assessment (assessment of damage caused by flood, causal factors affecting the flood, etc.) and 4) Constructions (maintenance and repairs of structures, installations serving for flood protection, etc.).

The flood forecasting service (meteorological and hydrological data indicating the occurrence and evolution of floods) is provided by the Czech Hydrometeorological Institute (CHMI) in co-operation with the administrators of watercourses. Then, the flood warning service shall ensure information to the flood protection authorities for warning the population at downstream localities where flood is expected.

Maintenance of hydrological regimes in mountain catchments

To control hydrological extremes in mountain areas, Protective Forests are claimed by the Forestry Act (289/1995, 90/2019 Coll., § 7 – 'protective forests on extreme sites' and § 8 – 'special purpose forests'), and Protected Headwater Areas by the Water Act (138/1973, 254/2001 Coll.). Then, during 1978 – 1981, Protected Headwater Areas on the Czech territory (Fig. 2) were established by follow-up governmental decrees 40/1978, 10/1979 and 85/1981 Coll. These protected areas are administrated by five state watershed enterprises managed by the Ministry of Agriculture of the Czech Republic. Generally, that institute of protected headwaters is based on restrictions to reduce and drain forest land (and to extract peat), but, there is still a serious gap in the optimization of forestry services (Křeček et al., 2019).

In medieval times, royal decrees on forest and water did not address the forest-water relationship but only protecting the wilds for effective game management (Krečmer and Křeček, 1986). In the Czech territory, the coincidence between the poor state of mountain forests (Fig. 3) and the occurrence of several catastrophic floods in the second half of the 19th century initiated the declaration of soil improvement (Act 116/ 1884 Coll.) and the safe diversion of mountain waters (Act 117/1884 Coll.) in the former Austro-Hungary (Dvořák and Novák, 1994). Consequently, a system of retention reservoirs, torrent control, and forest conservation measures were adopted there at the beginning of the 20th century. Later, Peřina et al. (1977) pointed out namely the important role of forest stands in runoff genesis by respecting the buffer strips around watercourses and reservoirs. This concept was adopted by FMI (2015) in regulating forestry activities in protective forests.

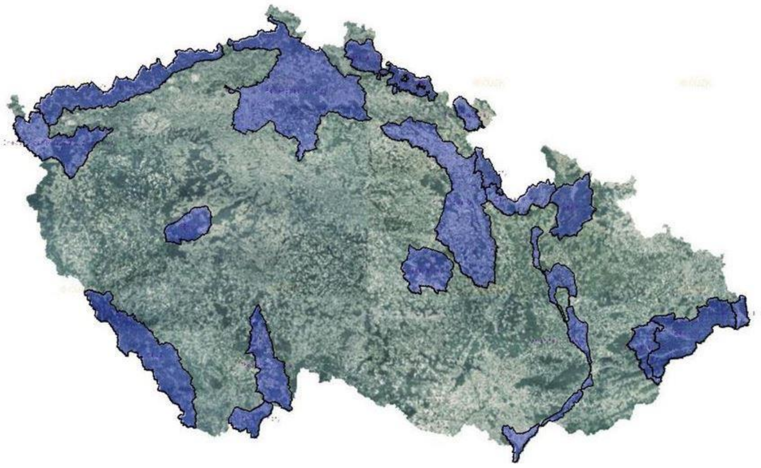

Fig. 2. Protected headwater areas in the Czech Republic (www.geoportal.gov.cz).

Fig. 3. Forest harvest in the Jizera Mountains by the end of the 19th century (Source: Museum of glass production, Kristiánov, Czech Republic).

Nowadays, the state supports the stabilization of mountain watersheds (including torrent control, environment-friendly forestry technologies and reforestation of damaged stands by air pollution) with CZK 96 million per year, which corresponds to almost 25 percent of annual subsidies (CZK 390 million) in forestry.

Climate change impact and environmental consequences of floods

Frequency of peak flows in relatively small mountain catchments is driven namely by the probability of summer rainstorms causing flash floods (Fig. 4). According to the case study in headwaters of the Jizera Mts. (Křeček et al., 2021), in 1961 – 2020, the maximum daily rainfall did not increase significantly. However, the warming projections (2081 – 2100) by scenarios RCP2.6 and RCP8.5 (IPCC, 2015), might lead to increasing specific peak-flows Q10 – Q100 (return period from 10 to 100 years) by 20 – 30 percent. Historical records in the Jizera Mts. identified the maximum daily rainfall of 345 mm observed on the 29th July 1897. This rainstorm (and related flood) might return in 600 – 700 years; during such an extreme event the role of forests (with retention capacity in an order of magnitude lower) is restricted only to a slope stabilisation and runoff retardation.

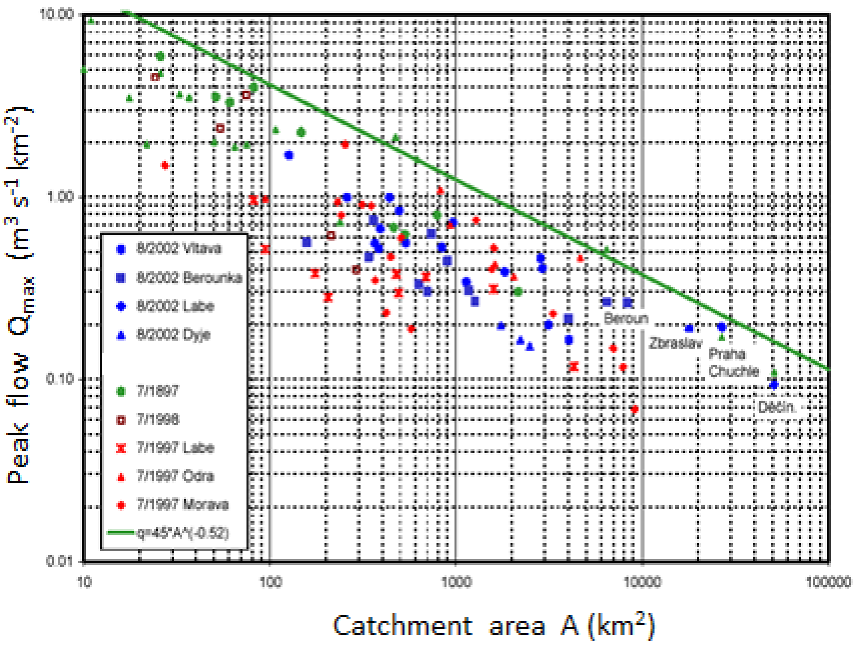

Fig. 4. Specific flood discharge with catchment area in the Czech Republic.

Generally, many factors have modified the environmental conditions in mountain areas, with impacts on geomorphic processes and the frequency, magnitude, and timing of floods in mountain watercourses (Stoffel *et al.*, 2016). In mountain catchments of the Czech Republic, during the 19th century, the mixed forests of native tree species (*Fagus sylvatica* L., *Picea abies*, and *Abies alba* Mill., Zlatník, 1976) were converted to spruce plantations (almost 90% of current forest stands) of lower ecological stability. In the 1980s, these catchments were affected by the acid atmospheric deposition leading to defoliation and die-back of spruce stands, resulting in temporary lower retention and rising flood risk. In this situation summer flash floods contribute to episodic acidification and snowmelt floods to seasonal acidification of the aquatic environment (Křeček *et al.*, 2021). Pažourková *et al.*, (2021) reported the devastating effect on macroinvertebrates during extreme (return period above 50 years) summer flash floods by flushing sand and gravel from the streambed. Both number of species/taxa and diversity were reduced by about 50 percent while the abundance of surviving taxa was reduced to about 10 percent compared with the status before the flood. On the other hand, by recovery from acidification, a significant drop in sulphate contents, and rising alkalinity in stream waters during base flow conditions after the flood indicate positive effects on recovery of the aquatic environment by depleting the catchment sulphur pool.

Conclusions

In the Czech Republic, flood protection is based on the Czech National Flood Protection Strategy, assured by flood protection authorities, following flood-event management plans generated by the Ministry of the Environment of the Czech Republic. The flood forecast is provided by the Czech Hydrometeorological Institute (CHMI) in co-operation with the administrators of watercourses. To control hydrological regimes (including flood risk) in mountain catchments, Protective Forests are claimed by the Forestry Act (289/1995, 90/2019 Coll.), and, Protected Headwater Areas by the Water Act (138/1973, 254/2001 Coll.) However, there is still a serious gap in adapting a complex system of forestry services.

References

FAO. 2006. *The new generation of watershed management programmes and projects*. FAO Forestry Paper 150, Food and Agriculture Organization of the United Nations, Rome, 128 pp.

Dvořák, J. & Novák, L. 1994. *Soil conservation and silviculture*. Elsevier, Amsterdam, 399 pp.

FMI. 2015. *Protection of water resources* (In Czech). Operating Methodology in Forestry, Forest Management Institute, Brandýs n.L. (Czech Republic), 41 pp.

Foy, C., Arabi, M., Yen, H., Asce, A.M., Gironás, J. & Bailey, R.T. 2015. Multisite assessment of hydrologic processes in snow-dominated mountainous river basins in Colorado using a watershed model. *Journal of Hydrologic Engineering*, 20: 04015017.

Gløersen, E., Perlik, M. & Price, M.F. 2004. *Mountain areas in Europe: Analysis of mountain areas in EU member states, acceding and other European countries*. European Commission – DG Regional Policy, Nordregio. 293 pp.

Hickey, J.T. & Salas, J.D. 1995. Environmental effects of extreme floods. *Hydrometeorology, Impacts, and Management of Extreme Floods*. Proceedings of US-Italy Research Workshop, Perugia, Italy, 1-22.

IPCC. 2015. *Climate Change 2014 – Synthesis Report*. Intergovernmental Panel on Climate Change, World Meteorological Organization, Geneva, Switzerland. 151 pp.

Křeček, J., Palán, L. & Stuchlík, E. 2019. Impacts of land use policy on the recovery of mountain catchments from acidification. *Land Use Policy*, 80(1): 439–448.

Křeček, J., Nováková, J., Palán, L., Pažourková, J. & Stuchlík, E. 2021. Role of forests in headwater control with changing environment and society. *International Soil and Water Conservation Research*, 9: 143-157.

Krečmer, V. & Křeček, J. 1986. Forestry and water management: a brief history of ideas. *Ambio*, 15(2): 120–121.

MEA. 2005. *Ecosystems and Human Well-being: Synthesis*. Millennium Ecosystem Assessment. Island Press, Washington, D.C. 155 pp.

MoE. 2021. Flood protection. Ministry of the Environment of the Czech Republic, Prague, https://www.mzp.cz/en/flood protection, accessed on 25 August 2021.

Pažourková, E., Křeček, J., Bitušík, P., Chvojka, P., Kamasová, L., Senoo, T., Špaček, J., & Stuchlík, E. 2021. Impacts of an extreme flood on the ecosystem of a headwater stream. *Journal of Limnology*, 80(2): 1998.

Peřina, V., Krečmer, V., Šach, F., Dressler, M., Réman, Z., Křeček, J., Skýpala, J., Beneš, J. & Jařabáč, M. 1977. *Advanced research project to demonstrate the role of forests in water resource recharge of drinking water reservoirs* (In Czech). Report of the Forest Research Institute, Opočno Research Station (Czech Republic), 112 pp.

Stoffel, M., Wyżga, B. & Marston, R.A. 2016. Floods in mountain environments: A synthesis. *Geomorphology*, 272: 1-9.

Tureček, K. 2002. The water act (In Czech). SONDY, Prague, 349 pp.

Zlatník, A. 1976. *Forest phytocenology* (In Czech). SZN, Prague. 495 pp.

France

EFFECT OF FOREST STANDS ON FLOOD

STATE OF KNOWLEDGE IN FRANCE

1 FLOOD CARACTERISATION

In France, we divide rivers into three main categories (Figure 1):

- torrents with steep slopes (>6% or even >2%) and small catchment areas;
- torrential rivers with medium gradients (> 1% or even between 2 and 5%) and larger catchment
- rivers with low gradients (<0.2% or between 0.2 and 1%) and large catchment areas.

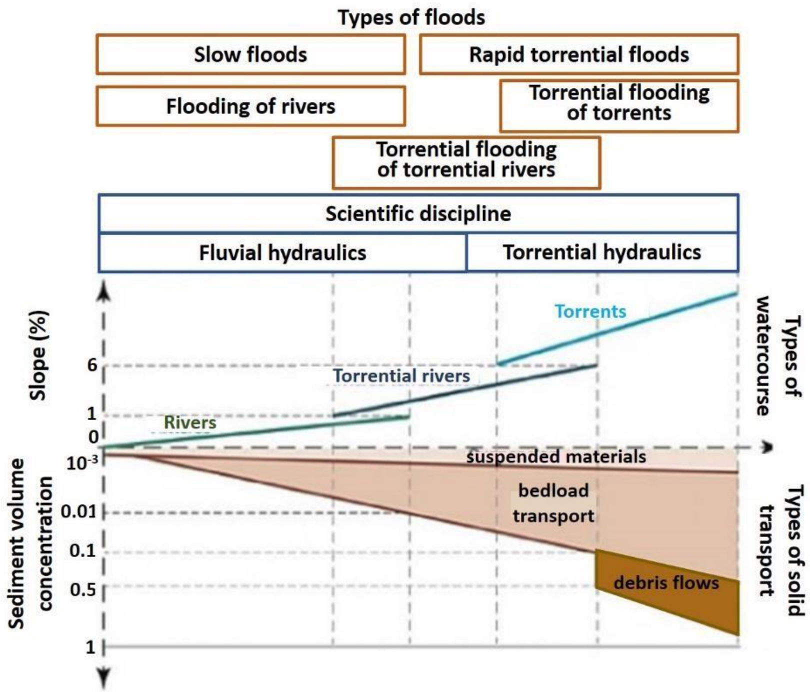

Figure 1 – Different types of floods according to French classification (translated from Naaim-Bouvet and Richard, 2015)

Thus, floods can be differentiated into two types:

- liquid floods concerning principally rivers and torrential rivers with only suspended materials and very rare geomorphological activity;
- torrential floods (including bedload transport and debris flows) characterized by a huge sediment transport and frequent geomorphological activity in torrents and torrential rivers.

The first ones occur in the main part of France, while the second ones are limited to the mountainous areas with catchment areas defined by high slopes.

1.1 LIQUID FLOODS

Flooding occurs when water floods an area of concern. A flood is then defined by a hydrograph at the level of this area, which is described by different hydrological variables (Figure 2) : peak flow ($Q_{L,p}$), total volume (V_L), rise time (t_m).

The flood hydrograph result from the interaction of many mechanisms (surface run-off, ingress, groundwater run-off…) influenced by many parameters: rainfall distribution and accumulation, infiltration ability, soil and watershed type, initial water content, slopes and sides configuration, forest stand types….

1.2 Torrential floods

Torrential floods are intimately linked to the presence of materials in the flow. The origin of the materials can be multiple and depends on the geological and geomorphological characteristics of the torrential watershed: large erosion zones, bed and bank erosion, landslides, upstream cliffs and glacial moraines.

Debris flows are specific to steeply sloping torrents with such a high concentration of solids that the flow is in a single phase that mixes water and materials. These floods are characterized by a lava hydrograph in the risk area (Figure 2).

The most frequent mode of solid transport is bedload (solid concentration in flows of a few % to 25-30%), or even hyper-concentrated scouring (even higher concentration that can reach 40-50%). In this case, there is a systematic evolution of the bed bottom and a breathing of the bed bottom during the flood itself. In the risk areas, this can then lead to liquid and/or material overflows, scouring and bank erosion, which can lead to avulsion phenomena with sudden changes in the bed. The transport of floating material that can form logjams is an aggravating factor in the occurrence of these phenomena, particularly in the presence of transverse structures (bridges, etc.).

Due to a differentiation between bed load transport and liquid water flow, torrential floods with bedload transport are defined, at the level of the area of concern, by a liquid hydrograph (like liquid floods) and by a solid hydrograph characterized by solid transport variables (solid peak flow rate – $Q_{S,p}$, total volume of transported materials – V_S). These last depend on the material source areas previously mentioned (Figure 2). The longitudinal profile of the watercourse is then a very important parameter to determine the preferential zones for the deposition or removal of these materials.

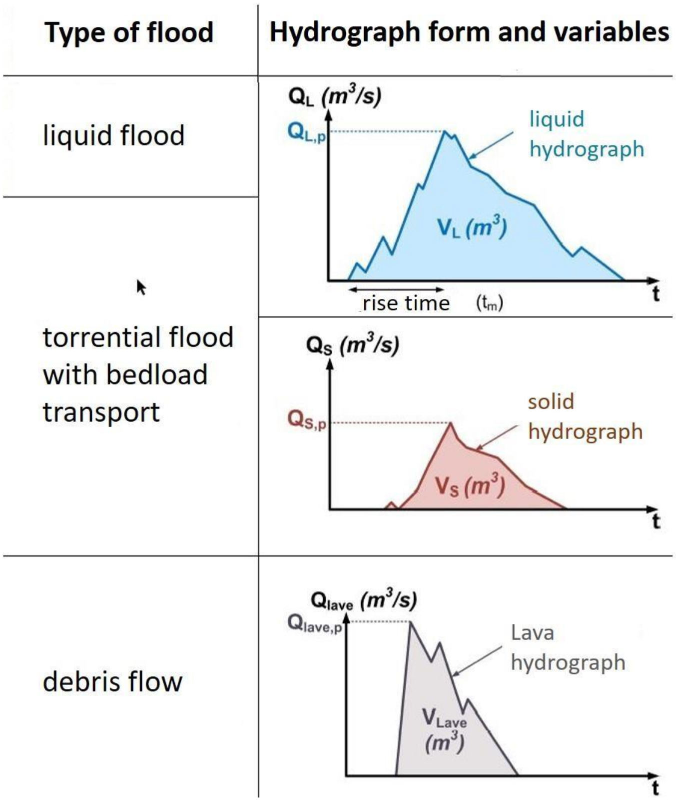

Figure 2 – Hydrograph variables given type of floods considered

2 IMPACT OF FOREST STANDS ON FLOOD

Given the characteristics of liquid and torrential floods, the impact of the forest stands must be seen, on the one hand, on its capacity to make the hydrological variables of the liquid hydrographs evolve and, on the other hand, those of the solid hydrographs, because of their action on the source zones of materials in the catchment.

In this report, we are not going to deal with the impact of forest stands on annual run-off characteristics of watershed but only floods which are sudden and punctual.

In France, the main studies and analysis of the effect of forest covers on floods have been done in mountainous watershed, due to smaller scale and more contrasting situations. Accordingly, identifying the impact of different parameters in small watersheds is easier and more cost-effective (Eisenbies et al., 2007).

2.1 HYDROLOGY

In France, scientists and politicians have taken into account the subject of the effect of forest and flood since the 19th century. The political side “won” in the late 19th with the Afforestation of Mountainous Areas lax (1860) then replace by the Restoration of Mountainous Areas (RTM) law (1882) and related policy. If the official aim was to stop the flood by afforestation of the mountainous watershed, the debate of its efficiency is already topical (Andréassian, 2004).

As explained in the 1.1, a flood hydrograph form is due to the interaction of a lot of parameters and forest stand is just one of these parameters. Presently, it's still difficult to analyse the real effect of forest stands on the different parameters involved in flood.

2.1.1 Small watersheds: results from French field experimentation

Globally, if the effect of forest cover seems real for frequent floods, it disappears with the intensity of the flood.

Cosandrey et al. (2005) is a synthesis of the French research results obtained in instrumented catchments. We can take the example of the French experimentation in black marls catchments of Draix (south of France) which has compared two 1 km^2 catchment areas: one without vegetation and subjected to erosion and one afforested with black Pine in the late 19^{th} century.

The effect concerns the different parameters involved in the phenomena (Richard, 2002):

- peak flow is divided by 5 in the catchment with forest cover even more for short and intense rainfall;
- rise time is extended by 3 in the catchment with forest cover (slowing of flood dynamics);
- infiltration is 5 times stronger in the forest cover catchment.

To illustrate how it's operating, one can compare the forest soil as a reservoir. When the reservoir is full, all the exceeded rainfall contributes directly to the flood. We can note that the cut-off for the forest is higher than for other types of vegetation (moors or grass) (Hurand and Andréassian, 2003).

In case of low or middle rainfall, the cut-off can't be reached easily (even if it's depending on the initial state) so that the mitigation effect for frequent flood is important. In contrast, forest become transparent for extreme events, the cut-off being largely exceeded. The difficulty is to define precisely the cut-off for the different occurrences of flood given that, in France, we consider that:

- a frequent flood is 10 to 30 years return event;
- a rare flood is 100 years return event;
- an extreme flood is 300 years return event.

The level of the cut-off of the positive effect of forest stands is depending on (Richard, 2002 ; Hurand and Andréassian, 2003 ; Poncet, 1968):

- hydrological initial condition of the soil (dry, wet…) before period of significant rainfall: the hydrological response (flood hydrograph) can be very different for similar rainfall depending on the initial level of saturation of the soil or rather equal in spite of various rainfall;
- forest species (hardwood, softwood…);
- undercover (presence, lake, density…);
- soil thickness: the deeper the soil, the smaller the effect of forest;
- the dynamic of the rainfall.

2.1.2 Extrapolation of French results to large watersheds

Extrapolation of previous analysis to bigger watersheds is difficult. It's principally due to:

- the size of the catchment area: the effect of each parameter on the liquid hydrograph is mitigated by the increase of the catchment area;
- the initial condition of the catchment before period of significant rainfall responsible of flood, also linked with the size of the watershed.

To conclude, the mitigation effect of forest on hydrology is as less clear as soil is deep, permeable and watershed is large.

2.2 EROSION AND SEDIMENT TRANSPORT

As said in the 1.2, floods, in mountainous areas, merged water and materials coming from several sources: diffuse erosion of slopes, riverbed deepening and scouring of downstream banks, landslides… It is accepted that the effect of forest stands on flood is probably more important on sediment transport component rather than on liquid component (Richard, 2002).

2.2.1 Small catchment area

The forest stand has a benefit effect on erosion control. It operates at different scales:

- some mechanisms directly stop the erosion on slopes (mainly on coarse materials), fixing the soil. Taking the experimentation in Draix, the production of sediment load in the degraded catchment is 35 times higher than in the vegetated one, reducing the volumes to the degraded surface of the two catchments
  (Mathys et al., 2003); others mitigate the downstream transit of the sediments by constituting an effective barrier. In Draix, the concentration of fine elements at the outlet is currently more than 300 g/l for the degraded one, compared to a maximum of 35 g/l for the vegetated one (Mathys et al., 2003).;
- the spatial distribution of the forest in the catchment is also decisive (Rey et al., 2002);
- on the banks, the trees are fixing the soil and limit the scouring of riverbanks. On the other side, declining trees can be wrested and contribute to the formation of jams.

But other types of land cover (moors, alpine grass) can control soil erosion, sometimes better than some forest stands without understorey (old and very closed pine stands) (Hurand and Andréassian, 2003).

2.2.2 Large watershed

The belief in the positive effect of forest on floods is the source of main public policies (Andréassian, 2004). In France, convinced that the erosion of slopes in degraded catchment can make devasting floods, the RTM policy has leaded to the afforestation of 260 000 ha of degraded lands in public forests since 1860 (ONF-RTM, 2014).

On the one hand, some examples of torrential flood occurred after a forest fire demonstrate the positive effect of forest stands on sediment transport (torrential floods in Angles – Alpes de Haute Provence, 1982; in Rimbaud watershed – Var, 1990).

On another hand, as a result of the afforestation policy, some negative effects are to be noted:

- the reduction of sedimentation flows due to afforestation and mitigation of sediment transport changes the river dynamics downstream the mountainous catchment areas. It can conduce to the incision of riverbeds even if it’s, here again, difficult to identify the responsible part of forest (extraction of materials directly in the main watercourse is the main cause) (Liébault, 2003);

- during extreme events, many damages are caused by floating debris: deflection of flow onto opposite bank, obstruction of crossing structures (e.g. bridges). To manage this problems, two complementary options can be taken:
    - regular management of riparian zones in watercourses;
    - specific structures such as float traps.

Given these effects, the French National Forestry Office (ONF) has developed specific tools for the management of forest stands with a protective role. They define silvicultural rules in order to maintain, or even improve, the protective role of forest stands against erosion on the slopes, and to limit the negative effects of trees in the riverbed. All the rules are based on the various studies, that have enabled a better understanding of the role of forests on floods, mentioned in this document.

3 OUTSTANDING ISSUES

From our point of view, four points need to be studied more:

- to analyse, assess, and quantify real benefit due to tree layer compared to other vegetal land cover, especially on the interception of a portion of incidental rainfall and its impact on flood;
- to improve the knowledge about the influence of the different parameters involved in the flood for large watersheds;
- to define monitoring and maintenance rules for forest stands liable to produce floating debris in case of extreme events;
- to optimize forest stands and to improve forestry technics, linked with:
    - the importance of the forest understory: which types of stands much be improved? where on the slopes?
    - forest fire: improvement of the resilience of the stands - define the principal element to be taken into account;
    - the assessment of the predicted impact of climate change on the sustainability of protective stands.

4 REFERENCES

Andréassian V. (2004). *Review - Waters and forests: from historical controversy to scientific debate*. Journal of Hydrology 291, pp. 1–27.

Cosandrey C., Andréassian V, Martin C., Didon-Lescot J.-F., Lavabre J., Folton N., Mathys N., Richard D. (2005).
The hydrological impact of the mediterranean forest: a review of French research. Journal of Hydrology, Elsevier, 301 (4), pp. 235-249.

Eisenbies M.H., Aust W.M., Burger J.A., Adams M.B. (2007). *Forest operations, extreme flooding events, and considerations for hydrologic modeling in the Appalachians—A review*. Journal of Forest Ecology and Management, 242, pp. 77–98.

Hurand A., Andréassian V. (2003). *Le couvert forestier et l'hydrologie des bassins versants.* Rendez-vous Techniques de l'ONF 2, pp. 37-41.

Liébault F. (2003). *Les rivières torrentielles des montagnes drômoises: évolution contemporaine et fonctionnement géomorphologique actuel (massifs du Diois et des Baronnies).* PhD Thesis, Univ. Lyon 2.

Mathys N., Brochot S., Meunier M, Richard D. (2003). *Erosion quantification in the small marly experimental catchments of Draix (Alpes de Haute Provence, France). Calibration of the ETC rainfall–runoff–erosion model.* Catena 50.2-4, pp. 527-548.

Naaim-Bouvet F., Richard D. (2015). *Les risques naturels en montagne*. Quae Edition, 392 p.

ONF-RTM (2014). *Renouvellement des Peuplements de Protection (RPP) Phase 1 : LA cartographie aléa/enjeu et sa prise en compte dans les aménagements forestiers*. Technical Report, 74 p.

Poncet, A. (1968). *Influence de la forêt sur les crues d'origine pluviale et possibilités offertes par le reboisement et par la gestion forestière pour le contrôle des crues.* Société Hydrotechnique de France, Xc Journées de l'hydraulique, Question 6.

Rey F., Robert Y., Vento O. (2002). *Influence de la végétation forestière sur la formation de dépôts sédimentaires en terrains marneux.* Géomorphologie: relief, processus, environnement 8.1, pp. 85-92.

Richard, D. (2002). *Forêts et crues*. La Houille Blanche 3, pp. 54-58.

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Integral approach to the flood protection effect of the forest in mountain watersheds with special consideration of water and sediment retention

Fig. 1: Forests – green infrastructure to protect against natural hazards. A high percentage of forest cover within torrent catchments is an important factor for integral hazard protection. A major challenge is reconversion of pure spruce stands into mixed forests and adaptation to climate change. ©R. Heitz

<u>Who are the responsible organizations or institutions for flood protection in mountainous regions in your country?</u>

In Bavaria flood protection is a public task with distributed responsibilities. In general, the water management administration and local authorities are in charge of planning and implementation of flood risk concepts, depending on the category of streams and torrents respectively. The maintenance of smaller streams and torrents as a major concern within the Bavarian Alps is in responsibility of the municipalities as local authorities, while implementation and measures of maintenance especially for technically controlled torrents are realized by the offices for water

[24] Note: all details in the text refer only to the forest area and torrent catchments within the Bavarian Alps

management (Wasserwirtschaftsämter) located on district level as part of the water management and environment administration. Private and corporate forest owners are responsible for adequate management of forests including the protective functions as a main goal. For the state forest the Bavarian State Forest Enterprise is in charge of exemplary management. The Bavarian Forest Administration provides consultation and funding to meet the challenges of climate change and to maintain and develop protective forests and is in charge of the restoration of dysfunctional protection forests. In terms of risk avoidance spatial planning has to adapt to risk plans. Citizens take the responsibility to get informed about flood and torrential risks and to implement measures of prevention and mitigation at property level. The German Weather Service (DWD) is in charge of weather forecast and warnings on extreme weather. Responsibility for flood forecasting, warning, and emergency response is located at state level. In case of torrential events the local fire departments help to prevent damages.

What is the legal basis for flood protection and the protection function of forests?

The legal basis for flood protection is given by the European Floods Directive (2007/60/EC), the German Federal Water Act (WHG) and the Bavarian Water Act (BayWG). Further laws like those concerning spatial planning, building, protection of soils and specifically for forests the Bavarian Forest Act add to the water-specific rules for an effective flood protection. As a principle and in accordance with an integrative and sustainable approach to maintenance and management of stream waters WHG §6 and BayWG Art. 44 emphasize the importance of water retention at catchment level and the function of soils to prevent against flood and torrential hazards. As a major topic planning and mapping of risks are addressed by the laws including the identification of areas endangered by torrential hazards being particularly relevant for the alpine space and planning of priorities and management measures (« Wildbachgefährdungsbereiche », see BayWG Art. 46). With its strategy on flood protection 2020plus Bavaria defines three pillars of action: natural retention, technical flood control and measures of precaution. The legal framework for the protective function of forests is given by the federal and the Bavarian forest Act. In accordance with the water-related acts the Bavarian Forest Act points out the protective function of forests, especially of mountain forests, as a main goal and explicitly lists the preventive function against floods, soil erosion, landslides and to secure the riversides (see BayWaldG Art 1, 5, 10). There are no specific legal rules for management of protection forest against floods and torrential hazards, but in general clear cutting is subject to approval in case of protective forests (BayWaldG Art. 14/3). Management measures necessary to maintain protective functions are to be tolerated by forest owners (BayWaldG Art. 14/2).

What is the major impact of forests on flood protection in mountainous areas?

The major impact of forests on flood protection in mountainous areas consists in an effective retention of water and solids on the catchment level resulting from a complex synergism of mechanisms. Important factors of that synergism are protection against soil erosion by roots and canopy-cover, improvement of soil infiltration, increase of total water storing capacity via humus accumulation and deep rooting, water-recycling to atmosphere, recharging of storing capacity and retardation of catchment run-off via interception, transpiration and physical water-vegetation-interaction. The contribution of the single factors varies dependent on the specific conditions of site and event. By these mechanisms forest can significantly moderate run-off peaks and solids cargo and limit the hazard of floods and torrential events. A permanent forest cover of mixed, well-structured and uneven-aged stands with continuous regeneration of trees is expected to be resistant and resilient to disturbances and to provide best water retention as well as protection against erosion.

In which way an integral (multifunctional) approach for the management of mountain watersheds influences the flood protection effect of the forest?

Integration and multifunctionality are relevant on several levels and from different points of view: Whilst there is no 100 percent security against natural hazards, a well-matched system of protective forest, torrent control and further measures of prevention and avoidance provide the most reliable protection. Stable and resilient close to nature mixed forests and a forest management caring for soil humus conservation and accumulation as well as protection against erosion meet best the needs of water and solids retention and decentralized/integral protection against floods and torrential hazards. They are also in line with multiple other forest functions like nature protection, timber production and recreation. As a basic requirement a forest access system supports integrative management and climate change adaptation. The protective effect of forest as natural ecosystem service allows at least for reduced dimensioning of additional torrent control measures - eventually with positive side-effects also for nature protection. Regular control of the torrent and – where possible - a special management of forests closest to the torrent work together in order to avoid driftwood input and locking while protecting steep riverbanks against erosion as well. Besides synergies integration and multifunctionality may also require prioritization or trade-offs for example in case of special aspects and measures of nature conservation like conservation of open forest structures and pasture being in conflict with optimal protection against natural hazards. An Austrian-Bavarian interreg-project (BASch) worked on materials and concepts to harmonize goals of protective function against natural hazards and of nature conservation. The State Program on Mountain Forests (Bergwaldoffensive BWO) as well as the Concepts on Integral Torrent Development (Integrale Wildbachentwicklungskonzepte IWEK) currently under development rely on participative approaches in order to plan and realize integrative and viable solutions.

What challenges do you see in the management of forests with special consideration of flood protection?

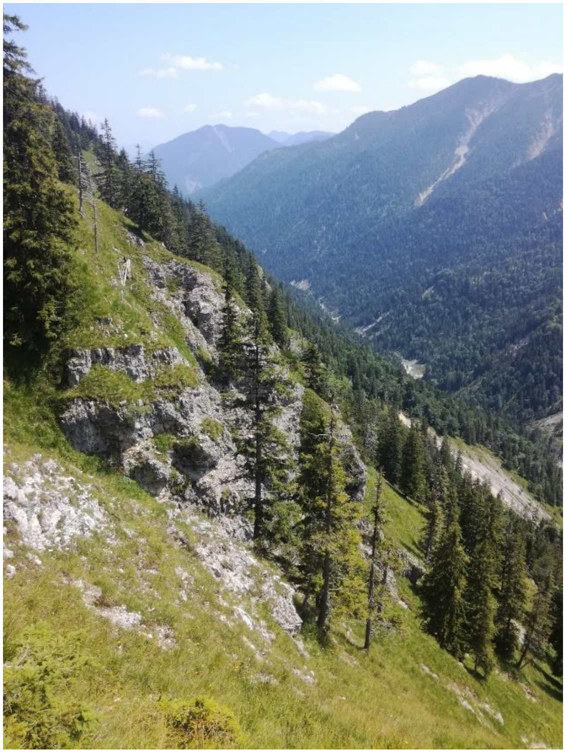

Fig. 2: Endangered protective functionality of declining forest without regeneration due to an interaction of browsing, humus loss and environmental stress in southern exposition. ©R. Heitz

Climate change challenges protective function of forests in two respects, raising the hazard potential by more frequent and more extreme events and putting additional pressure on the forest ecosystem itself challenging it´s resistance, resilience, adaptivity and functionality by rapidly altered and more extreme site conditions including **natural disasters** like storms, snow gliding, bark beetle infestations and (so far with less significance) forest fires.

High **game browsing** pressure on forests hinders both natural and artificial regeneration of mountain forests. For example, in wide regions of the Bavarian Alps regeneration of protective key-species like silver fir still is strongly hindered. Regeneration potential of remnant seed trees is put at risk to get lost unused. Less browsing sensitive species like European larch are heavily damaged by fraying. Advanced loss of canopy shelter and long-lasting lack of regeneration further worsen the abiotic regeneration conditions by **loss of soil organic matter** and exposure to weather extremes. Locally **cattle and sheep grazing** further impair forest regeneration by trampling damages and selective browsing of broadleaved trees.

Conversion of pure coniferous forests into mixed, uneven-aged forests is a challenge of high priority especially on labile and sensitive sites within torrent catchments.

Despite of generally high synergies and conformities between the structural goals of nature conservation and protective forest management some **special aspects of species conservation** demanding extended and permanent almost tree-less structures may conflict with natural forest ecosystem dynamics and protective function.

Fig. 3: Natural hazards like storms and insect infestations put pressure on protective forests and reinforce the need of conversion into adapted and more resilient mixed forest structures with key species like silver fir and integrated game management being a key factor. ©R. Heitz

The so called indirect protective effect of forests against torrential hazards and floods may not result in a lower prioritization of the concerned protective function and the connected forest management measures. Further emphasis on profound **mapping** of forests with special protective function against floods and torrential hazards is needed to further establish this important and aerial function of forests in planning processes beside the more prominent and direct protective functions like the one against avalanches and rockfall. There is also a need and chance to rise **public and professional awareness** of forest management benefits in flood and debris flow protection.

Fig. 4: Reconversion of pure spruce stands into stable, mixed forests is a central measure of protective forest management and climate change adaptation ©R. Heitz

A **high silvicultural standard** of well-adapted management measures is to be applied on catchment level to enable sustainable protectiveness and multifunctionality including

- optimization of short and long term forest protectiveness,
- a well-adjusted trade-off between avoidance of deadwood locking and protection of steep riversides against erosion (remote and steep terrain putting limits of accessibility),
- planning and construction of forest access systems as needed for regular and effective protective forest management in torrential catchments considering the specific geohydrological situation,
- integration of nature conservation and
- uncertainties of high amplitude in climate change prognosis exceeding breakpoints between more conservative and more radical adaptation strategies for example with respect to tree species selection.

Silviculture itself is challenging especially in the context of climate change and may not be continuously impaired by factors like excessive game browsing hindering essential ecosystem processes like regeneration and by that ecosystem adaptation and resilience.

Fig. 5: Rosalia alpina – an endangered key species integrated in protective management of mixed mountain forests. ©R. Heitz

Which kind of calculation and simulation approaches are used for flood protection issues?

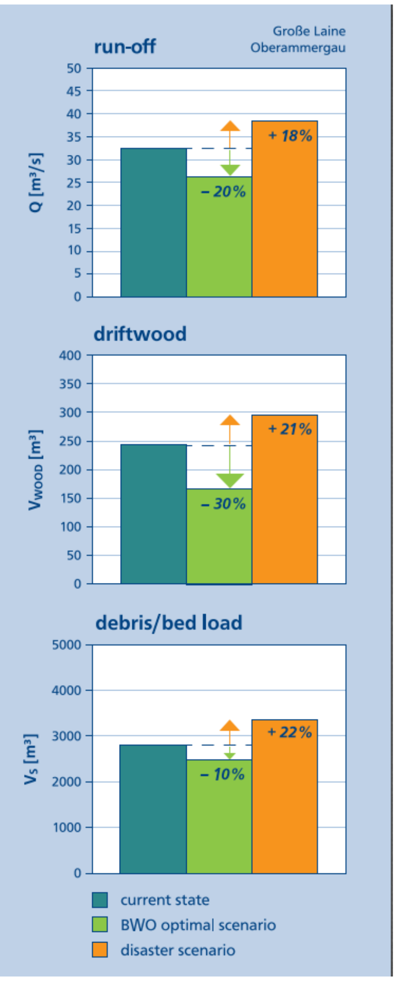

Fig. 6: Model calculations of run-off, driftwood and debris/bed load underline the protective effect of forests against torrential hazards and reinforce the need of adaptive forest management (nach IWEK Pilotstudie Große Laine (patscheider & partner gmbh-srl)

On administrative level for torrents within the Bavarian Alps hydrological SCS-Method is in use to compute the run-off and design events at torrent outlet with specific, standardized parameterization. A security surcharge of 5% up to 40% as dependent on the solids load is added. For modelling of areas endangered by torrent events the hydraulic model HYDRO_AS-2D is applied in up to 3 scenarios. The program RAMMS::Debris Flow is used for debris flow simulation.

For mapping of protective forests against floods and torrential hazards GIS-based approaches are under development using available data of the water administration.

Are there best practices of watershed management measures that have a positive impact on the runoff capacity of mountainous torrents and streams and subsequently in the settlement area?

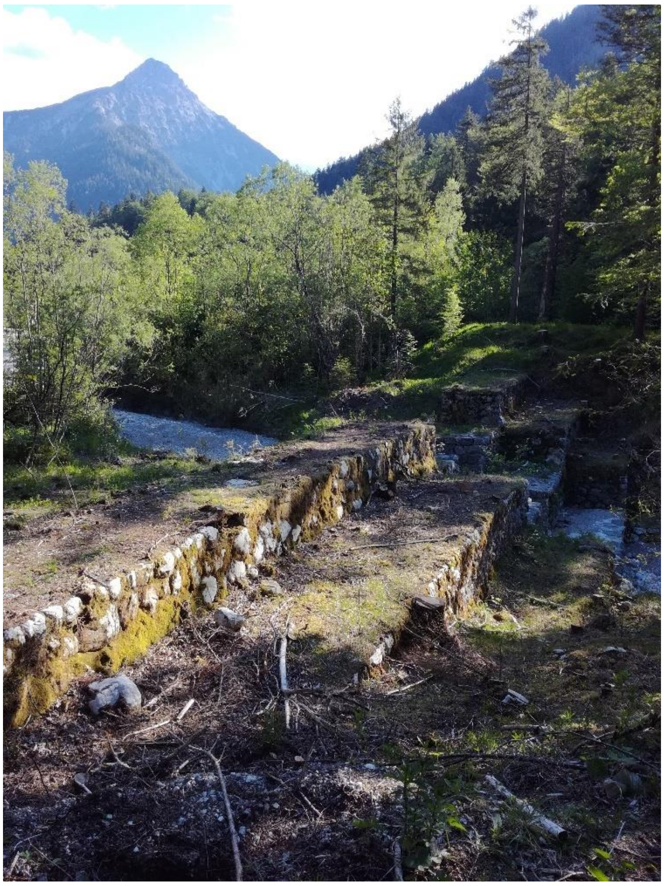

Fig. 7: Protection against torrential hazards with proven synergy of protective forest management and torrent control to be optimized within integral concepts. ©R. Heitz

Best practice example « Concerted management of torrent catchment Große Laine, Oberammergau »:

An integrative and comprehensive management of torrent catchment « Große Laine » has been facilitated by parallelization of three Bavarian specialized programs: The **State Program on Mountain Forests (Bergwaldoffensive BWO)**, the **Protective Forest Restoration Program** (Schutzwaldsanierungsprogramm, SWS) and the **Integral Torrent Development Concepts (Integrale Wildbachentwicklungskonzepte, IWEK)**.

BWO: The BWO as a state program has been established in order to adapt vulnerable protective forests to climate change within selected project areas. As an instrument for private and corporate forests it follows a participatory approach establishing cooperation, dialogues and networks between stakeholders. Planning and implementation of suitable management measures including structural adaptation and reorganization are elementary part of the project process. Starting from 2009, important measures /milestones at Oberammergau/Große Laine have been so far:

- reorganization and reduction of pasture within protective forest in exchange with new meadow pasture within less sensitive areas,
- rearrangement of hunting grounds and shift to self-directed hunting to allow for natural regeneration and planting of mixed species.
- improvement of forest access system to facilitate measures of forest maintenance and re-conversion of instable pure spruce stands into mixed mountain forests.
- stabilizing thinning measures supported by cable crane logging in steep and remote terrain.
- concerted planting actions of mixed tree species
- expert document on integrated grouse protection
- accompanying public relation events like « Day of Mountain Forest »

SWS: The Protective Forest Restoration Program (SWS) addresses forests with severe disorder of protective function. Restoration of those forests (actually about 13.500 ha equalling 10 percent of the forest area within the Bavarian alps) is planned, coordinated and monitored by specialized offices of the Bavarian forest administration providing expert knowledge and financial and personal support to forest owners. At Oberammergau urgent restoration measures will be continued and intensified on basis of reorganized and more effective hunting.

Fig. 8: Involvement of stakeholders at Bavarian State Program on Mountain Forests (BWO) - a main success factor for integrative management of protective forests ©StMELF

IWEK: IWEK strives to adapt torrent control to climate change taking into account the specific catchment conditions with regard to protective forest situation, nature protection as well as social and economic aspects. The existing system of technical measures for torrent control is revised and optimized to protect against 100-year hazard events. Most important steps and measures at Große Laine, Oberammergau have been:

- Modelling, mapping and preliminary administrative approval of flooding areas and hazard zones.
- Development and evaluation of 7 alternative options for the torrent control system
- So far have been realized
    - new construction of a driftwood rake and a debris retention lock (capacity of 12.000 m³)
    - reconstruction of most existing buildings and controlled decay of single dispensable ones
- As alternative measures are under further examination:
    - adaptation of the conduit within the settlement area of Oberammergau
    - passive water divisioning building including relief channel

The case of catchment Große Laine, Oberammergau gives an example how activities of protective forest management, game and grazing management, torrent control and nature protection go hand in hand for adaption of the flood protection system to modern standards and future challenges of climate change. Results of modelling highlight the substantial contribution of an optimized protective forest for retention of runoff and solids as compared to the present situation and the more to a possible disaster-scenario.

Italy

Role and management of mountain forests for flood hazard mitigation in Italy

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Introduction: the role of forests in mitigating flood hazards in mountain areas

The key role of forests in protecting slopes against shallow landsliding and debris flow, as well as in buffering runoff peaks, has been recognised for centuries. For instance, the Republic of Venice acknowledged and carefully ruled the protective role of forests covering its territories across the Eastern Italian Alps already back in the 13th - 14th centuries (Bischetti et al. 2005), and similar acts can be found in other Alpine countries. In mountain areas, where large sediment and wood fluxes may pose a greater threat than runoff peaks alone, several mechanisms exerted by forests mitigate flood hazards, involving mechanical and hydrological actions at hillslope and channel scales. At the hillslope scale, the stabilisation effect given by forests is mainly due to the mechanical action of the plant root systems, and to a lesser extent on the hydrological action of reducing soil water content through interception and evapotranspiration. During intense and/or prolonged rainfall, in fact, interception represent a small portion of the total precipitation, and evapotranspiration occurs at a slower rate compared to rainfall intensity. From the mechanical perspective, roots can importantly increase soil shear strength by acting as a fibre reinforcement which can be evaluated in terms of root cohesion that adds up to soil cohesion or as individual anchors (Bischetti et al., 2009), although the latter is generally not considered.

In contrast to hillslope stabilisation, the hydrological action of hillslope forests can be quite effective in reducing peak flows in the channel networks downstream. In well-developed forest soils, subsurface flow is the dominant runoff mechanism (Sidle et al., 2017) and overland surface runoff is very infrequent and/or just localised. As subsurface flow is much slower than overland flow, quite low runoff coefficients are observed in forested catchments, especially for short-duration storms (Bathurst et al., 2017). In addition, riparian forests may increase the flood retention capacity of floodplains, thus lowering peak flows, by reducing flow velocities in forested river corridors of sufficient width. Riparian trees also provide additional resistance of channel banks towards lateral erosion, thus reducing bank erosion rates (Andreoli et al., 2020). However, both the mechanical and the hydrological "protection" of forests on hillslopes and channel banks have been documented to be most effective during ordinary to moderate floods. During very high-magnitude floods, especially when induced by prolonged precipitations, the stabilising/buffering capacity of forests (Bathurst et al., 2017) is often exceeded. However, in the case of mature hillslope forests, protection against shallow landsliding has been observed to persist up to extreme rainfalls. Nonetheless, forests do not provide protection against deep-seated landslides (Bathurst et al., 2017).

Are Italians aware of the protective actions of mountain forests?

Despite forested catchments feature lower flood runoff coefficients, when compared to urban- and agriculture-dominated basins, and forests generally impart a greater stability to hillslopes and river banks, in Italy the current recognition of the role played by mountain forests in mitigating flood hazards is very low at all levels, from the general public to land planners and politicians. Actually, the general perception of the forest role in terms of flooding is highly negative, especially after large events, and this is the case also in other countries. A possible reason could be that high-magnitude floods (e.g., events with recurrence intervals > 30-50 yr) are naturally able to erode and transport a large quantity of forest trees (e.g. Comiti et al., 2016; Cislaghi and Bischetti, 2019), and the consequent obstructions occurring at critical cross-sections (bridges and culverts) may increase inundation and thus damages (Lucia et al., 2015).

This is particularly valid for most of the Italian territory, whose hillslopes often feature marginal stability despite being densely forested. In fact, unfavourable topographic (steep slopes) and lithological (highly fractured and/or "weak" substrates) make Italian mountain areas naturally prone to frequent and widespread mass wasting processes, even if forests cover the slopes. In addition, forests in large parts of Italy are still at an early stage and far from being mature – as they stem from the recolonisation of abandoned agricultural areas during the last decades – and often degraded by wildfires, especially in the Apennines. Therefore, the overall stabilising effectiveness of Italian forests is highly variable, both spatially (across regions and single catchments) and in magnitude, as it depends on a complex interaction among topography, soil and forest characteristics. Regarding the hydrological buffering of Italian forests, degraded soil conditions associated with past agricultural practices (e.g.., compacted soils by grazing) and/or following wildfires most likely impair their actual capacity in large areas of the country, especially in the Southern regions. In contrast, large flood events often leave abundant woody material – eroded from slopes and banks – deposited on floodplains and channels. Even in those cases where transported wood did not cause any clogging problem, the immediate public reaction in Italy (but also elsewhere) is to blame the lack of proper land and river cleaning for the inundation (Borga et al., 2019). Indeed, several studies have ascertained how people perceive dead wood and vegetation in rivers as "dirt" and negative in most countries, despite their crucial role in fluvial ecosystems (Wohl et al., 2019). In such a situation, flood mitigation, preservation and restoration of rivers' quality and forest management should be tightly integrated into a common strategy. Indeed, until the 1970s-1980s, flood hazard mitigation in Italian mountain areas was included in the forest policy, as in all the Alpine countries. Subsequently, major changes in the Italian legislation were implemented in the last decades, and they have brought about important consequences on forests and flood management, as it will be summarised in the next section.

Flood risk mitigation in Italy: historical changes and current situations

Italy is not a federal country, although "autonomous Regions" (Valle d'Aosta, Trentino-Alto Adige, Friuli Venezia Giulia, Sicilia, Sardegna) have been present since the establishment of the Italian Republic in 1948. In the last 50 years, however, ordinary regions have also increased their autonomy in many fields, and the two Provinces of Trento and Bozen-Bolzano (part of the Region Trentino - Alto Adige) have also obtained an autonomous status.

The agriculture and forest management competencies were first decentralised in 1970, when they were passed from the central State to the regions, and such a step represents a "tipping point" in the organisational model for flood risk mitigation in the vast mountainous areas of Italy. In fact, until then, flood mitigation in the smaller mountain catchments was under the responsibility of the "Corpo Forestale dello Stato" (National Forest Service) controlled by the Agriculture and Forest Minister, while for the larger river channels it was under the responsibility of the "Genio Civile" (National Civil Corps of Engineering) headed by the Minister for Public Works, similarly to many countries of the Alps. In the following decades, each region developed its own forest service, with varying organisational modes and different approaches to mountain watersheds. In most cases, such a transformation heavily weakened the tight interlinkages between forest management and flood mitigation that had characterised mountain catchment management since the 19th century.

Subsequently, a second level of decentralisation was introduced in 2000 when the number of competencies entitled to the Regions greatly increased. Since then, river management and flood mitigation over the whole country – including mountain regions – have been passed to the regional authorities, although within a general national framework. As a matter of fact, however, the practical application of flood mitigation strategies in mountain basins is based on a combination of national and regional laws, with different degrees of complexity varying from Region to Region, ranging from the "in-house" forest service approach – which integrates forest management, civil protection actions and construction of structural interventions – to the contracting of several private companies for the development of hazard and risk mapping, for forest management plans as well as for the design and construction of engineering works.

Within the context sketched above, the legal basis for flood risk mitigation in Italian mountain areas appear quite composite. At the higher level, national laws applying the European Directives 2000/60/CE (Water Framework Directive – WFD) and 2007/60/CE (Floods Directive – FD) set the general framework, but at the regional level several laws rule on many interconnected issues (e.g. flood risk mitigation, civil protection, forest planning and forest activities, urban development and land-use change, etc.), and such laws can be significantly different from Region to Region. In addition, 8 Italian River Basin District Authorities – as foreseen by the WFD (and key for the FD too) – have the challenging task of coordinating different Regions, some being highly autonomous and thus having even the legal status of river basin authority themselves. Remarkably, each river basin district can apply different regulations, e.g. in terms of flood hazard mapping, and therefore the Italian legal framework regarding flood risk mitigation resembles a very complex mosaic. However, similarly fragmented in Italy are the legal basis for the protective functions of forests. In fact, although the recent national forest law (2018) mentions the protective role of forests and the importance of managing mountain catchments against floods and landsliding, legally binding actions are foreseen only in different regional forest laws.

Remarkably, a long-standing law (issued in 1923) which prohibits any land use change in forests with a protective role is still included in the forest laws of all Italian regions. Despite this excellent regulation, which has protected mountain catchment for almost a century now, the true recognition of the protective functions of forests and their links with flood mitigation strategies are not present in most of the Italian Regions, at all levels (political, technical, and citizens). A wide dissemination to the whole society regarding the major role of Italian mountain forests in reducing flood hazards is urgently needed.

Perspectives and challenges

In our view, the most important action to be undertaken in Italy should be to (re)educate Italians – at all levels and with different degrees of technical details – about the importance of the protective role of forests. Such a knowledge – which was quite widespread until about mid 20th century, when forested areas were smaller and degraded for the heavy agricultural use of mountain lands – got lost during the last decades during which the expansion of mountain forests took place for the abandonment of mountain agriculture. The current perception of the general Italian public is that forests exemplify a return to "wilder", "difficult" periods and that flood hazards were lower when mountain catchments were deforested and heavily used for agricultural production. A nostalgic feeling for idealised "old good times" of the past is possibly the reason for Italians' current view of forests, besides the possible consequences of wood transport during floods, as previously mentioned.

Unfortunately, the extreme spatial variability of Italian territory (in terms of topography, geology, climate and forest characteristics) poses a great challenge to the use of simple approaches (hydrological, geotechnical, hydraulic) through which the protective roles of forests could be included. However, recent advancements concerning the contribution of forests to hillslope stabilization (e.g. Cislaghi et al., 2017; Schwarz et al., 2012), to river functioning (e.g. Wohl et al., 2019) as well as regarding hillslope-channel connectivity (Cavalli et al., 2013) represent very useful tools for a sustainable management of mountain catchments. Nonetheless, only a field-based knowledge at the catchment scale enable us to adopt meaningful values for the parameters needed in models for flood hydrology and soil stability prediction. We believe the integration of high-resolution forest structure and forest management scenarios into such models is the way forward to correctly assess and value the protective functions of forests, and therefore there is a clear necessity to better constraint numerical models through field-based and remotely-sensed monitoring data. The challenge is now to include such quantitative tools into practice, for an integrated forest and geo-hydrological risk management.

We also think that while the soil stabilising and hydrological buffering effects of forests should be maximised wherever possible, the potential adverse consequence of floating trees during floods should be adequately predicted and managed by means of dedicated retention structures (Schalko, 2020) as well as by (re)designing bridges to minimize clogging probabilities (Schalko et al., 2019). In fact, while the upper portions of the catchment have been abandoned, valley floors have become heavily urbanised, and especially vulnerable during floods are roads and related infrastructures, often of vital importance for local communities.

References

Andreoli, A., Chiaradia, E., Cislaghi, A., Bischetti, G., & Comiti, F. (2020). Roots reinforcement by riparian trees in restored rivers. Geomorphology, 370, 11. https://doi.org/10.1016/j.geomorph.2020.107389

Bathurst, J.C., Birkinshaw, S.J., Cisneros Espinosa, F., Iroumé, A. (2017) Forest Impact on Flood Peak Discharge and Sediment Yield in Streamflow. In: Sharma N. (eds) River System Analysis and Management. Springer, Singapore. https://doi.org/10.1007/978-981-10-1472-7_2

Bischetti, G.B., Chiaradia, E.A., Simonato, T. et al. (2005) Root strength and root area ratio of forest species in Lombardy (Northern Italy) Plant Soil, 278, 11–22, https://doi:10.1007/s11104-005-0605-4

Bischetti, G.B., Chiaradia, E.A., Epis, T., Morlotti, E. (2009) Root cohesion of forest species in the Italian Alps Plant and Soil, 324, 71-89, https://doi.org/10.1007/s11104-009-9941-0

Borga, M, Comiti, F, Ruin, I, Marra, F. (2019) Forensic analysis of flash flood response. *WIREs Water*, 6:e1338. https://doi.org/10.1002/wat2.1338

Cavalli, M., Trevisani, S., Comiti, F., Marchi, L. (2013), Geomorphometric assessment of spatial sediment connectivity in small Alpine catchments, Geomorphology, 188, 31-41. https://doi.org/10.1016/j.geomorph.2012.05.007

Cislaghi, A., Bischetti, G.B. (2019) Source areas, connectivity, and delivery rate of sediments in mountainous-forested hillslopes: A probabilistic approach, Science of The Total Environment, 652, 1168-1186, https://doi.org/10.1016/j.scitotenv.2018.10.318.

Cislaghi, A., Chiaradia, E.A., Bischetti, G.B. (2017) Including root reinforcement variability in a probabilistic 3D stability model, Earth Surface Processes and Landforms, 42 (12), 1789-1806. https://doi.org/10.1002/esp.4127

Comiti, F., Lucia, A, Rickenmann, D. (2016). Large wood recruitment and transport during large floods: A review. Geomorphology, 269, 23-39. https://doi.org/10.1016/j.geomorph.2016.06.016

Lucía, A., Comiti, F., Borga, M., Cavalli, M., Marchi, L. (2015) Dynamics of large wood during a flash flood in two mountain catchments. Natural Hazards and Earth System Sciences, 15 (8), pp. 1741-1755. DOI: 10.5194/nhess-15-1741-2015

Sidle, R.C., Gomi, T. (2017) Hydrologic Processes in Forest Headwater Catchments: Implications for Policy and Management, in Tognetti, R., Scarascia Mugnozza G., Hofer, T. (editors) Mountain Watersheds and Ecosystem Services: Balancing multiple demands of forest management in head-watersheds, EFI Technical Report 101, 94-105

Schalko, I. (2020) Wood retention at inclined racks: Effects on flow and local bedload processes. Earth Surf. Process. Landforms, 45, 2036– 2047. https://doi.org/10.1002/esp.4864.

Schalko, I., Schmocker, L., Weitbrecht, V., Boes R.M. (2019) Laboratory study on wood accumulation probability at bridge piers. J Hydraul Res 58(4), 566–581. https://doi.org/10.1080/00221686.2019.1625820

Schwarz, M; Cohen, D; Or, D. (2012) Spatial characterization of root reinforcement at stand scale: Theory and case study, Geomorphology, 171, 190-200, https://doi.org/10.1016/j.geomorph.2012.05.020

Wohl, E., Kramer, N., Ruiz-Villanueva, V., Scott, D., Comiti, F., Gurnell, A., Piégay, H., Lininger, K., Jaeger, K., Walters, D., Fausch K. (2019) The natural wood regime in rivers. Bioscience, 69(4), 259-273. https://doi.org/10.1093/biosci/biz013

North Macedonia

Bundesministerium
Landwirtschaft, Regionen
und Tourismus

Food and Agriculture Organization of the United Nations

Integral Approach to the flood protection effect of the forest with special consideration of water and sediment retention

Republic of North Macedonia - Country Report

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33rd Session of the EFC Working Party on the Management of Mountain Watersheds (WPMMW)
13th – 15th of October 2021, Traunkirchen, Austria -

1 - Who are the responsible organizations or institutions for flood protection in mountainous regions in your country?

On national Level - Ministry of Environment and Physical planning – Dept. of waters, *Crises management center, Administration for hydrometeorological affairs (monitoring and forecast),*

On local /regional level - Local municipality administration; Water management enterprises in the area cover by their hydro-systems.

2 - What is the legal basis for flood protection and the protection function of forests?

– Law on Waters – chapter V – Harmful impact of waters (art.122 -141)

add.: Law on crises management, Law on hydro -meteorological affairs, Law on protection and rescue, GAP related to mountain torrents : Territory in the mountain (forest area) is under competences of PE "National Forests". ???? – How LMA can manage torrent floods when more of the torrent basin is not under their competences?

- Law on Forests – relevant for protection forests. GAP: According to the Law, Government should proclaim protection forests that is unsustainable. Before 3 tears started delineation of protection forests during preparation of 10-years Forest management plan for each forest management unit.

3 - What is the major impact of forests on flood protection in mountainous areas?

Generally, forest ecosystem can reduce erosion, to regulate shallow and surface landslide runoff and torrent floods Significant role have water permeability of the soil and rocks and depth of soil layer. In a case of extreme events(1% probability and rare) taking in consideration characteristics of soil and rocks in the country, very fast can be achieved saturation and appearance of SOF or HOF.

It is different in Western part of the country(Alpine configuration) and other territory (Serbo-Macedonia old massif). In WP relief is rough, dissected, peaks are up to 2764, forest up to 1750 masl. Forests slightly contribute to protection in a case of torrent flood event because flood wave formed on the high-mountain grasslands. Beside it, there are rockfalls and significant fluvial erosion and debris flow.

On the other hand in other part of the country (no such high peaks) forest influence significantly to decrease of sediment yield and with roughens of the litter increase of retention and decrease of runoff and it combined decrease the pick of flood fluid Afforestation on bareland especially in cordons not only reduce erosion but significantly influence the flood wave

There are numerous good examples in the 108 years experience in afforestation of bareland. At least 20% of forests in the RNM are planted even on low altitude. The most used species is Pinus Nigra then Cypres spp., Robinia Pseudioacacia, Fraxinus spp, Acer spp)

4 - In which way an integral (multifunctional) approach for the management of mountain watersheds influences the flood protection effect of the forest?

Notorious fact is that IM of MW is very important.

In the RNM is problem that different institution manage the area of mountain watersheds: forest area – PE National Forests, high mountain grassland – PE for Pasture management. In the western part of the country – in some watersheds, forest cover 20%, while grasslands 50 -60%. In other parts of the country where forest cover >80% of the watershed it can be implemented.

5 What challenges do you see in the management of forests with special consideration of flood protection?

In the RNM, state owned forest (90 -% of all forests) are managed by PE “National Forests” mostly, and part of forests by PI National Parks. These institutions are self-financing and it is the main problem. Mean biomass is 74 t/ha. Annual yield is 2,02 m^3/ha. It means that productive capacity is low and PE NF in greater part manage forests and woodland with very low productivity in the areas prone to fires or damages by insects and pests (monoculture) . IN the past (during the period of SFRY) there was a state FUND for afforestation (1971 -1990) and there were finances for afforestation but also for maintenance. Now it is not fully recognized by the Government.

6 - Which kind of calculation and simulation approaches are used for flood protection issues?

Erosion intensity and sediments - modelling in a GIS environment

- Erosion Potential Method by Gavrilovic (Z-erosion coefficient, absolute and specific annual quantity of produced (W) and transported (G) sediments {m^3 ; m^3/ km^2]

  RUSLE (only for agriculture terrains) and MUSLE give lower results in mountain basins

- Event based Sediments – f-las by: Rickenman, D'Agostino, Takahashi … slight modification

Water discharge

- Parametric f-las of Gavrilovic, Predominant factors, Envelopes by institute J. Cherni
- Rainfall-Runoff modeling - US SCS CN method; Method of Concentration time
- Mudflow discharge and Debris flow discharge – increase of results for water discharge based on traces In the bed and using expert judgment

- Software

Flood hazard (HEC – GeoHMS, HEC – RAS), FLO2D (torrent debris discharge) , HEC -FIA (flood impact assessment) , HEC -WAT

7 - Are there best practices of watershed management measures that have a positive impact on the runoff capacity of mountainous torrents and streams and subsequently in the settlement area?

YES, in many places in the country.

The most successful is Vodno Mt. erosion and torrent control system. Torrent affected the central part of Skopje city (capital town). Numerous floods were registered up to 1951. Set of measures were carried out: administrative (proclaiming as erosive area, displacement of citizens of small2 villages, ban on agriculture activities, obligation for afforestation); bioengineering works (cordons, small wattles , mass afforestation with high density with more then200 various species, afforestation on rocky areas using explosive for opening holes…), Hydraulic structures (canals, weirs, numerous check-dams). In the whole mountain erosion intensity is decreased up to 2,5 times.

Within the most dangerous watershed (attack the center of the city, foreign residency quart, clinical hospital..) are carried out the huge measures, erosion intensity is decrease almost 9 times. Discharge is decreased almost 40%.

Before 1951 there were only 451 ha on the whole mountain, and now is 2579 ha result of planation and self restoring and sustainable management of the PE Parks and Greenery Skopje.

Slovenia

Slovenia

Country report on the flood protection effect of the forest in mountain watersheds

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Introduction

Slovenia's terrain is, besides the coastal area and flat northeast part, mainly elevated with hills in the east and mountains in the north and northwest. For this reason, more than 75 % of Slovenia's surface has inclination greater than 20 %, and 90 % of surface inclination greater than 35 % (NFP, 2007). Combining topographical variety and abundant orographic precipitation, influence of alpine, Mediterranean and continental climatic types from this area (Ogrin, 1998), and adding frequent extreme weather events as a result of collisions between the polar air masses and moist Mediterranean air, causes high potential soil erosion and torrential nature of many water bodies.

From organizational and practical perspective, it is clear, that managing of torrential areas is not only a matter of focusing on the water stream, but on a broader watershed area. Since forests cover majority of watersheds, can forest management plans represent the most important part of the overall watershed management. After all, are the main reason for the significantly reduced actual erosion in Slovenia actively managed, well-preserved and biologically diverse protective forests (Fajon, 2007).

Managing of torrential areas in Slovenia dates back to the year of 1884. Since then have been knowledge on measures, materials and technologies, as well as the torrent control works substantially and continuously improved. In recent decades cause weather extremes increasing number and frequency of natural disasters, and because of the economic development, the consecutive damages are getting proportionally bigger. The significance of maintenance and modernisation of the existent torrent control structures is therefore getting larger. Only well maintained torrent control structures and systems can perform the required function.

There is no doubt, that forests, covering more than 58 % of Slovenia, reduce rapid surface runoff and significantly reduce the influence of torrents (Papež and Kobal, 2018). The main management objective in the steep areas of forest land is the protective role of forests, so by implementing forest interventions we aim to alter forest structure and tree species composition in a way to achieve (at least near to) optimal protection. Direct and indirect protective functions of forests is especially in mountainous areas well recognized and accounted for in the forest management plans.

Despite meaningful events from the past, recognized importance of protective forest functions and all the effort of the forest service, some challenges remain. Forests alone cannot do all the preventive work against natural disasters and disturbances. For this reason must be forest protective role integrated with biotechnical and technical solutions. Main overarching goal is therefore to preserve the balanced conditions in torrential catchments.

The main aim of this article is therefore to present state of the art in understanding the flood protection effect of the forest, including management, research and challenges related to the protective forests.

Responsible organizations and sectoral legislation

The highest political competence in the flood protection in Slovenia has the Ministry of the Environment and Spatial Planning and at the operational level Slovenian water Agency, being responsible for the planning, and the supervising of the water management in the hands of the concessioners. Main legislation for the management of the inland and groundwater is Water Act (2002 and its subsequent amendments and by-laws), defining limitations and measures to protect against harmful effects on areas where erosion, avalanche or landslides can take place. As in the other EU member states, the general planning documents at national level are the Water Management Plan and the Flood Risk Reduction Plan; both are renewed every 6 years.

Important for the flood protection in Slovenia is also forestry, which is under the competence of the Ministry of Agriculture, Forestry and Food. Main legislation, covering protective forests, are the National forest program (NFP, 2007), Forest act (1993 and its subsequent amendments) and the Decree on protection forests and forests with a special purpose (2005 and its subsequent amendments). Slovenia forest service, among other tasks, prepares forest management plans with prescribed measures and guidelines for all forest functions, directs and monitors the rehabilitation of torrential areas, develops a forest protection program, and ensures the implementation of measures in protection forests. An important part of forest management plans in Slovenia is also integration of guidelines of water management prepared by Slovenian water agency. Guidelines among other contain limitations on flood risk areas. In the preparation process of the forest management plans, Slovenian Water Agency reviews the content of plans in the light of water and environment legislation.

Despite the implementation of various measures in both watercourses and forests, are floods and torrential events relatively common in Slovenia, creating the need for urgent and rapid intervention. In such events, Protection against Natural and Other Disasters Act (2006 and its subsequent amendments) clearly positions protection measures in order to reduce the number of accidents and to prevent or reduce the number of victims and other consequences of such disasters. Parties included in the actions are the state, municipalities, and other self-governing local communities, organizing protection against natural and other disasters as a unified and comprehensive system. Forest service is alongside with the firefighters, mountain rescuers, and other parties, included in observation, providing information and alerting on natural disaster (art. 50).

In case of flooding, can Administration of the Republic of Slovenia for Civil Protection and Disaster Relief be activated, representing a constituent body of the Ministry of Defence. Civil Protection can perform administrative and professional protection, rescue and provide relief tasks as well as other responsibilities regarding protection against natural and other disasters. Within the Rules on the methodology for determining areas endangered by floods and related erosion of inland waters and the sea, and on the method of classifying land into endangered classes (2007), endangered areas, floodplains and related erosion areas are defined.

Despite agreed administrative cooperation between the fields of the forestry and water management, some space for improvement remains. Good practise is the cooperation between the services on the field, where mostly positive synergies exist and prevail.

Important to mention is also curriculum practise on torrents of the Biotechnical faculty, Department for forestry and renewable forest resources. All students gain specific knowledge on managing and development of forests on torrential areas, as well as to be familiar with all the measures of protections against torrents, erosion and landslides. Simultaneously can also gain licence for engineering torrential objects, issued by the Slovenian Chamber of Engineers.

Very important is also the modelling and research of how forest management influence watershed, torrents and flooding dynamics, mostly being done at the Biotechnical faculty, Slovenian Forestry institute, and the Faculty of Civil and Geodetic Engineering. Slovenia forest service is also included in the research, providing data on forest stand and management practises. One of the essential elements for good modelling are LIDAR data with 1 m resolution covering the entire country and other geodetic data. Key goals are to provide aspects on the positive role of forest in preventing soil erosion and in reducing and slowing down the floods' peak discharge on vulnerable agricultural or urban areas.

Slovenia has numerous cases of subtle threats, recognized challenges, ongoing activities and finalized good practises. Unfortunately, due to the lack of financial resources in the research, management and the governance are several cases still not well inspected and investigated. This limits forestry in being recognized as the solution to the arising current and future challenges.

Figure 3: Forestry students on field trip on torrent control. Picture credit: J. Papež, M. Kobal.

Management of mountain watersheds

Forest management in all forests, irrespective of ownership, is committed to respect the three main principles: sustainability, close-to-nature and multi-purpose forest management. Main tool for implementation of these principles are forest management plans, defined in the participatory process, addressing forest owners, relevant public and various stakeholders. All together 17 forest functions can be addressed and included into management of forest stands. Direct and indirect protective functions are just two of them. Forest functions of the highest level dictate forest management and need to be fully respected.

Properly managed forests and silviculture protect soil, sites and surroundings from all types of erosion processes, especially on extreme sites, at upper timberline, on very steep slopes, dry areas and on shallow or rocky soils. Such forests have a significant effect on downstream areas, regulate the water runoff, causing decrease in intensity and lag travel time of the flood waves down to agricultural land and urban space. As a result, forests prevent blocking of the watercourses with soil sediments.

On the other hand, can forests and forestry represent source of woody debris (Papež and Kobal, 2018). Combination of infrequent torrent supervision or control, extreme weather events, passive forest management (mostly in the forest with insufficient forest road network or difficult access), improper storage of logs and wood in the torrent areas, can result in the so-called logjam. A good solution to this problem could be an amended legislation, giving the forest service better authority to actively cooperate with the public water management service and forest owners to be proactive regarding removing timber from torrents and areas of potential impact of high flood torrential waters in the headwaters.

In general, it is vital to obtain healthy and resilient forests to climate change. In recent years, the biggest threats represent bark beetle attacks, causing damage on the altitudes as never before. In mostly spruce forest stands, this represents a challenge in preserving forest cover and stand protection function. Another challenge, linked to the changed precipitation regime and increased air temperatures, are forest fires, especially in areas with difficult access (steep terrains, lack of forest roads).

Forest management strives for resilient forest, able to provide protective function. Especially in times of disturbances and disasters it becomes evident, how fragile is this balance and how deceptive can be our reliance on the protective forest function. Failing in obtaining protective function can result in excessive financial outcome. In disturbed areas it is important to reforest forest sites as fast as possible when natural regeneration is not sufficient, limited or too slow. There is another challenge; represented in the form of unfavourable conditions for seed and sapling planting, especially in the form of spring drought, and the question of availability of the genetically diverse and suitable saplings of various tree species.

Close-to-nature principles

Same as in the forestry, also in managing water courses nature based solutions are welcomed, especially taking into consideration all the restoration demands and providing favourable water body status. Such solutions can be used in the protection against riverine flooding and in preventing other water dynamics, causing erosion and other harmful effects. Decisions on the forest stand age structure and species diversity, promoting the highest rooting intensity of the soil, are the decisions enabled with mimicking natural dynamics and applying measures on broader areas. The Slovenian Water management plan for the period 2016-2021 states, that hydromorphological status can be obtained or improved with the selection of the close-to-nature way of the watershed management practises, helping to decrease hydromorphological burden on waters. Such principles of integrated water management begin already in torrent catchments. Where purely nature solutions are not sufficient, correctly positioned and designed consolidation and retention structures are used to successfully provide bedload transport control. These structures are generally integrated in a system and therefore are their functions interactively supplementing. The majority of torrent control structures constructed took into consideration the best possible way of their integration in the landscape.

Conclusion

Although we have long history of managing of torrential areas in Slovenia, both with measures on waterstreams and in forests, there are still some issues that have to be addressed. Uncertainties related to the climate change are high, especially at the local level. Organization of forest management must be prepared to adapt to the changing environmental conditions. It will be necessary to solve the difficult professional question on how to preserve ecological, social and economic forest functions. All this will be even more important in forests with protective function. Sustainable, close-to-nature and multifunctional forest management, that has developed in Slovenia in the last decades, is an effective framework for responding to the climate change. Still, the greatest progress will have to be made on the better coordination of the forest management measures and measures on water streams. Crucial will also be the research and international cooperation through the exchange of experiences and examples of good practices.

Literature

Fajon Š. 2007. Forest and water – results of the project Interreg IIIA. In Slovene.

Forest Act (Official Gazette of the Republic of Slovenia, No. 30/93, 56/99 - ZON, 67/02, 110/02 - ZGO-1, 115/06 - ORZG40, 110/07, 106/10, 63/13, 101/13 - ZDavNepr, 17/14, 22/14 - odl. US, 24/15, 9/16 - ZGGLRS in 77/16).

NFP – Resolution on National Forest Programme. (Official Gazette of the Republic of Slovenia, No. 111/07).

Ogrin D. 1998. Climate. In: Geographic atlas of Slovenia. Fridl J., Kladnik D., Adamič Orožen M., Perko D. (ur.). Ljubljana, Research Centre of the Slovenian Academy of Sciences and Arts: 110-111. In Slovene.

Papež, J., Kobal, M. 2018. Floating large woody debris in selected torrential areas (in Slovene). Conference: 29. Mišičev vodarski dan 2018 – Managing watersheds as a measure to reduce erosion and flooding events. p.: 86-94.

Rules on the methodology for determining areas endangered by floods and related erosion of inland waters and the sea, and on the method of classifying land into endangered classes (Official Gazette of the Republic of Slovenia, No. 60/07).

Water Act (Official Gazette of the Republic of Slovenia, No. 67/02, 2/04 - ZZdrI-A, 41/04 - ZVO-1, 57/08, 57/12, 100/13, 40/14, 56/15 and 65/20).

Turkey

In Turkey, various institutions and organizations are responsible for flood protection before, during, and after floods, with the General Directorate of Forestry and the State Hydraulic Works being the most significant institutions and organizations responsible for flood protection in mountainous areas. These two organizations do the majority of their work at the basin level. The General Directorate of Forestry is in charge of flood management in the upper basins, while the General Directorate of State Hydraulic Works is in charge of flood control in the lower basins.

Many laws, rules, and circulars in Turkey address the flood issue since it has an impact on the work of numerous governmental organizations. Many laws, guidelines, and circulars in Turkey address the flood issue because it has an impact on the functioning of numerous governmental organizations. Numerous laws and regulations deal with floods in one way or another, but the most significant is the "Flood and Rust Control Regulation". The regulation's goal is to establish the basic hydraulic design criteria for river engineering structures like bridges and culverts, as well as engineering structures for flood and sediment control, as well as the necessary permits and approval procedures for other works, interventions to riverbeds, and flood control facilities. A flood management program is being undertaken in the upper basins, as per Circular 14. (Considerations in Erosion Control Applications).

The impact of forests on hydrological processes can be analyzed by looking at the five main hydrological processes that determine the effects of precipitation, which have the potential to cause flooding, and which can be listed as 1) interception, 2) infiltration, 3) soil water storage, and 4) surface and subsurface flows.

Interception: After a strong precipitation, the forest will catch and store part of the rainwater on the leaves, shoots, branches, and trunks of the trees in its canopy. Shorter rainfalls are the best for infiltration; however, the impact fades quickly in more intense or longer rainfalls. Interception, without a doubt, lowers the amount of precipitation that makes it to the stream beds and causes floods.

Infiltration: If we think of infiltration as "the process by which water moves through the topsoil," limited infiltration will lead to runoff and erosion. No runoff occurs on undisturbed forest floor by human intervention. In the broadest sense, storage includes intercepted amount, surface storage in trenches of land, soil and bedrock storage, bedding storage.

Soil water storage: Generally, the storage characteristics of a basin are the main factors that determine at what rate and at what flow rate the precipitation waters that cause floods or overflows will reach a certain point downstream. Undoubtedly, the amount of water held by the organic material on the forest floor has a great impact on the soil to reach high storage values. The water holding (storage) capacity of a humus layer with an average depth of 5 cm reaches up to 20 mm.

Surface and subsurface flows: Surface runoff in the forest is negligible, even during precipitation with the potential to create flooding. Therefore, the flow that creates the flood hydrographs of streams in forested basins is mainly due to subsurface runoff.

A integral approach always has a positive effect on flood protection, but for this, necessary legal regulations and flood and flood-related job descriptions of each institution are required. In this regard, an intensive study is carried out on legal regulations by the General Directorate of Water Management. DSI, the institution responsible for flood and flood control in the main streams in our country, works in the upper basins of the GDF in the parts other than the main stream. In the studies where the applications are made in terms of OGM, there is no other difficulty in property problems.

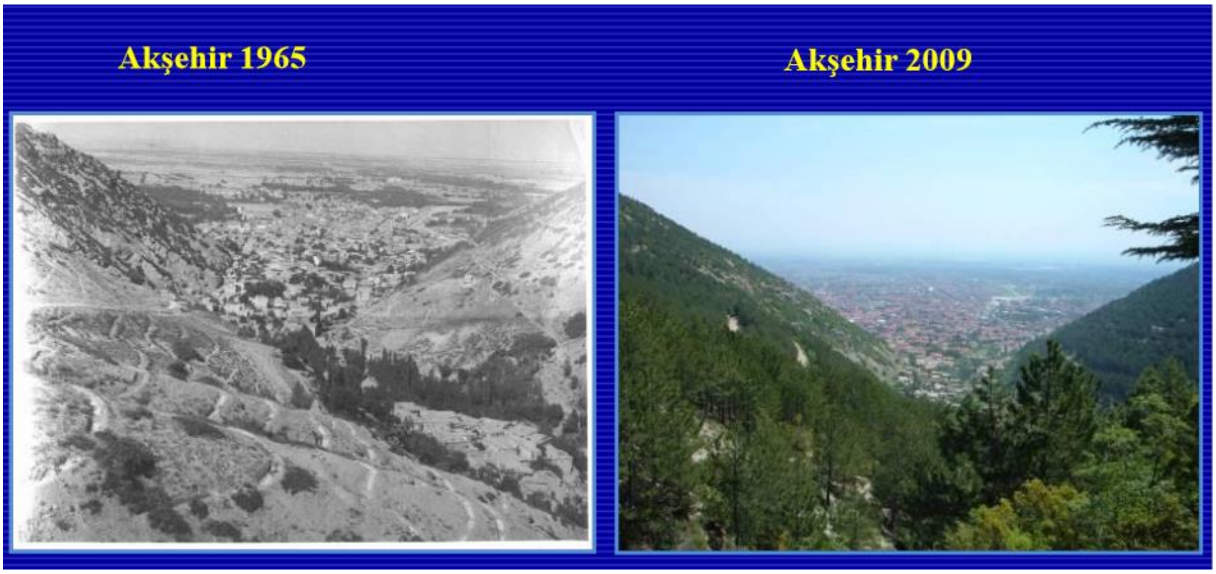
Although it is not possible to prevent natural disasters, it is possible to minimize the loss of life and property by reducing their destructive effects with today's information and technologies. High greenhouse gas emissions due to the increasing population and the development of industry have brought the danger of climate change, and the management of water resources due to this change has become even more important. In case the water transmission capacity of the river bed decreases for various reasons or if more water comes out of the capacity, floods that cause loss of life and property by overflowing the bed are among the important disasters that need to be taken care of.

In our country, 1D (Mike 11 and Mouse) and 2D (Mike 21) model techniques were first used with the computer program called Mike Flood. It was followed by SOBEK integrated water modeling program, and today HEC-RAS (Hydrologic Engineering Centers River) developed by the United States Military Engineering unit. Analysis System) package program is used.

In order to reduce the flood formation in the upper water basins and to regulate the precipitation-water regime; afforestation, erosion control, terracing, slope land reclamation, rehabilitation of flood streams, improvement of pastures and rehabilitation of degraded forests are carried out. Between 1946 and 2020, 1.573,871 ha of erosion control work was carried out in our country, which directly and indirectly plays a major role in preventing floods and overflows. In order to reduce the loss of life and property, it is planned to work in the field that will affect the general area of 4,155,000 hectares in 227 flood basins between 2013 and 2019 in order to combat floods and overflows. After the action plans, a separate appropriation was created for flood control works after 2019, and the continuation of the works was ensured. In this context, 1250 ha in Rize Esendered in 2019. 3 HIS in the area, and 3 flood basins in Bolu, Balıkesir and Rize provinces in 2020, work was carried out in an area of 1,950 hectares.

https://docplayer.biz.tr/31113-Turkiye-de-sel-kontrol-calismalari.html

Figure 1: An example of afforestation in Kahramanmaraş to reduce flooding



Picture 2: Example of afforestation in Akşehir to reduce flooding

Picture 3: An example of activities to reduce flooding

Ukraine (observer)

PRACTICAL WAYS TO IMPROVE THE QUALITY OF MOUNTAIN FOREST WATERSHEDS IN THE UKRAINIAN CARPATHIANS

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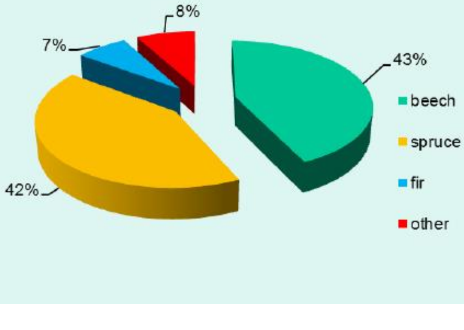
Ukrainian Carpathians

The Ukrainian Carpathians are part of the mountain system of the Eastern Carpathians in Western Ukraine. Their length is 280 km, width over 110 km. The mountains are medium-altitude with altitudes of 1000 - 1500 m, only some peaks rise more than 2000 m. This is one of the narrowest and lowest sections of the Carpathian mountain range. The highest peak is Hoverla (2061 m). Mountain forests cover an area of about 1.5 million hectares. Commercial forest – 46%, protective forest – 28%, recreational and health-improving forest - 9%, forest of nature protective, scientific, historic and cultural purpose - 17%. The main species are beech, spruce, fir.



Dangerous floods

The densest river network in Ukraine has formed in the Carpathians. In spring and summer due to melting snow in the mountains and heavy rains on rivers there are dangerous floods. There is an increase in the frequency of historical floods (1941, 1969, 1998, 2001, 2008, 2009, 2019).

Inefficient forest transport infrastructure

More than 90% of the harvested timber in the Ukrainian Carpathians is transported by skidding tractors or horses. Cable way systems have a single use. Insufficiently developed network of forest roads leads to the need to build a significant number of trails on mountain slopes. The main trails are used for a long time and are the centers of erosion processes. A similar pattern is observed on agricultural lands.

Implementation of international commitments in the framework of the Carpathian Convention

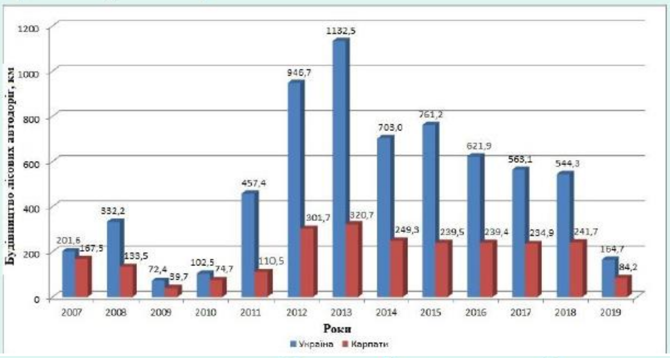
Strategic Action Plan for the implementation of the Protocol on Sustainable Forest Management (2014)

Objective 9 - Improve the forest transport infrastructure of mountain Forests

According to articles 1, 3, 9, 14 and 15 of the Protocol, Parties should:

Action 9.1. Take a part in a building of new forest roads in mountain forests, where necessary, and improve the technical condition of existing ones.

Action 9. 2. Adopt measures to improve ways of primary transportation of wood.



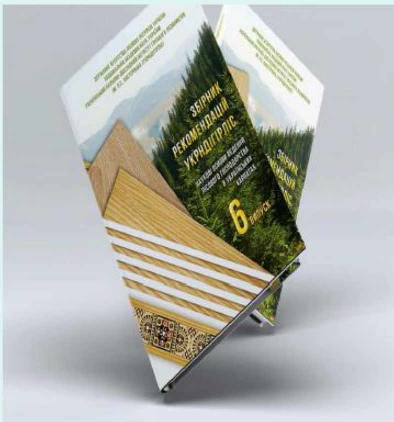
Creating modern regulations

The Ukrainian Research Institute for Mountain Forestry (UkrRIMF) established in 1963, is an institute of the State forest resources agency of Ukraine and the National Academy of Science of Ukraine. UkrRIMF focuses on developing a scientific basis for the management of mountainous forests and for forest legislation in Ukraine. In recent years, several recommendations have been made to improve the hydrological functions of mountain forest:

"Recommendations for forest management according to landscape-watershed and forest typological principles, taking into account the functional purpose in the forests of the Ukrainian Carpathians" (2018);

"Recommendations for ecologically oriented forest use, taking into account different methods of cutting during the transition to the landscape-watershed principle in the mountainous conditions of the Carpathians" (2020) ;

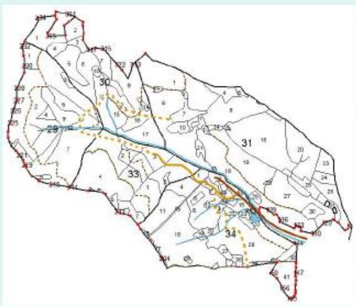
"Recommendations for application of environmentally friendly technologies of primary transportation of wood, taking into account the network of forest roads during the transition to the landscape-watershed principle in the mountain conditions of the Carpathians " (2020).



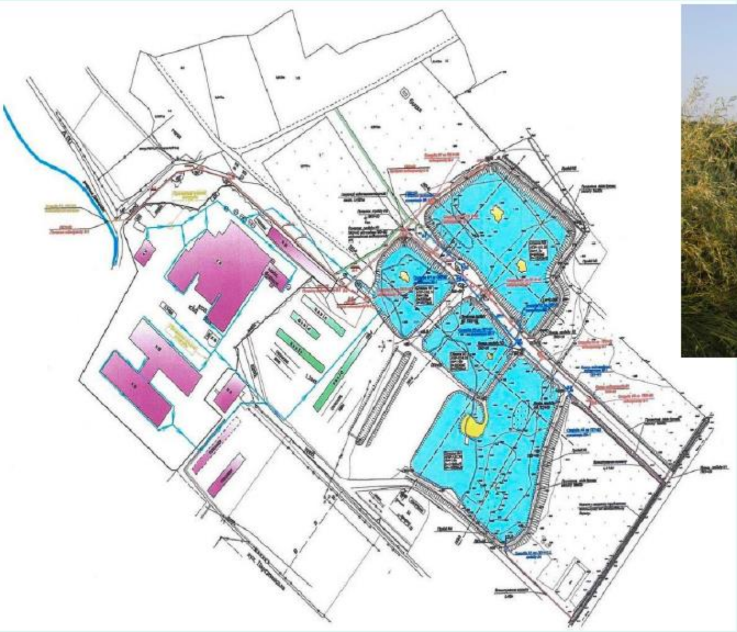
Ukrainian-Slovak project "HYDROFOR: Systems of optimal forest management for enhancing the hydrological role of forests in preventing the floods in Bodrog river catchment" (2013-2015)

Two watersheds were studied and used as demonstration plots to showcase application of sustainable forest management, effects of recultivating skidding trails, building of new forest road using landscape design principles, applying simple engineering structures/devices to decrease flood risks. Simulation was done to demonstrate hydrological effect of forests and management practices to the occurrence of floods.

Cross-border meetings and discussions of watershed approach and forest management practices



Intersectional cooperation in the direction of improving the hydrological role of mountain forest areas



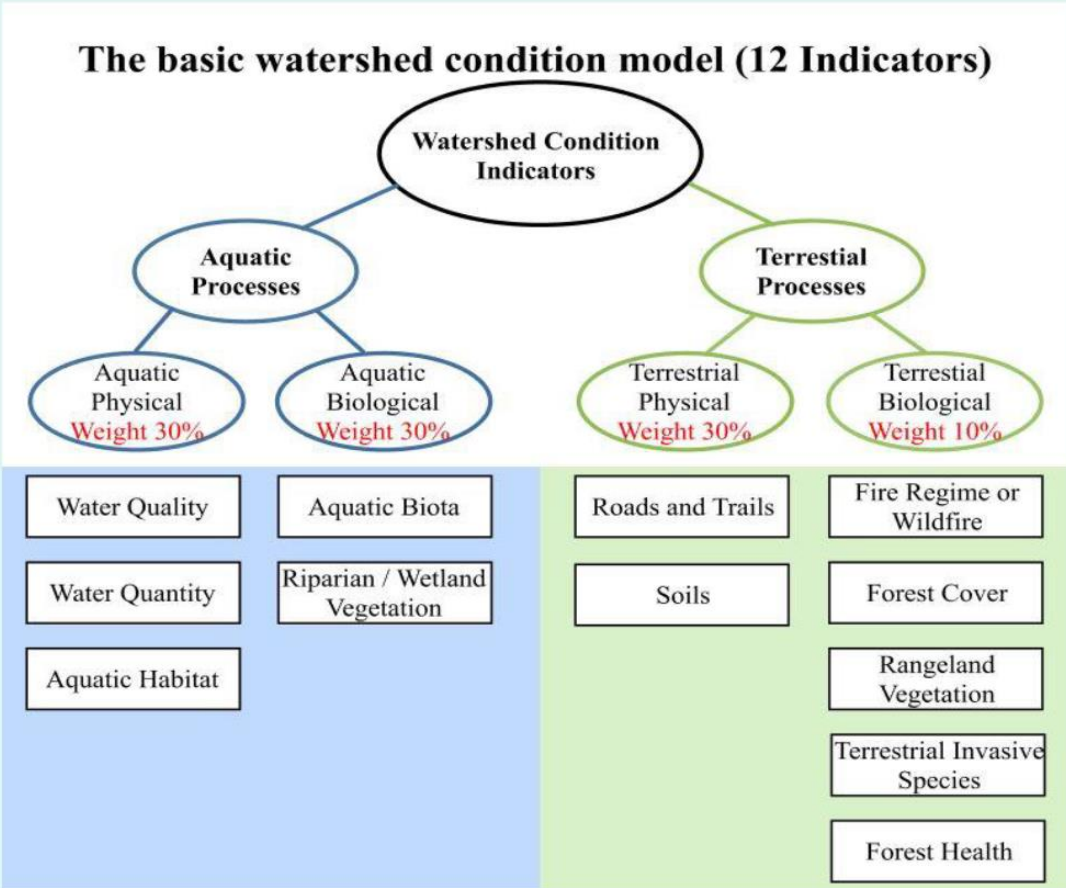
Location plan for the objects of the private woodworking enterprise "Samver" in Transcarpathia.

International projects: "Qualified foresters - the best forests" (2016-2018) and "Classification of the state of the catchment - the transfer of experience of the US Forest Service to Ukraine" (2019-2021).

The implementation of these projects took place on the initiative and under the leadership of the NGO "FORZA“ (Ukraine) with the financial support of the US Forest Service. In the United States, two documents are used - "Classification of watersheds. Technical Guidelines ”(FS-978) and “Water catchment assessment and monitoring system ”(FS-977), which came into force in 2011.

As a result of these projects, the draft of the "Recommendations for the classification of watersheds for the Ukrainian Carpathians" was prepared.

Assessment of watersheds status will be carried out using 12 indicators divided into four main groups. Of these, five are aquatic and seven are terrestrial. The condition of the catchment is assessed by three classes: functioning properly, functioning at risk and impaired function.



Ukrainian-Slovak project "Roads to healthy forests: resilient, adaptive, diverse and sustainable forests in the cross-border region of Ukraine and Slovakia" (2019-2022)

This project, being the first large infrastructure project in the forest sector of Ukraine, is aimed at increasing stability and adaptability of Carpathian forest ecosystems to climate change impacts in Slovak-Ukrainian cross border region.

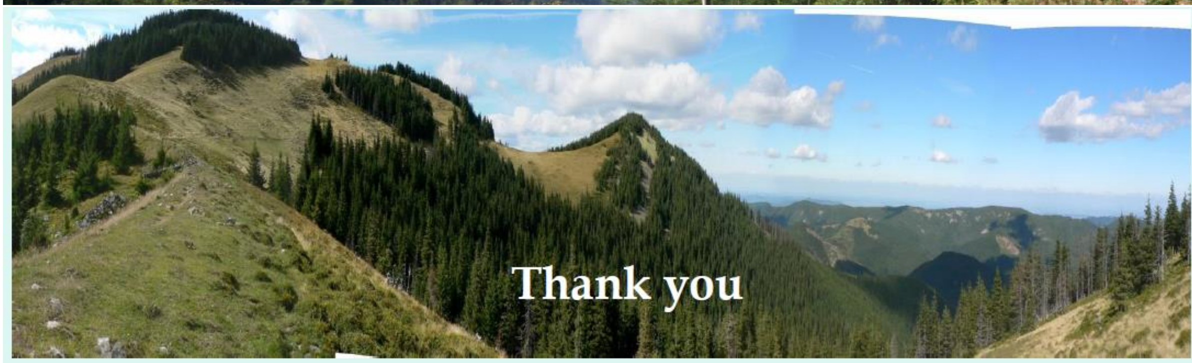
Conclusions and suggestions

1. Forests cover a large part of mountainous areas, so the application of practical measures aimed at improving the hydrological role of forests is relevant and important.

2. The quality of mountain watersheds can be achieved through the introduction of sustainable forest management, which should be based on the integration of forestry and water management.

3. The condition of forest transport infrastructure has a decisive influence on the quality of mountain watersheds.

4. It is important to develop at the European level regulatory requirements for the establishment of a forest transport network in mountain forests, taking into account the need to ensure the quality of forest watersheds.



PRACTICAL WAYS TO IMPROVE THE QUALITY OF MOUNTAIN FOREST WATERSHEDS IN THE UKRAINIAN CARPATHIANS

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