“PREMO ‘98”

PREVENTION IN THE MOUNTAINS FOR PROTECTION OF THE VALLEYS

“PRINCIPLES AND GUIDELINES FOR THE ENVIRONMENTAL PROTECTION OF DRAINAGE BASINS PRONE TO FLASH FLOODS. EXPERIMENTAL INTERVENTION IN A PILOT DRAINAGE BASIN”

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1 INTRODUCTION

Partners

The work group participating in this project was co-ordinated by the Regional Agency for Development and Innovation in Agriculture and Forestry (ARSIA) of the Tuscan Regional Government and also included the following partners:

- Geoplan S.r.l. - Pistoia (Italy);
- Wasserwirtschaft - Styria (Austria);
- CEHIDRO (Instituto Superior Tecnico) - Lisbon (Portugal).

It was brought together the DG-XI sponsored workshop "Flood Related Hydrogeological Risks" held at Castel Nuovo di Porto (Rome) in May 1996 when representatives of four European countries (Austria, France, Italy and Portugal) agreed to promote joint initiatives on the subject of preventing flash floods. The French partner (Office National de Forets - Cemagref) who participated in the initial "PREMO" project, after its completion, was unable to continue its co-operation with the team activities of PREMO ’98 due to reasons related to its internal organization.

In view of the operational nature of the participating organizations and the interdisciplinary nature of the hydraulic risk conditions, the involvement of persons with different skills and experiences in the fields of engineering, hydraulics, geology, agronomy and forestry proved to be very useful.

Within the framework of the project, the experiences of each partner were presented during work meetings held in each country, thus providing an opportunity for comparing, discussing and analyzing different approaches and techniques in relation to the specific (technical and legislative) aspects of each country.

Scope

European countries and other countries around the world face problems related to hydraulic risk conditions and flash floods. The need for solving these problems prompted the Directorate General for the Environment, Nuclear Safety and Civil Protection (DGXI) of the European Community to issue, in 1997, a "Call for proposals for pilot projects in the field of environmental protection of areas prone to flash floods".

Project "PREMO '98: Principles and Guidelines for the Environmental Protection of Drainage Basins Prone to Flash Floods - Experimental Intervention in a Pilot Drainage Basin", results from that Call and was approved by EC-DGXI, under reference N. B4-3040/97/734/JNB/C4. This project represents a logical continuation and complement to the experiences and studies undertaken during a preceding project, sponsored by the same DG, concerned the preparation of a general methodology to study basins subject to hydraulic risks (Project "PREMO: Action towards environmental projection of areas subject to flood risks"), and was carried out by the same work team.

The work reported herein corresponds to the final report of Project PREMO '98 and follows the orientations defined in the work meetings held in Graz, Austria, 29-30 June 1998, Lisbon, Portugal, 29-30 October 1998, Firenze, Italy, 14-15 January 1999, 14-16 April 1999, and 3-4 June 1999. Its main purpose is to collect, illustrate and compare the best preventive measures, currently applied within each participating country, for protection of areas subject to the risk of flash floods. In fact, the acronym PREMO stands for “Prevention in the Mountains for the Protection of the Valleys”. This project, conducted on the basis of mutual co-operation, allowed an overview of technical, legislative and management experiences in this field developed in Austria, Italy and Portugal.

The project calls for the drafting of a monograph that not only elucidates the regulatory, management and application techniques implemented in each of the participating countries but, at the same time, defines general guidelines for identifying both structural and non-structural preventive actions aiming at the mitigation of flash floods. This methodological approach presents the standard actions to be undertaken in basins subject to hydraulic risks in relation to specific environmental conditions (both natural and related to human interference) that affect the development of flash floods.

A flash flood, the fastest-moving type of flood, occurs when heavy rains collect in a stream or gully, turning the normally calm current into an instantly rushing one. The quick change from calm to raging river is what catches people off guard, making flash floods very dangerous. Any flood involves water rising and overflowing its normal path, but a flash flood is a specific type of flood that can roll boulders, tear out trees, destroy buildings and bridges, and scout out new channels. It appears and moves quickly across the land, with little warning that it is coming.

Flash floods are generally the result of heavy rainfall concentrated over one area. Most flash flooding are caused by slow-moving thunderstorms, by several thunderstorms that move over the same area, or by heavy rains from hurricanes and tornadoes. Dam failures can create the worst flash flood events: when a dam or levee breaks, a gigantic quantity of water is suddenly let loose downstream, destroying anything in its path.

The U.S. Corps of Engineers (1965) defines flood as a temporary inundation of soils not usually covered by water, which are used or usable by men. A flash flood is defined by the World Meteorological Organization (WMO - UNESCO) as a short duration inundation with a high peak flow. In the Unites States, the National Weather Service defines "flash flood" as the inundation that happens few hours after the phenomena that caused it. Considering the WMO criterion, the classification of a flash flood caused by high levels of rain is based on a concentration time lower than 6 hours for its basin.

Given the peculiar nature of flash floods which typically occur in small and medium size basins, the field of application of this project is concentrated on this typology of basins that can be defined by the following morphometric and hydraulic conditions:

- small-to-medium area, in the order of 1-50 square kilometers, with a highest value of 100 square kilometers;
- water courses in the order of $\leq$6 (Strahler 1964);
- length of the main watercourses in the order of 30-35 km with a highest value of 100 km;
- concentration time within 3 hours with an upper limit of 6 hours.

On the basis of the above listed features, the project focuses its attention on hydrographic basins in areas of prevalently hilly and medium mountainous morphology with limited plain areas in the bottom of the valley. Although some technical-application and management aspects can be exported to different morphological-hydraulic conditions, the applicability of the guidelines contained in this study is limited to small-medium basins with significant sloping features.

The protection measures against this type of natural risk involve the protection of human lives and goods, minimization of losses, maximization of benefits caused by this kind of incident and attenuation of flood impacts.

In any event, it is important to emphasize the following aspects of the applicability of the methods developed in this project:

- the principles and guidelines were drawn up on the basis of experience accrued by the participating countries and therefore directly respond to the operational needs of those countries;
- the "open" arrangement adopted in the project method makes it possible to tackle hydraulic issues that are widespread in many countries by adapting the proposed guidelines to the specific differences of each geographic context.

Due to the greater ecological sensitivity developed over the past few years in the context of hydraulic arrangements of hydrographic basins, special attention was dedicated to actions employing naturalistic engineering techniques and materials that can reduce environmental impact. Also, the analysis of possible legislative and territorial management-planning tools proved to be of fundamental importance in certain local contexts, these tools can be more effective in reducing the risk of flash floods than structural actions undertaken on the hydrographic networks.

The final result of the project is a monograph, hopefully of practical use, for those - technicians and decision makers - who deal with territorial management, flood prevention or are in charge of solving hydraulic problems that are difficult to quantify and foresee.

Practical Application

In parallel with the writing of the project monograph, the group studied a basin located in the northwestern part of Tuscany, which is affected by flash floods: Civiglia Torrent Basin in the Province of Massa and Carrara. This basin (Case Study) proved to be a practical example for stimulating discussion in the preparation of the monograph and provided an opportunity for applying the adopted methodology to a real case.

The method used to study the basin was developed during "PREMO" project and called for analysis of the territorial features of the basin, definition of the main aspects responsible for the conditions of hydrogeological risk and identification of proposals for solving the detected problems.

In order to arrive to a better management and representation of the territorial data collected in the course of the study, surveys were implemented and managed using a digital geographical information system (GIS). This made it possible to prepare a cognitive basis tool that can be easily updated and completed in the future.

Summary

The second Chapter refers to the institutional and legislative framework, that is, the laws in force at the different levels, from local to global, in each partner's country and concludes with considerations on optimal levels of coordination. Chapter III begins with the methodology recommended for the study of small-medium basins, based upon the previous work done by the same team[1]. It continues with the non-structural solutions (basin land-use plans and floodplain management, urban development regulations and constraints) for preventing flood hazards in the studied areas and the adopted structural interventions (sound and efficient environment-friendly engineering techniques, design and execution of structural works aiming at the protection of areas prone to flash floods). A schematic view of the criteria for the intervention alternatives is presented in Chapter IV. Chapter V and VI refer to ex-post evaluation and a glossary of the technical terms commonly used in Austria, Italy and Portugal, and in English. The Annex includes (under a separate volume), the application of principles and guidelines for flash flood prevention in the Civiglia Basin, described in the preceding project[1].

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[1] Project PREMO "Action towards environmental protection of areas subjected to flood risks – 1998.

2 INSTITUTIONAL AND LEGISLATIVE FRAMEWORK

2.1 INSTITUTIONAL FRAMEWORK

Power, attributed to the state by the people, is exercised under separate headings on a vertical axis - representative, legislative, executive and judicial arms of state authority - and it is organized on a horizontal axis - local, regional and central government.

In order to understand how each partner country operates in the field of prevention and protection from flash floods, it is convenient to compare the institutional frameworks through a synthetic description of the general administrative structures and of the responsibilities in hydraulic risk prevention and defence, water resources, environment management and land use planning described in Chapter 2.2 and summarized in Chapter 2.3.1.

2.1.1 Administrative Structures

The comparison among each national reality highlights the difference in the organization of administrative and institutional frameworks. The differences in the institutional schemes are linked to local situations that depend on each historical, cultural and traditional background.

In the following table (Table 2.1.1), a comparison of the institutional framework is given on the basis of European Classification (NUT – Nomenclature of Territorial Unit).

Table 2.1.1 - Terminology for NUT's and Current Names

NUT	Austria	Italy	Portugal
0	State (Bund)	State (Stato)	State (Estado)
I			Continent, Madeira, Azores
II	Region (Land)	Region (Regione)	Coordinating Commissions of Regions (CCR's)
III	District (Bezirk)	Province (Provincia)	Sub-region (Distrito)
IV			Municipality (Concelho)
V	Commune (Gemeinde)	Commune (Comune)	Commune (Freguesia)

2.1.1.1 Austria (Styria)

Three different levels prevail for hydraulic and territorial management of this country. Austria is characterized by a Federal Government that co-ordinates the action of Regional Administrations. Districts represent an intermediate level for executing the laws in their competence. Local Authorities, inside the Regional boundaries, represent the smallest subdivision of administrative structures (Table 2.1.1.1).

Table 2.1.1.1 - Institutional framework in Austria (Styria)

Level	State	Region (Styria)	17 Districts	543 Communes
Representative *Legislative* *Executive*	President Parliament Federal Government	Governor, Regional Parliament, Regional Government	Commissioner Commissioner	Mayor Municipal Council
Enforcement with...	Pres. Decrees, Laws	Regional Laws, Decrees	Administration	Ordinances

<u>Federal Government</u> (NUT 0) - The Ministry of Agriculture-Forestry is directly involved in the defence from hydraulic risk conditions. It mostly performs a technical co-ordination of regional activities, the dealing of fundamental questions in the field of water-management and of questions of prominent importance, and the setting of uniform principles for territorial management.

Regional Administrations (NUT II) - They represent the prominent element of Austrian Institutional framework and mainly concern the planning action on the basis of Ministerial indications with a predominant interest in water management.

Local Authorities (NUT III, V) – The District Commissioners and the Mayors collaborate with the Regional authorities also in the management of hydrographic networks and give financial support in the construction of new hydraulic structures.

2.1.1.2 Italy (Tuscany)

The Italian Administrative framework foresees four different administrative levels for hydraulic and territorial management. Italy is characterized by a National Government that represents the prominent element of Italian Institutional framework. In the last years, a great part of the national authority has been transferred to the Regional and Local Administrations (Provinces and Communes) also concerning hydraulic risk management (Table 2.1.1.2).

Table 2.1.1.2 - Institutional framework in Italy (Tuscany)

Level	State	Region (Tuscany)	10 Provinces	238 Communes
Representative *Legislative* *Executive*	President Parliament Government	President Regional Council Regional Government	President Provincial Council Provincial Government	Mayor Communal Council Communal Government
Enforcement with...	Pres. Decrees, Gov. Decrees, Laws	Regional Laws, Decrees	Decrees	Ordinances

National Government (NUT 0) - The Ministry of Agriculture and Forests and the Ministry of Environment together with the Civil Protection structure (Ministry of Interior) are directly involved in the prevention and defence from hydraulic risk conditions. National action foresees the preparation of guidelines (National Laws) for the co-ordination of Regional Laws and Prescriptions, the dealing of national questions in the field of water-management of main public hydraulic infrastructures and questions of national relevance.

Regional Administrations (NUT II) - They receive the national inputs and prepare Regional legislation also concerning hydraulic risk protection and prevention. Regional institutional activity usually co-ordinates actions of Provincial and Communal Administrations. Furthermore, Regional Administrations have a decision-making role in the field of major public infrastructures. It also gives indications and guidelines in the hydraulic risk territorial planning.

Provincial and Communal Administrations (NUT III, V) are the local authorities directly involved in land use planning and control, representing the link between the national and regional authorities and the population. These local administrations guarantee the application of the national and regional legislation on land use, hydraulic and hydrogeological risks and, at the same time, give indications, in an iterative way, to the regional administrations for the preparation of global planning actions.

River Basin Authority – In regard to the hydraulic risk management, River Basin Authorities represent a transversal technical-administrative structure that is in charge on the main river basins (Po, Arno, Tevere, etc.). It draws up a Basin Plan containing a technical analysis of the basin and the limitations and prescriptions on land use that have to be acknowledged and respected by local and regional administrations.

2.1.1.3 Portugal

The Portuguese political-administrative framework is composed by a national level and a local level, represented, respectively, by ministries and municipalities. Each ministry, the national level figure, co-ordinates and drives its sectorial policy and foresees, in some cases, an intermediate administrative regional level in order to perform the best public interest (Table 2.1.1.3).

Table 2.1.1.3 - Institutional framework in Portugal[2]

Level	State (Continent)	18 Districts[2]	278 Municipalities[2]	4037 Communes[2]
Representative *Legislative* *Executive*	President Parliament Government	Governor[3]	Mayor Municipal Assembly	President Communal Assembly
Enforcement with...	Decrees, Laws	Ordinances	Decisions	Ordinances

National Administration (NUT 0) gives national political indications concerning also hydraulic risk defence and prevention and land use planning and control.

Municipalities (NUT IV) guarantee the application of the national legislation and are in charged of preparation of land use in their territories - Municipal Master Plans (PDM); they are also directly involved in civil protection, during the occurrence of emergencies.

The Ministry of Equipment, Planning and Territory Administration is the national entity responsible for the general European funds application. It supervises, in the continental part of Portugal, five Regional Co-ordinating Commissions (CCR's - NUT II), which are responsible for the co-ordination and execution of measures that concern the respective region, and the promotion of technical and administrative support to the municipalities, in connection with the central services involved in its realization.

The Ministry of Environment is the national authority responsible for flood management in the context of river basin management. The Water Institute (INAG) and the Five Regional Authorities (DRA's) dependent on Ministry for Environment are the main public agencies establishing specific regulations and implementing control measures in flood affected areas.

In urban situations, Municipalities also play an important role, and are responsible for licensing of land use, once that use complies with the specific regulations established by INAG and DRA's.

In rural areas, the Ministry of Agriculture, Rural Development and Fishing play a significant role in building structures for land drainage.

2.1.2 Water Resources, Environment Management and Land Use Planning

Within each administrative framework, the public authorities that directly deal with the water resources and environment management are identified.

2.1.2.1 Austria (Styria)

Due to the distribution of competences established by the Austrian constitution, questions concerning water legislation are in the domain of the federation. The implementation of acts of law, however, is mainly shouldered by the regions (Länder) and their administrative organs, on behalf of the federal government.

Legislation and implementation of acts of law in the field of environmental protection lies with the regions (Länder).

As for regional policy planning, the legislative competence lies with the regions (Länder), but implementation takes place mainly at the communal level.

[2] The Atlantic Islands (Madeira and Azores) are not included in these figures.

[3] Not elected.

Besides the Styrian Regional Government (Amt der Steiermärkischen Landesregierung), whose seat is in Graz, there are the Prefecture and District Building Boards. These are primarily responsible for the implementation of actual projects and the concession of permits.

In general, the distribution of competences between administrative organs at district level and the central authority, i.e. the Styrian Regional Government, depends on the type and scope of the specific project.

2.1.2.2 Italy (Tuscany)

Water resources and environment management are typically of the competence of the Ministry of Environment while land use planning the Ministry of Environment shares responsibilities together with the Ministry of Public Works.

The Italian legislative framework foresees a national co-ordinating action through laws and directives that represent a point of reference for the legislative action of the regional institutions.

Each regional administration, on the basis of these national guidelines, has the power to make its own regulations in different matters. In particular, on the basis of the National Law n. 616/77, the competencies in matters concerning agriculture, forestry, water resources, pollution, land use planning, hydraulic risk, land reclamation, etc. were transferred from the State to the Regions.

In the last years, the legislation of the Region of Tuscany in these fields has tried to regulate competencies on local levels by identifying homogeneous areas of competence for a co-ordinated policy and correct exploitation of the natural resources; for example, in the case of soil defence and hydraulic risk, these areas correspond to the River Basin Authority.

Local administrations, namely Provincial and Communal administrations prepare and actually carry out local management plans in accordance with the main regional plans that gives general and some peculiar indications on the management of the territory.

Three other institutions operate on the territory with different functional tasks:

- In hillsides and mountain areas, a series of Communal administrations act together by forming Consortiums of Mountain Communes, that manage activities principally in matters of agriculture, forestry and hydraulic interventions;
- In flood-plains areas and where the Consortiums of Mountainous Communes are not in charge, Land-Reclamation Syndicates carry out the planning, construction and management of works of land-reclamation and soil defence on one or more hydrographic basins;
- National and Regional Parks are managed by specific entities called Park Authorities which must always be consulted by the Institutions (Regions, Provinces, Communes, Consortium of Mountain Communes, River Basin Authorities and Land Reclamation Syndicates) when dealing with any type of intervention on their territory.

2.1.2.3 Portugal

The structure of the Ministry of the Environment, which is responsible for the political leadership and global co-ordination, is composed of five sector-based institutes and five regional directorates. The sectorial institutes are: Water Institute (INAG; the major agency responsible for water planning and management at the national level), Institute for Wastes, Institute for Meteorology (IM), Institute for Nature Conservation (ICIM) and Institute for Environmental Promotion (IPAMB). The five Regional Directorates for the Environment, are responsible for all aspects of environmental management and for co-ordinating all environmental policies at the regional level.

The five Regional Administrations of Industry and Energy of the Ministry of Economy play a significant role in defining and implementing criteria for licensing all industrial activities.

The Ministry of Agriculture, Rural Development and Fishing (through its Institute of Hydraulic, Rural Engineering and Environment) also plays an important role in relation to environmental management and, together with its Regional Directorates, is involved with INAG in the construction of some multi-purpose water systems, participating in the strategic planning of water use in agriculture.

2.1.3 Civil Protection

Disastrous flood events and other calamities have imposed the creation of specific public administrative and operative structures that deal with risk prevention and public defence. Civil Protection Services, in matter of floods, have the aim of being Services that can efficiently guarantee a preventive analysis of hydraulic risk conditions and the preparation of emergency plans during and after the occurrence of floods. Comparing the different experiences of the partner countries involved in this project, it results that one of the main difficulties that these Services face is the co-ordination of the many public and private actors that participate in the different tasks and phases involved in these events.

2.1.3.1 Austria (Styria)

The tasks allocated to the Civil Defence sector in general and to the Civil Protection sector in special are defined in the National Defence Plan.

Pursuant to this plan, which is still in force but under discussion, Overall National Defence may be defined as the sum of all civil and military provisions and measures designed to counter threats.

Overall National Defence includes in particular military, mental, economic and civil defence.

A Cabinet decision assigned working committees to each of the above aspects. The committees are chaired by the ministries responsible for the respective field; the Civil Defence Working Committee thus comes under the authority of the Federal Ministry of the Interior. In addition to this working committee, the Military Defence Working Committee, the Mental Defence Working Committee and the Economic Defence Working Committee, a special committee for traffic and telecommunications was created.

Each province established a Provincial Coordinating Committee to coordinate measures required by the comprehensive national defence plan at a regional level.

Supraregional and international crisis situations are coordinated by the National Crisis Management Board.

Civil Protection proper covers

- provision for relief missions, thus Disaster Protection
- measures for Self-Protection
- warning and alerting facilities
- construction of shelters
- provision for medical facilities
- provision for veterinary facilities
- protection against radiation fallout

Civil Protection in Austria must be seen as a pluralist system to prevent disasters and provide aid, embedded in the hexagonal responsibility borne by the authorities at the federal, provincial, district and local level, by relief organizations and by the population.

Civil Protection means safety for the population by preparatory measures taken by the:

- authorities**,**
- relief organizations
- individual citizens**.**

That means, Civil Protection in Austria is subdivided into three sections:

- **Precautions taken by the authorities**
  Besides providing the legal framework and the platform for international cooperation, the authorities are responsible for warning and informing the population in case of imminent danger and for the coordination of relief and rescue operations.

- **Precautions provided by the relief and rescue organizations**
  The work and activities of these organizations are of great importance for Civil Protection in Austria. Since these voluntary organizations are highly motivated, well trained and optimally equipped, there is no need for Austria to have a separate Civil Protection force as instituted in other countries.

- **Precautions taken by the general public; individual Self-Protection**
  All precautions taken by the authorities and the rescue organizations would not be effective, if the public did not accept them and was not prepared to cooperate.
  Special attention must thus be given to thorough information and training of the public on Self-Protection.

  In contrast to other states, Austria has no special civil protection units.
  Civil protection in Austria is provided by existing relief organizations, in particular the fire fighting squads, the Austrian Red Cross, the Worker's Ambulance Service of Austria, the Knights of St. John Ambulance Service, the Knights of Malta Hospital Service and the Austrian Mountain Rescue Service. In these organizations, some 300.000 well trained and equipped men and women are available - mostly on a voluntary basis - to a assume civil protection tasks.

2.1.3.2 Italy (Tuscany)

The Italian Civil Protection depends on the Ministry of Interior and it is the public structure in charge of prevention and in giving first aid to the population in case of disaster. This structure involves the administrative levels of the institutional framework and several other public bodies with different competencies, co-ordinating their action.

The National Service of Civil Protection combines the following institutional structures:

- the National Council of Civil Protection, that fixes the general criteria for provision and prevention programs against calamities, management plans during emergencies, co-ordination of civil protection operational structures and preparation of norms about civil protection;

- the National Committee for the prevision and prevention of risks, that gives indications concerning studies and researches about civil protection topics;

- the Operative Committee of civil protection that co-ordinates the activity of civil protection, operational structures during the emergency phases.

The National Civil Protection operational structures include:

- Armed forces;
- Police;
- Fire Brigades;
- Forest Corps;
- State technical services;
- Red Cross;
- State sanitary service;
- Volunteers.

The Mayor is the first authority to be involved during the activation of the civil protection machine although all the other institutional levels, in relation to the entity of the disaster, can be put in action.

Within the sphere of its responsibilities, the Regional Government drafts and implements regional forecasting and prevention programs in harmony with the national guidelines, and organizes offices, facilities and means needed to carry out the civil protection activities.

Emergency management, from the moment the calamity occurs, is the duty of the Prefectures (provincial level). In this phase, the Regional Government's activities are complementary.

2.1.3.3 Portugal

The Civil Protection missions, in Portugal, are: a) prevent natural or man-made hazards related to major accidents, disaster or calamity; b) mitigate losses and damages upon population, material resources and environment; and c) relieve population every time emergency situations strike.

The Civil Protection system integrates the National Service for Civil Protection (SNPC), the Regional Services for Civil Protection (SRPC) and the Municipal Services for Civil Protection (SMPC). Delegations of the SNPC are based on each of the 18 districts (NUT III) that are part of Portuguese administrative organization.

The Prime Minister is responsible for directing the Civil Protection policy and emergency response in case of disaster at national level; responsibility belongs to the Presidents of Government of Azores and Madeira Autonomous Regions (NUT I) and to the Governors of District (NUT III) in the mainland.

At local level (NUT IV), responsibility belongs to the Mayors. The National Emergency Operations Center (CNOEPC) is activated by SNPC, soon after a major disaster cannot be solved either by the means assigned to the Municipality or the District where it takes place, for co-ordination and control of the relief operations and logistics support at the national level.

A National Disaster Emergency Response Office works out 24 hours a day in SNPC to control and manage the current situation. At regional and local levels, Emergency Operations Centers in Districts (CDOEPC) and Municipalities (CMOEPC) are activated every time a major accident or disaster takes place in their respective administrative areas.

There are no organic disaster response units nor schools for Civil Protection in its organization. The training of Civil Protection agents lies down under their commands, that have schools and training centers for such a purpose and are financed by their own budgets. However, SNPC is responsible for a systemic public awareness, information and education campaign, through the dissemination of security and self-protective measures to be adopted by the population in case of an emergency situation, paid by its own financial assets.

The main Civil Protection agents are the National Fire Service (SNB), the security forces (Police and National Guards), the Armed Forces, the Maritime and Aeronautics Authorities, and the National Institute for Medical Emergency (INEM).

So to speak, the paramount rescue forces are the corps of firemen, because they are located all around the country (36 000 firemen as a total, from which 4.5% are professionals and 1.5% are private professional corps belonging to hazardous chemical industries).

The leagues of volunteer firemen, health services, social institutions, NGO's and other volunteer organizations, public services responsible for forestry and natural reserves, industry and energy, transports, communications, water resources and environment, security and relief services, belonging to private and public companies, seaports and airports, have the duty to co-operate with Civil Protection agents already mentioned.

Several scientific and technological institutions and organizations are particularly assigned for cooperation with SNPC and are important contributors to the Civil Protection system, namely those related to meteorology and geophysics, engineering, industrial technology, forestry, nuclear protection and natural resources. Among them, the Ministry of Environment, which is the national authority for flood management in the context of river basin management, assumes an essential role.

2.2 EUROPEAN, NATIONAL, REGIONAL AND LOCAL REGULATIONS

This Chapter gives an overview and an indirect comparison of the laws in force that deal with flood management, hydraulic risk defence and soil protection applied in each partner country.

The legislation described involves different institutional levels and includes European, national, regional and local regulations. In order to simplify the description and to facilitate the comparison of legislative situations of each partner country, it is divided in the following sub-Chapters:

- River Basin Plan Legislation;
- Agricultural and Forestry Legislation;
- Ecological and Environmental Legislation;
- Land Use and Urban Planning Legislation;
- Civil Protection Legislation.

These topics do not have definite limits and therefore this subdivision is not always sharp. In some cases, the previous topics are faced in the same law in relation to the general water management.

2.2.1 River Basin Plan Legislation

2.2.1.1 Austria (Styria)

With the exception of minor cases as defined by law, the construction of protective and regulating hydraulic structures are subject to approval pursuant to Art. 41 of the Water Act. Thus, according to Sect. 1, all protective and regulating hydraulic works to be constructed in public waters, including the necessary provisions to safely discharge mountain waters, require the prior consent of the water authorities, unless they are railways installations. In private waters, prior consent must be obtained for such constructions, according to Sect. 2, if they affect third party's rights or if they affect the course or level of publicly or privately owned waters.

For the implementation of such protective and regulating hydraulic constructions, it is mandatory, apart from their compliance with the state-of-the-art, that they be planned and carried out in such a manner so as to avoid the violation of public interests as well as the infringement of third party's rights. These public interests are specified in Art. 105, Sect. 1 of the Water Act. According to the ruling of the Administrative Court, in addition to these individual criteria for protective and regulating hydraulic structures, such as endangering public safety, obstructing the runoff of floods or ice, substantial impeding of use by the public, endangering water supply, natural landscapes, natural monuments or scenic beauty and the like, all other public interests, which are specifically mentioned in Art. 105 or are similar in nature, must be considered as well.

Apart from these general conditions for approval, a provision must be included in the notice of approval relating to any interruptions of works and abnormal occurrences. This obligation arises from Art. 105, Sect. 2 of the Water Act. An abnormal occurrence is defined as a state of the works that deviates from the legal norm by which human life or health may be damaged or by which major damage may be caused to third party's property or to the environment. In general, it is likely to be interpreted as an external event that cannot be influenced and which may cause the above-mentioned impacts.

Arrangements against such abnormal occurrences may also include the taking of the necessary measures to avoid or to minimize such detrimental effects.

Flood protection measures in the form of flood retention basins, dams, etc. provide also, apart from expert monitoring (basin supervisor), for warning facilities, dissemination of information and the like by the respective authorities, always based on Art. 105, Sect. 2 of the Water Act.

Maintenance is another important aspect for all protective and regulating hydraulic structures. According to Art. 50, Sect. 1 of the Water Act "... the parties authorized to use the water shall, unless there is no legal obligation for another party to do so, maintain and operate their works including any ancillary installations in such a way so as not to violate any public interests or any third party's rights ....". In addition, Sect. 6 provides for the party concerned, in the absence of any explicit obligation, the duty to maintain protecting and regulating structures to such an extent only so as to prevent any damage that may be caused if they become dilapidated.

Apart from the obligations, which have to be complied with according to the notice of approval and which are specified therein in detail, to maintain the works and keep them in good repair, Sect. 6 establishes also the general obligation for the party having carried out the regulation of maintaining the works. As the operator of the works (retention basin, linear measures, etc.) the latter has thus the obligation to keep up and guarantee the function underlying the approved project. Apparent neglect of an installation whose construction and maintenance was supported with public funds may, according to Art. 50, Sect. 7 of the Water Act be considered a violation of the public interests, which, in turn, justifies the obligation of maintaining the works.

So called "passive regulation measures", by which land adjacent to embankment may become part of public water property, is not subject to approval according to the Art. 41 of the Water Act, on the grounds that the legislator refers to regulating hydraulic structures, which always implies some building measures.

Irrespective of the arrangements relating to flood protection and regulation measures, Art. 47 of the Water Act contains also a provision for the maintenance of waters and inundation areas. According to this provision, the owner of a piece of land abutting an embankment may be ordered by official notice to clear river banks and land that is exposed to recurrent floods of trees shrubs and the like and to manage existing vegetation accordingly. Furthermore, he may be instructed to plant appropriate vegetation along the embankment and, in case of smaller flumes, to remedy bank erosion and to remove trees and debris as well as other objects that obstruct the run-off.

Worth mentioning is also the right to issue ordinances provided for in Art. 38, Sect 2 of the Water Act according to which the water authority may generally decree prohibitions or regulations if these are deemed necessary in order to maintain waters and to keep them clean as well as to avoid damage to the water in certain stretches or groundwater areas. This includes grazing on embankments and dams, every kind of land use that encourages soil to loosen and break away as well as the deposition of substances that are harmful to the condition of the waters on embankments and in inundation areas.

The Water Construction Promotion Act (Hydraulic Structures Promotion Act) - BGBL. 148, 1985, amendment 1994 is an instrument that supports and governs water management activities in Austria. It offers an opportunity, within the framework of private economy administration as provided by the Federal Government, of influencing and steering water management issues by the provision of public funds.

The scope of the law ranges from river improvement, torrent control and avalanche defence structures to the corresponding planning and investigation measures.

The flood events between 1970 and 1980, in particular, reinforced activities in protective hydraulic engineering, which then focused on regulation. Since about 1980, a new approach has been adopted in protective hydraulic engineering, in which measures close to nature, flood retention and passive flood prevention are gaining in importance. Meanwhile, the concept of safeguarding and improving the ecological functions of waters has become an essential criterion in protective water management. The Styrian River Basins are shown in Figure 2.2.1.1.

The Danube. According to the Hydraulic Structures Promotion Act, the costs of regulating mean and low water are borne by the Federation (Competence Ministry of Economy). Flood protection works are subsidized by Federal funds. Loans are granted for development and expansion of public ports.

Boundary waters and other waters under Federal authority (Federal rivers). The costs are borne in total or primarily by the Federation.

Torrent control and avalanche defense works. Hazard zone maps and projects are financed entirely via Federal funds. For all other measures the Federal contribution may be as high as 75%.

Other waters (waters of interested parties). Federal subsidies may be granted, depending on the type of measures that are planned.

Article 10 of the Austrian Constitution states that the Federation has powers of legislation and execution in matters of regulation and maintenance of waterways for safe diversion of floods or for shipping and raft transport.

Torrent control and avalanche protection are managed together with forestry in the Forestry Division of the Federal Ministry of Agriculture and Forestry. The Forestry-Engineering Service for Torrent Control and Avalanche Defense Structures is the authority at the next lower level and carries out its duties on site.

Matters pertaining to protective hydraulic engineering, with the exception of navigable waterways, have been assigned by ordinance to the Governors (the Laender). However, the Federation has reserved the right to issue directives and instructions. This coordinating supervisory tasks is carried out at a higher level by the Hydraulic Engineering Section of the Ministry of Agriculture.

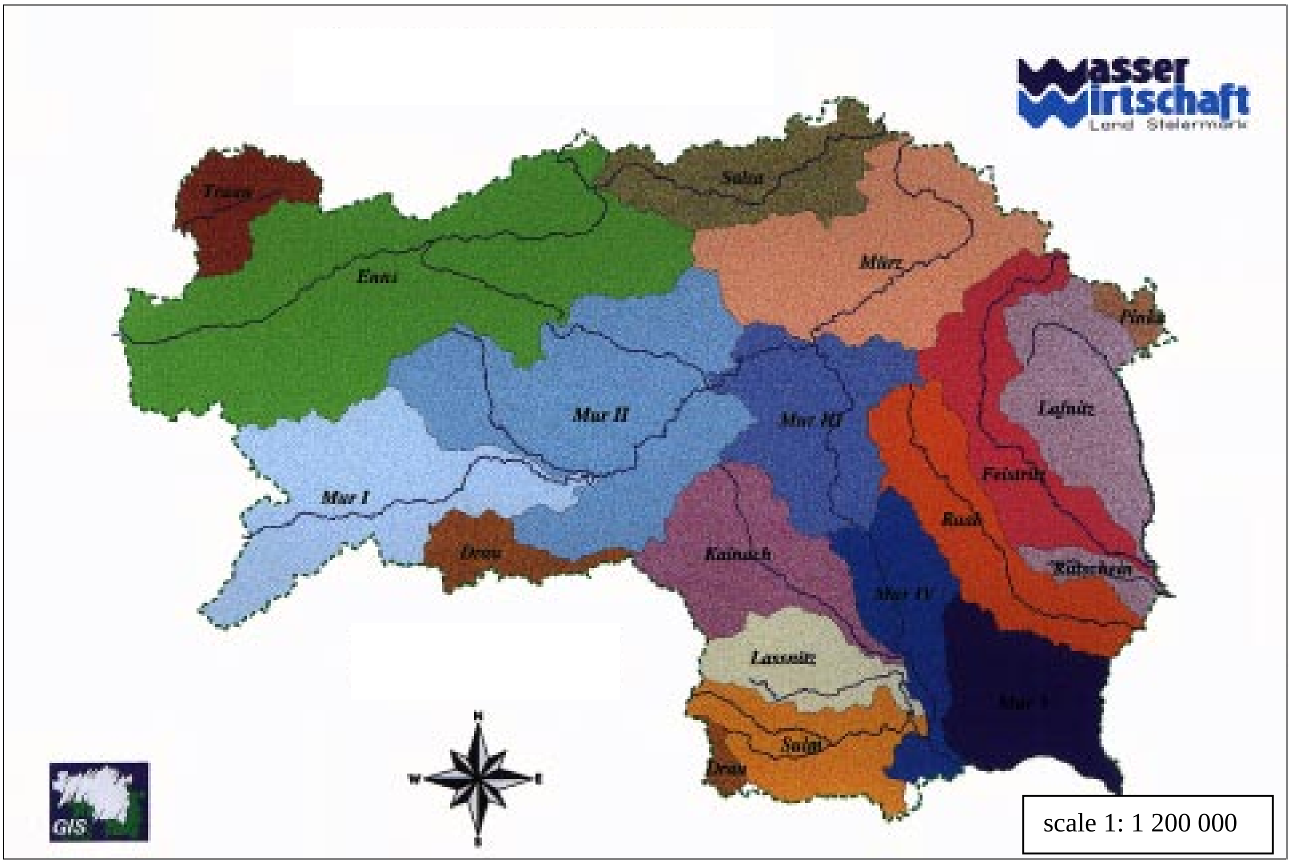


Figure 2.2.1.1 – River Basins in Styria

2.2.1.2 Italy (Tuscany)

National Law 183/89 - 18/5/1989 "Norms for the organization and functional realignment for the defence of soil" has the object to assure the defence of the soil, the cure of the waters, the correct use and management of the water resource for a rational, economic and social development, and for preservation of the related environmental aspects.

To reach such objectives, the national territory is divided in basins of national (Po, Adige, Arno etc.), interregional (Magra, Reno, Fiora, etc.) and regional significance, that define organic areas of study and intervention (Figure 2.2.1.2).

The operating tool within such hydrological homogeneous areas is represented by the Basin Plan, that constitutes the cognitive, normative and technical-operational base that programs the norms and actions for land use management and correct exploitation of territory in relation to the physical and environmental characteristics of the basin. Local administrations must respect the indications fixed in the Basin Plan especially regarding land use management.

Among the different sectors of intervention of the Plan, one part concerns hydraulic risks (its reduction, stability of the river beds and of the lowlands) and another one the hydrogeological risks (hydraulic-forestry arrangements, stability of the slopes and landslides).

The Law provides that planning and carrying out of interventions must be directed towards:

- defence, re-arrangement and regularization of the torrents,
- moderation of the floods events and reduction of the inundation risk,
- re-arrangement and conservation of the soil with hydraulic, hydraulic-forestry and forestry interventions.

Financial resources for the planned interventions are given by the State and are assigned by means of triennial programs of intervention for soil defence.

Figure 2.2.1.2 – Hydrographic network - Interregional and Regional basins of Tuscany according to National Law 183/89 and Regional Law 91/98

On the basis of D.P.C.M. (Government Decree) – 23/03/1990 concerning "Guidelines and co-ordination for the definition of provisional and programmatic plans for soil defence deriving from Art. 31 of the above mentioned Law 183/89", the preparation of these triennial programs of interventions is carried out on each basin with the collection of information about:

- Geology and geomorphology;
- Topography;
- Pedology;

- Erosion and sedimentation;
- Surface and underground water;
- Meteorology.

On the basis of these guidelines, the Regional Administration of Tuscany has recently issued Regional Law 91 - 11/12/98 "Norms for soil defence" concerning actions of soil rearrangement and defence". This Law identifies the basins of regional interest (Ombrone, Serchio, etc.), in which the Basin Plans must be drawn up. The Basin Plans shall contain the structural and non-structural interventions to be carried out concerning soil defence and water management and the prescriptions for land use management to which local management plans of territory (Provincial, Communal, etc.) must conform and should be fulfilled on the basis of medium-term plans (three years) of interventions. Local, regional, national or European funds guarantee the carrying out of the planned interventions.

For each basin, the regional law imposes the existence of four different institutional subjects:

- The Basin Council, which is composed by representatives of the Public Administrations within the basin. The Council co-ordinates and gives inputs during the preparation of the Basin Plan;
- The Technical Committee, which prepares the Basin Plan and an annual report about the use of soil;
- The General Secretary, which controls the work of the Technical Committee and updates the Regional Administration on the preparation and accomplishment of the Basin Plan;
- The Technical-operative Secretary's Office, which helps the Technical Committee in the preparation of the Basin Plan.

Regional Law 34/94 - 5/5/94 "Norms about Land Reclamation" underlines the importance of the reclamation activity as an enduring way for development, conservation and exploitation of agricultural productions, defence of soil, control of waters and conservation of the environment and of natural resources.

The regional territory is divided into Reclamation Districts, which correspond to one or more hydrographic basins, where, Land-Reclamation Syndicates, on the flood-plains, and Consortium of Mountain Communes, on hillsides and mountain areas, carry out the planning, construction and management of reclamation works and soil defence.

The reclamation activity is carried out according to the indications of a general Plan of Reclamation that fixes the intervention guidelines in the reclamation districts, determines which reclamation works of public interest must be accomplished and their order of precedence. It also includes the improvement interventions of landed property to be put in action by private landowners.

A proposal for the general Plan of Reclamation is prepared by each Land-Reclamation Syndicate or Consortium of Mountain Communes. The local administrations (Communes and Provinces), in accordance to their own territorial plans, can give their indications or observations to the proposed plan. Finally, the Regional Admistration of Tuscany, in relation to the indications and observations coming from the local administrations, and the River Basin Authority approves the Plan of Reclamation of each Reclamation District.

The interventions planned for land reclamation actions are represented, concerning the defence from hydraulic risk, by the following typology of works:

- water control and regulation of the river;
- arrangement of the slope;
- stabilization of landslides;
- erosion control;
- agricultural-hydraulic works.

Land-reclamation Syndicates design, carry out, manage, control and maintain the interventions foreseen in their Land-reclamation Plan, but they also manage, control and maintain the public hydraulic structures that were built in their district before the institution of the Syndicate.

Financial resources of the Land-Reclamation Syndicates derive from regional contributions and from the payment of annual consortium contribution by the estate owners. Furthermore, the estate owners have to pay an extra contribution (at the most 25% of the work cost) for construction of reclamation structures that give a direct benefit to their property.

2.2.1.3 Portugal

Water resources legislation has evolved over time, reflecting the priorities of different generations, becoming sometimes disperse and inconsistent. The oldest legal documents still in use are the regulations of the Hydraulic Services, formulated in 1892, and the Water Law, dating from 1919. Afterwards, a stream of legal procedures, following and adapting these basic laws have been implemented, e.g., Water Public Domain and Adjacent Zones [Decree-Laws (DL) 468/71 and 89/87], Reservoirs and Surrounding Areas (DL 2/88 and 37/91), Civil Protection and Emergency Planning Legislation (Law 113/91), Dam Safety (DL 11/90), "Basic Law for the Environment" (Law 11/87), "National Ecological Reserve (REN)" (DL 93/90), "Environment Impact Assessment (EIA)" (DL 186/90), "Agricultural National Reserve (RAN)" (DL 196/89), among others.

In 1994, provided a solid framework for interconnecting water resources planning and sectorial requirements was provided by a package composed of three Decree-Laws (Decree-Laws no. 45/94, 46/94 and 47/94).

Decree-Law 45/94 aims to establish the valorization, protection and balanced management of national water resources, ensuring the harmonization between sectorial and regional development through the economy of its employ and rationalization of the uses. Decree-Law 46/94 establishes the licensing regime of public hydric domain utilization. Decree-Law 47/94 establishes the economic and financial regimes for public hydric domain use.

The legal obligation of preparing 15 river basin plans (PBH's) (Figure 2.2.1.3), covering the contineta1 territory, the National Water Plan (PNA) and a complete review of the licensing procedures for all uses of the "water domain" are the most important aspects of this new legislation for flood control and flood plain management.

The Water Institute (INAG) of the Ministry of Environment is responsible for the National Water Plan and for the four major international watersheds, namely, Minho, Douro, Tejo and Guadiana. The Regional Directorates of the Ministry of Environment (DRA) are preparing the remaining eleven basin plans, which are Lima, Cávado, Ave, Leça, Vouga, Mondego, Lis, Oeste, Sado, Mira and Algarve.

River Basin Plans must consider the following topics: i) diagnosis, ii) definition of short, medium and long-term objectives, iii) proposed actions, alternative scenarios and priority definitions, iv) physical, financial and institutional implementation of the proposed actions.

The National Water Council (CNA), under the direct presidency of the Minister of Environment, supervises the water resources policy, in Portugal. Each one of the fifteen national river basins has its own River Basin Council (CBH) chaired by the President of INAG.

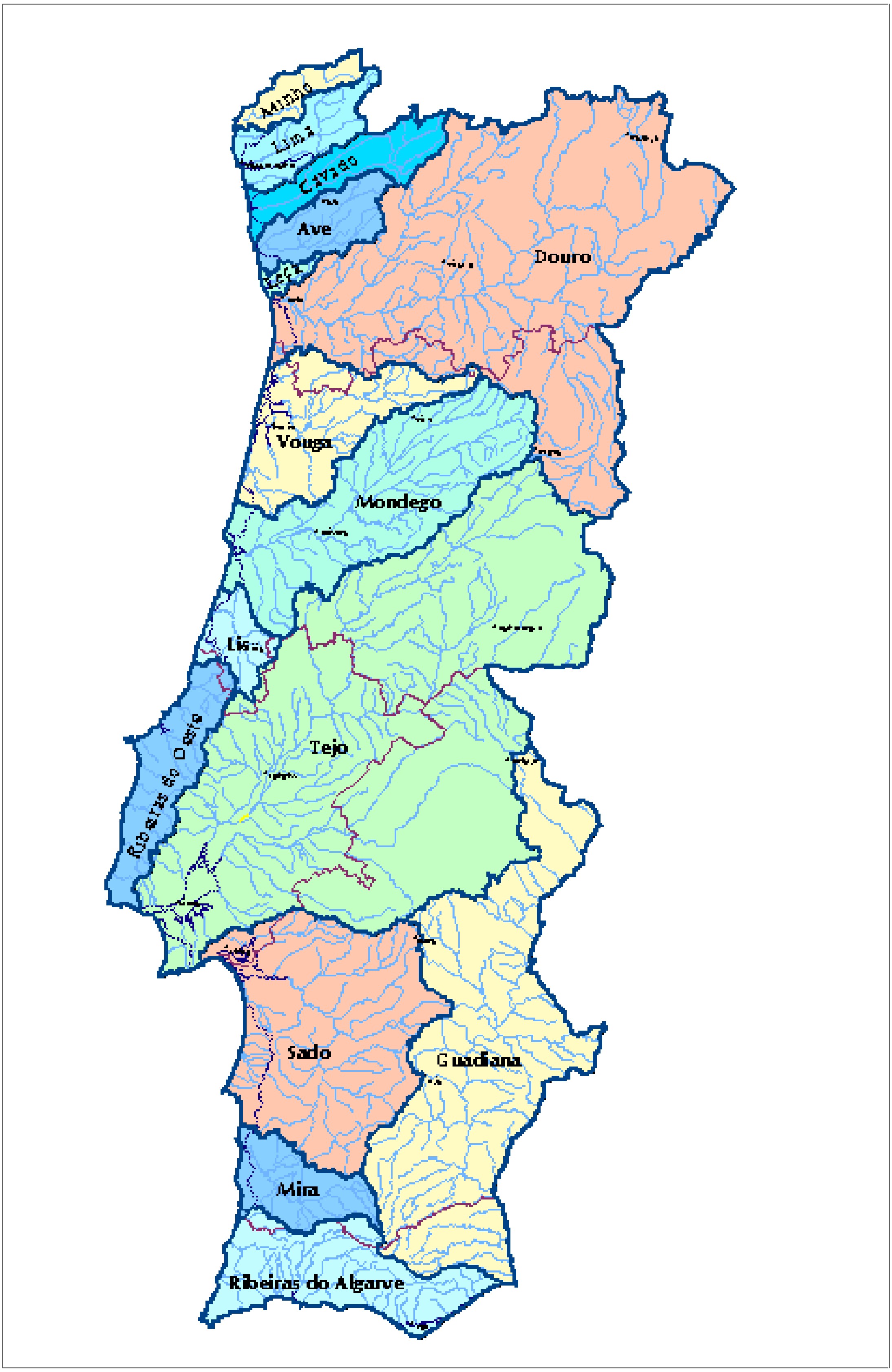


Figure 2.2.1.3 - River Basin Plans in Portugal

2.2.2 Agricultural and Forestry Legislation

2.2.2.1 Europe

The rural areas of the European Union, characterized by their diversity - countryside, culture and traditions - account for more than 80% of its territory and more than a quarter of its population.

Rural areas are nevertheless facing several problems such as decline in traditional agricultural activities, exodus from rural areas, remoteness of some areas and weakness of infrastructure and basic services.

On 30th June 1960, the European Commission tabled the proposals for the creation of a Common Agricultural Policy (CAP). On January 1962, the general orientations of CAP were introduced, built upon three pivotal principles: market unity, Community preference and financial solidarity. The objectives of CAP, set out in Article 39 of the Treaty of Rome, were: i) increase productivity; ii) ensure a fair standard of living for the agricultural Community; iii) stabilize markets; iv) assure food supplies; v) provide consumers with food at reasonable prices.

The identification of the specific needs of rural areas, in 1988 and reinforced in 1993, gave rise to "a specific rural development policy with defined objectives, principles, instruments and financial means". The Cork Declaration, presented in November 1996 in a major European conference on rural development, calls for the sustainable rural development in all rural areas and introduces more subsidiarity, simplification and integration in relation to the different measures available to support rural development.

The recognition and acceptance that, while farming remains a key economic activity in rural areas, it is necessary to promote new economic activities and new sources of income in these areas, is a basis for the EU commitment to rural development. The specific contributions of the Community to assist rural development considers: a) structural funds programs (regionally targeted assistance, horizontal measures and Leader initiatives), b) accompanying measures of the CAP (helping the farming community to the consequences of the changes in the market regimes and to provide new sources of income), c) other policies related to forestry, d) environment, agriculture, forestry and rural development research, e) conservation, characterization, collection and utilization of genetic resources in agriculture.

In July of 1997, the European Commission published the document “Agenda 2000” which illustrates guidelines and strategies of the European Union for the period 2000 – 2006. In March of the following year, the Commission presented the proposals of regulations for structural funds which are based on three objectives: a greater concentration of aid, a more simplified and decentralized intervention on structural funds and a reinforcement of their effectiveness and of control.

From these documents, rural areas assume a growing importance in the safeguard of the environment and in recreational activities; this will probably impose further adjustments to agricultural activities that still represent the most widespread use of territory. It is therefore clear that in the years to come agricultural-environmental instruments will acquire a fundamental role in the promotion of a sustainable development of rural areas and for the satisfaction of an increasing demand for services in the environmental field.

The most important European Regulations and Directives in force in agriculture and forestry that have a direct influence on territorial management in relation to flash floods, are:

- Council Directive 75/268/EEC on less-favoured areas;
- Council Directive 85/337/EEC, 96/61/EEC and 97/11/EEC on the assessment of the effects of certain public and private projects on the environment;
- Council Regulation (EEC) 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs;
- Council Regulation (EEC) 2078/92 on agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside;
- Council Regulation (EEC) 2080/92 instituting a Community aid scheme for forestry measures in agriculture;
- Council Regulation (EEC) 2081/93, which amends Council Regulation (EEC) 2052/88, on the tasks of the Structural Funds and their effectiveness and on coordination of their activities between themselves and with the operations of the European Investment Bank and other existing financial instruments;

- Council Regulation (EEC) 950/97 concerning the improvement of the efficiency of agricultural structures;
- Community Initiatives (EEC) LEADER I and LEADER II concerning integrated programmes of rural development;
- Community Initiatives (EEC) INTERREG II “Laying down guidelines for operational programmes which Member States are invited to establish in the framework of a Community Interreg initiative concerning transnational cooperation on spatial planning”;
- Council Regulation (EEC) 1257/1999 on support for rural development from the European Agricultural Guidance and Guarantee Fund (EAGGF) and amending and repealing certain Regulations.

2.2.2.2 Austria (Styria)

The Styrian Soil Protection Act of 1987 envisages measures to achieve a balanced soil moisture regime, taking into consideration both the preservation of water resources and the protection of the soil against the action of water, especially erosion.

The Forestry Act, a piece of federal legislation, envisages the following forestry development planning measures for the regulation of the water regime: the extension of forestry-covered areas must be such that the protection against harmful environmental effects, soil erosion due to the action of water and landslides may still be guaranteed. Their balancing effects on climate, water regime and the cleaning and regeneration of waters must be preserved and enhanced.

Forestry development planning must also cover the identification of danger zones in the water basins (danger zone maps). The issuing of such maps lies in the province of the federal minister. The issuing of danger zone maps and the task of precisely describing all single danger zones according to the type and extent of potential danger was introduced in 1976 by a decree of the Federal Ministry of Agriculture and Forests.

In the water basin of certain torrents, to be indicated in a decree issued by the head of the regional government, the authorities will prescribe the cultivation of specific cultures.

2.2.2.3 Italy (Tuscany)

Royal Decree-Law (RDL) 3267/1923 "Rearrangement of legislation about woods and mountainous areas" is the main law for hydro-geological protection of the soils. Hydro-geological obligations apply only to certain defined areas, delimited by the law, that are mainly situated in the hills and mountains.

The main restrictions of the hydro-geological obligations are:

a) Prohibition of transformation of woods and not cultivated land into other crops without authorization of Provincial Administrations;
b) Regulation of forestry and pasture use according to the Directives of each Provincial Administration.

This same Law provided for the works of torrent control and slope rearrangement of areas subjectd to Hydro-geological obligations in mountain catchments. Extensive works of reforestation and torrent control were State financed and carried out by the Forest Corps up to the late ’70’s when these competencies were transferred to the Regions.

In relation to the transfer or forestry competencies from the State to the Regions, some Regional Administrations have issued laws which complete the national policy. In Tuscany, Regional Law 1/90 “Transitory norms for the safeguard of woods” integrates RDL 3267/23 establishing that the regional wooded areas must be subjected to hydrogeological obligations. Therefore, these areas are automatically subjected to the provincial Directives. Furthermore, this regional Law fixes criteria for cutting of woods, transformations of woods and pastures, and all sort of terrain movement.

Regional Law 10 - 23/01/89 "Norms for the administrative duties in agriculture, forestry, hunting and fishing" redefines administrative competencies in these matters between the Regional admistration and local administrations. In particular, this law confirms that Provincial Administrations are in charge of the hydrogeological obligations (RDL 3267/1923) and all the prescriptions and controls concerning hydraulic-forestry management of woods and pastures.

The preparation of interventions for forestry rearrangement (reforestation, etc.) and the planning, construction, management, and maintenance of the public hydraulic-forestry interventions in the mountainous and hilly basins are delegated to the Consortium of Mountain Communes, on montain areas, or to the Land-Reclamation Syndicates (LR 34 - 5/5/94), on the flood-plain areas.

2.2.2.4 Portugal

The Agrarian Development Basis Law (86/95 of 1 September) considers in Article 2 that the agrarian development policy is based on three general principles: multi-functionality of agriculture (whilst an economical activity with an important impact on social, environmental and rural soil occupation), equity on production conditions in the communitarian area and protection of areas affected by permanent natural disadvantages.

Decree-Law 196/89 of 14 June, altered by Decree-Law 274/92 of 12 December, defines the National Agricultural Reserve (RAN) and establishes the areas which morphological, climatological and social characteristics present higher potential for the production of agricultural goods.

Soils included in the national agricultural reserve (RAN) must be exclusively affected to agriculture and all actions that decrease or destroy its agriculture potentialities are forbidden. The agriculture activities in RAN soils deserve special treatment in all instigation and support from public entities.

Decree-Law 139/89 of 28 April establishes the actions exposed to municipal authorization and considers a sanctionary system against illegal actions. All the actions that destroy vegetal covering and that do not have any agricultural purpose and all the actions of embankment or digging that alter natural and arable soil stratum relief need municipal licence.

The agricultural activity is more exposed to risk than any other economical activity and among these, meteorogical risks play an important role. Decree-Law 395/79 of 21 September, reviewed by Decree-Law 283/90 of 18 September, created the crop insurance, to guarantee farmers profit stability. Decree-Law 326/95 of 5 December establishes an Integrated Protection System against Climatic Aleatorities composed by a crop insurance, a disaster found and a damage compensation. Crop insurance is an agricultural investment incentive and contributes to guarantee farmers profit stability, and also works as an agricultural policy instrument in view of a correct crop planning. It warrantees the defence of fire, ray, explosion and hail risks and, as complementary insurance, tornado, rainfall, frost and fall of snow risks.

Woods, as a natural renewable resource are important not only for economic reasons, but also for its whole in the protection of the biodiversity, in the equilibrium of climatic conditions and as a fixation factor of population.

The Portuguese forests occupy about 36.5% of the national territory. The major fraction is located in the interior mountain areas of the country and, lately, it has acquired importance as a factor of regional development and fixation of population.

In Portugal, there was not a global nor coherent policy about defence and development of the forest, neither a co-ordination among different departments with attributions or interests on this subject. In fact, there was a variety of separated legislation without a guiding line. This line should be the support of forestry management and, at the same time, an instrument of forestry defence against adverse human activities.

The social, economical and environmental importance of forest, its irregular evolution, the danger of forestry fires and the increase of the desertification process and erosion of extensive forestry areas were finally faced with the approval of the Law 33/96 of August 17. This law defines the bases of forestry policy and establishes the following objectives:

- promote and guarantee a sustainable development of forestry spaces and the set of forestry activities;
- promote and guarantee the access to social use of forests, promoting and encouraging the harmonization of multiple functions and protecting their scientific, cultural and landscape features;
- guarantee the increase of global income of farmers, producers, and users of forestry systems as a contribute to the socio–economic equilibrium of the rural world;
- optimize the use of the productive potential of forestry goods and services and of its associated natural systems, regarding its multifunctional values;
- promote the management of the national forestry heritage by the management of forestry explorations and the dynamization and support of associations;

- guarantee the essential role of the forestry in the regularization of water resources, in the landscape and air quality conservation and in the control of erosion and physical and human desertification;
- guarantee the protection of forestry formations with special ecologic importance and sensitivity, namely fragile mountain ecosystems, dune systems, cork plantations and riparian formations;
- guarantee the protection of forests against biotic and abiotic agents (namely fires);
- encourage and promote scientific and technologic research in the forestry domain.

2.2.3 Ecological and Environmental Legislation

2.2.3.1 Europe

Article 175 of the Treaty establishing the European Community, as amended on 7 February 1992 and last modified by the Amsterdam Treaty, establishes the integration principle of environmental policy: "Environmental protection requirements must be integrated into the definition and implementation of other Community policies".

Water policy cuts across other policies. Hence, environmental policy requirements must be integrated into the formulation and implementation of a water policy on one hand. On the other hand, the requirements of water resource protection - part of environmental policy - must be integrated into other policy areas. The environmental integration principle is thus bi-directional.

The institutional scheme of the partners countries foresees two or in some cases three different levels of legislation for the territorial management:

- European regulations;
- National Laws;
- Regional Laws.

The ecological and environmental legislation has mainly covered the following areas:

- Nature Conservation
- Water quality
- Air quality
- Waste management
- Noise
- Chemical products.

In this Section, only the Nature Conservation area is covered, since it is the only one that deals with aspects directly related to the protection against flash floods.

The European Union Nature Conservation Legislation contains two principal Directives. These directives concern the protection of natural habitats in the European Union Habitat Directive (92/43/EEC) and the flora and fauna which inhabit them Birds Directive (79/409/EEC). While the former tries to have a wider approach by establishing a coherent European ecological network called "Natura 2000", the latter has a specific scope.

The “Habitat Directive” aims to establish a “favourable conservation status” for habitat types and species selected as being of EU interest. This is defined broadly for both habitats and species by reference to factors such as species population dynamics, trends in the natural range of species and habitats, the area of remaining habitats and the proportion in a Member State.

Apart from the habitat protection, Directive 92/43/EEC also provides for the strict protection of certain species of plants and animals. The species are grouped in Annexes which give different levels of protection status according to their ecological needs. This prohibits deliberate collection, capture or killing of species at any stage in their life cycle or the deterioration or destruction of breeding sites or resting places.

The “Birds Directive” protects wild bird species and sites of importance for the maintenance of populations of wild birds. It establishes a scheme for the protection of migratory birds and their habitats.

As for “Habitat Directive”, the sites protected under the Birds Directive (79/406/EEC) are also included in the "Natura 2000" network (Figure 2.2.3.1)

This Network includes:

- the Special Areas of Conservation (SAC's): the sites hosting the natural habitat types and the habitats of species to be designed under the Habitat Directive;
- the Special Protection Areas (SPA's): the habitats of listed vulnerable species as well as migratory species are classified according to the Birds Directive.

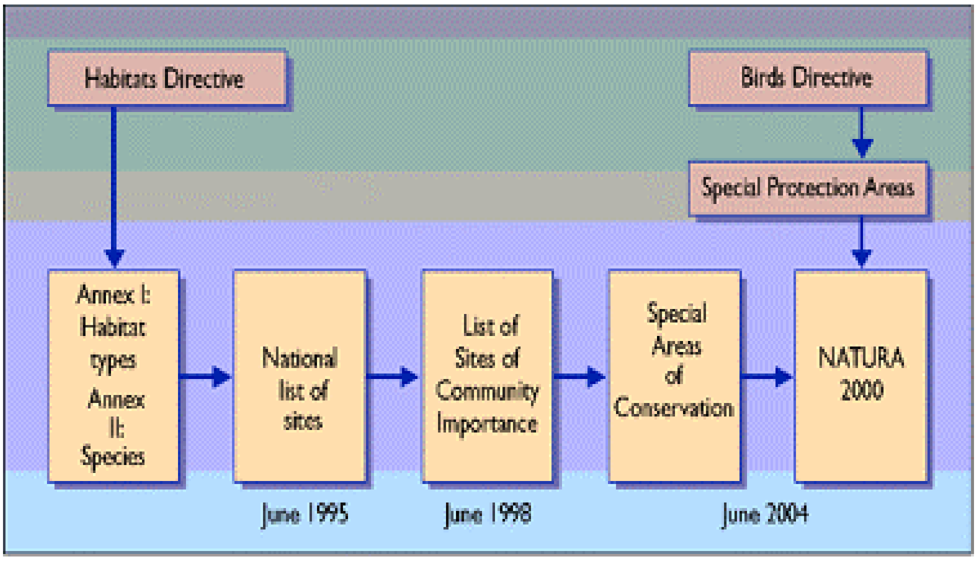


Figure 2.2.3.1 – "Natura 2000" network

2.2.3.2 Austria (Styria)

The Styrian Act on Environmental Protection of 1976 regulates environmental safeguard, landscape protection and upkeep, conservation and organization of the environment seen as a vital resource and habitat for human beings, plants and animals. Besides envisaging general protection measures, which have to be complied with in any kind of undertaking, the Act establishes that specific projects (for example the building of a dike or a petrol station) must be denounced.

Furthermore, special protection measures are laid down for areas such as natural reserves and protected landscapes that have a particular interest because of their exceptional character. For a large number of undertakings in such areas, a legal permit is required.

Protected areas are established as such by the authorities as a result of a relevant procedure. The mode of the procedure, the marking of the area, eventual indemnities and sanctions are also regulated by law.

For the implementation of regulations, environmental protection appointees have to be chosen, one at regional level and one in every political district.

Figure 2.2.3.2 shows nature and landscape protection regions and Special Areas of Conservation (SAC's) in Styria - 92/43/EEC and 79/409/EEC Directives).

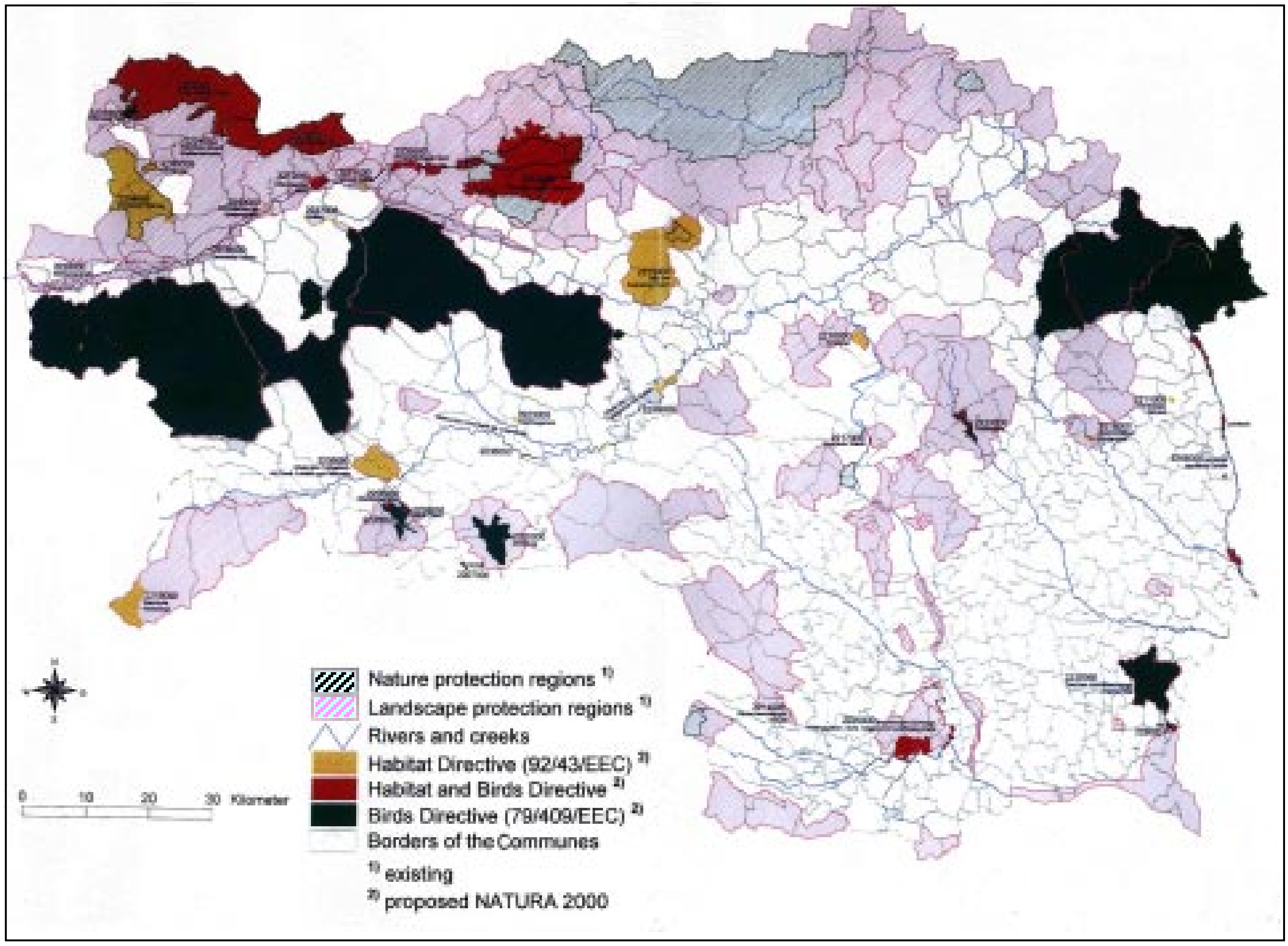


Figure 2.2.3.2 - Nature and landscape protection regions and Special Areas of Conservation (SAC's) in Styria - 92/43/EEC and 79/409/EEC Directives.

2.2.3.3 Italy (Tuscany)

Italy has put the Habitat Directive 92/43 into effect by accomplishing the so called Bioitaly project by means of collaboration of the Ministry of Environment with the different Regions.

The Bioitaly project has made a census of national sites of habitats with a particular value and of the areas where species of Community interest exist, also compiling a data base with this information. By the end of 1996, the project had listed 133 SAC's of Community interest, which also comprised SPA's, that the Ministry of Environment indicated to EC for inclusion in the Natura 2000 network, besides listing 22 other sites of particular interest (7 of national level and 15 of regional level) not included in the SACs (Figure 2.2.3.3 a).

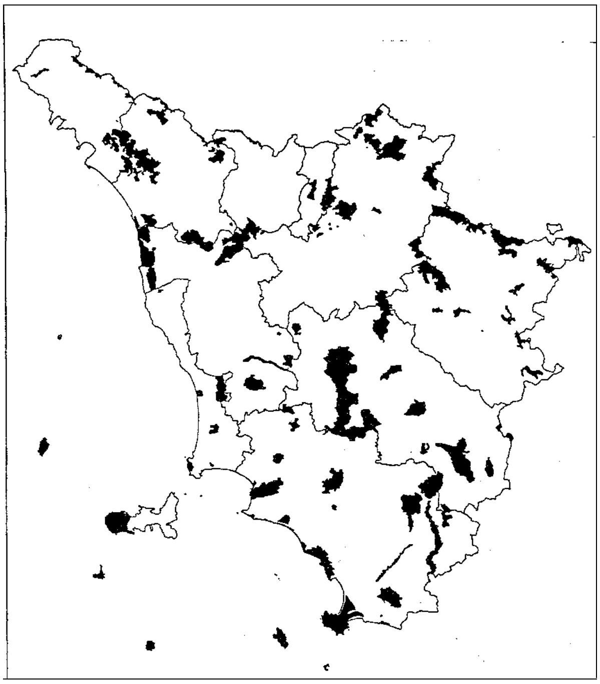
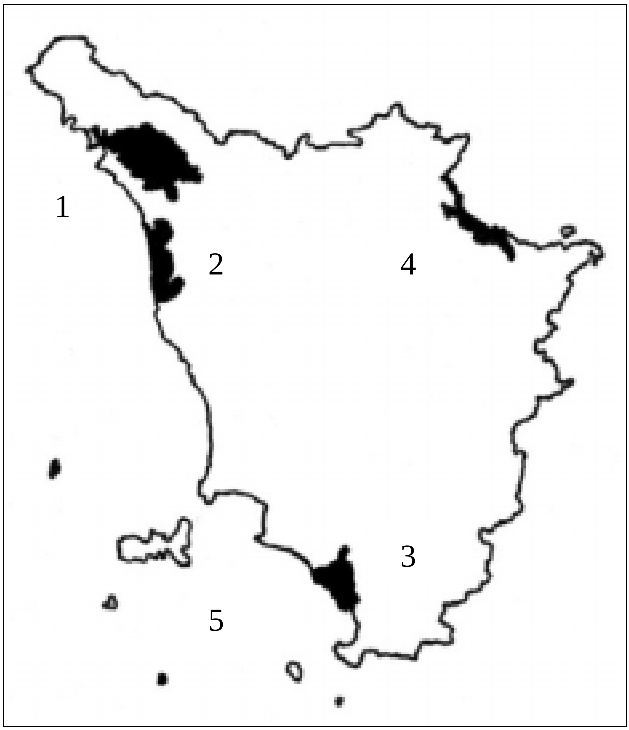


Figure 2.2.3.3 a - Special Areas of Conservation (SAC’s) of Tuscany - 92/43/EEC and 79/409/EEC Directives.

Regional Law 49 - 11/4/95, in accordance to National law 394 - 6/12/91, establishes criteria for the institution and management of regional and provincial parks, wildlife reserves and areas of natural protection of local interest. These laws provide for the creation of specific Entities called Park Authorities, which must always be consulted by the Institutions (Regions, Provinces, Communes, Consortium of Mountain Communes, River Basin Authorities and Land Reclamation Syndicates) when dealing with any type of intervention on their territory.

In the following figure, the national and regional parks of Tuscany are shown (Figure 2.2.3.3 b).



1- Regional Park of “Alpi Apuane”

2- Regional Park of “Migliarino San Rossore - Massaciuccoli”

3- Regional Park of “Maremma”

4- National Park of “Foreste Casentinesi - Monte Falterona – Campigna”

5- National Park of “Arcipelago Toscano”

Figure 2.2.3.3 b – National and Regional Parks in Tuscany.

In addition to the previous laws concerning Nature Conservation the two following Decrees fix specific criteria for ecological protection of river beds, in the planning and construction of structural interventions:

- Decree of President of the Republic (DPR) - 14/04/93 "Co-ordination of regional legislation for fixing criteria and guidelines in planning of hydraulic and forestry maintenance actions" establishes the typology of structures that can be put in practice in order to protect or recreate the natural habitats along the national hydrographic networks, to guarantee the hydraulic efficiency of torrent sections and to prevent the formation of hydraulic risk conditions along urbanized torrent stretches of water courses.

The law concerns all the typologies of intervention both in the torrent bed and along the banks and, in particular:

- Removal of wastes and vegetal materials that represent an obstacle to high flow during floods with return time periods of 30 years, yet maintaining natural riparian habitats;
- Renaturization, applying bioengineering works that guarantee bank protection and the formation of new riparian habitats;
- Rearrangement of hydraulic cross sections, with the distribution or removal within the bed, of sediments that represent an obstacle during high flows;
- Reshaping and protection of banks with blocks; substitution of destroyed gabions with blocks;
- Re-establishment of an efficient cross section in covered torrent stretches (bridges, underground passages, etc.) by removal of sediments;
- Increase of stability of slopes along river courses with use of bioengineering works.

Rearrangement and maintenance of torrent are carried out by the Consortium of Mountain Communes, Land-Reclamation Syndicates, Communes or by private landowners, depending on who is in charge of that particular torrent stretch.

- Regional Council Decree (DCR) 155 - 20/5/97 "Planning criteria for hydrogeological defence structures". Following the indications of the above mentioned D.P.R. 14/04/93, it establishes rules and principles about soil defence action favouring the use of bioengineering techniques.

New interventions must respect the environment as much as possible. In fact, in preliminary planning phases, new environmental-friendly structures (bioengineering works) must be preferred to the traditional ones wherever it is technically possible to do so.

DCR 155/97 indicates different typologies of bioengineering works that should be used in the following fields of application:

- Propping up structures;
- Slope stability and protection;
- Bank protection and water course management;
- Hydraulic transversal works.

Concerning longitudinal transversal works, bioengineering structures must be carried out in water courses that have a small-medium drainage basin. Along larger courses, bioengineering works must be adopted only when the hydraulic safety conditions are guaranteed.

Furthermore, the Regional Decree establishes that the substitution or integration of pre-existing structures has to be made through environmental-friendly works.

Finally, it establishes a series of interventions that, as a rule, must not be carried out:

- Concrete hydraulic structures without mitigation works;
- Cliffs made with stones or gabions without cuttings;
- Lining of torrent bed;
- Covering of water courses;
- Modification of natural water courses;
- Complete destruction of the riparian vegetation.

2.2.3.4 Portugal

The most important regulation about Nature Conservation is DL 19/93 of 23 January. This regulation establishes Network of National Protection Areas. These areas can be classified as being of National, Regional or Local interest, depending on the meaning of the values to preserve.

The protection areas of national interest should be preserved in the following categories:

a) National Park (PNac)
b) National Reserve (RN)
c) Natural Park (PN)
d) Natural Monument

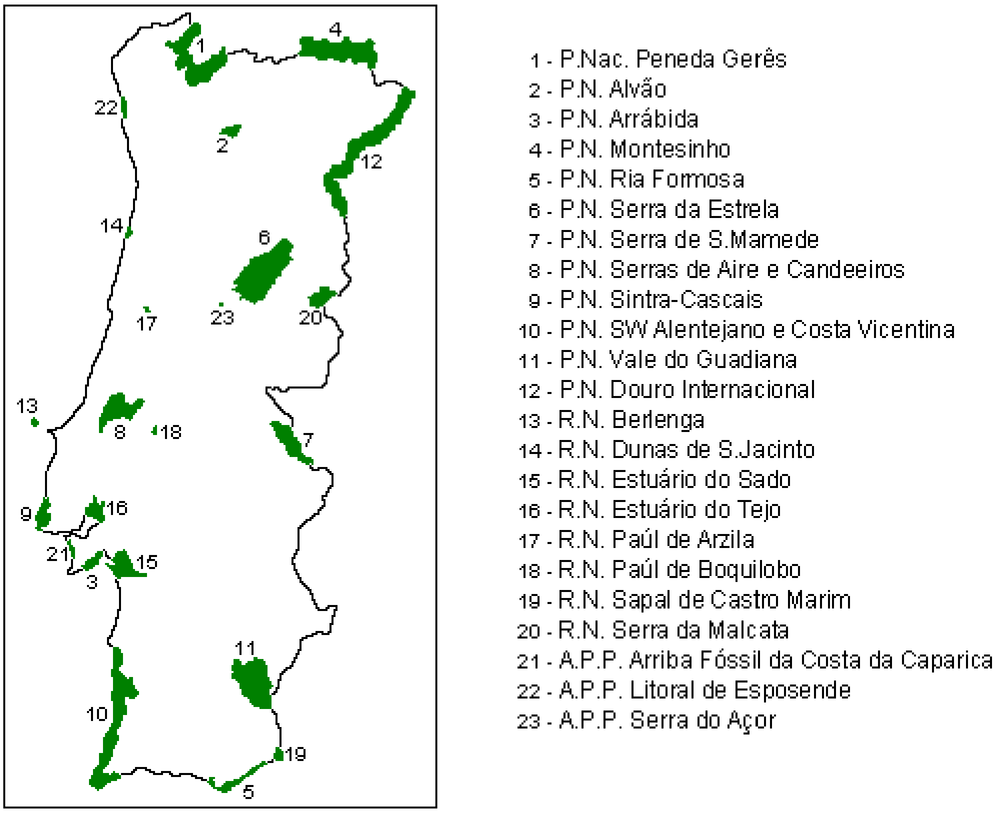


Figure 2.2.3.4 – Protected Areas of National Interest in Portugal

The protected areas of regional or local interest are designated as Protection Landscape (APP)(Figure 2.2.3.4). The protected areas with private status are designated as Biologic Interest Site.

2.2.4 Land Use and Urban Planning Legislation

Flood risks can be aggravated in urban areas when artificial changes to natural drainage networks, such as obstructions in the floodplains, extended impermeable areas and storm sewers with limited capacity are built. Also, most probably in this case, the costs of both human and material damages increase sharply due to the concentration of resources generally associated with an urbanization process. Thus a correct land use and urban planning turn out to be the principal instruments for prevention and mitigation of damages associated with flooding.

2.2.4.1 Europe

According to the “European Chart for the Management of the Territory”, approved in 1984 by the European Conference of Ministers of Environment and later approved by the European Council, “Territory management is the spatial expression of economical, social, cultural and ecological policies of the society ….. it is also a scientific discipline, an administrative technique and a policy, developed on an inter-disciplinary perspective and integration, towards a balanced region development and a physical spatial organization, according to a whole strategy."

The European territory management, as a supranational search for solutions, aims to the creation of a common identity, considering North-South and East-West relations.

The principal objectives of territory management are:

- socio-economical development of regions, attempting the contention of super-populated regions or regions where development occurs in a very fast way, encouraging the less evoluted areas;
- improvement of life quality, allowing a fine space use;
- responsible management of natural resources and environmental protection, as a way of minimizing the conflicts between the growing demand of natural resources and the need of its conservation;
- rational territory use, aiming a responsible management of the environment, the soil and subsoil resources, air and water, energetic resources, fauna and flora, landscape and patrimony;
- territory management objectives fulfil, in view of an inter-disciplinar coordination and integration and of the cooperation among all the implicated organizations;
- coordination among the different sectors, namely refering to the population, the economical activities, the equipments, the transports and the sanitation distribution;
- coordination and cooperation among the different levels of decision and financial resources acquisition in such a way that ensures the optimized coordination of local, regional, national and European levels;
- participation of the citizens who must be clearly and comprehensively informed of all planning process phases.

The European Chart is a document that establishes the general objectives of territory management. It aims at the regarding of the principles and established objectives and the promotion of an international cooperation, essential to a true management of the European territory.

2.2.4.2 Austria (Styria)

In Styria, regional policy regulations are contained in the Styrian Regional Policy Act of 1974 and the relevant decrees. The Act attributes competences to the Land at the regional level and to the Communes at the local level.

The objective of land use planning at the regional level is to work out development programmes, evaluate relevant measures, give advice and assistance for planning and regional initiatives and represent planning interests at the level of the EU and the federation and with neighbouring regions.

Instruments at the regional level are: the Regional Development Programme, the Development Programmes for specific fields and the Development Programmes referring to specific areas.

Land use planning at the local level covers questions and projects that are entirely or predominantly in the interest of a commune. Higher rank plans, i.e. regional or federal ones, have to be taken into consideration. Furthermore, the land use planning activity of the communes is subject to inspections by the authorities of the Land.

Instruments at the local level are: the Local Development Framework, the Land Use Plan and the Construction Plan. Individual authorization procedures are not envisaged in the Styrian Regional Policy Act. The implementation of obligatory local and regional programmes is therefore regulated by other laws (e.g. the Styrian Building Act).

2.2.4.3 Italy (Tuscany)

Regional Law 5 - 16/1/95 "Norms for the management of the territory" provides indications for the management of the territory, creating a new way of planning and acting that, articulated in an organic sequence, can guarantee the development of human activity on the territory side by side with the respect of the natural resources and protection of people from natural risk conditions. It determines that the most important aspect to be considered in laying out the Town Planning Plans is the protection of the settlements from inundation or landslide risks. The procedure involves different administrations and foresees the following sequence:

- The Regional Administration draws up the Plan of Territorial Direction (PIT) which contains policies concerning the use and conservation of resources, by identifying territorial systems on the basis of economical, social, cultural and morphological aspects and points out particular installations of regional interest (airports, harbours, highways, natural parks, etc.) and peculiar sites by setting environmental and landscape priorities. The policies estabilished in the PIT must be adopted by the provincial Plan of Territorial Coordination (PTC);
- The Provincial Administration is responsible for the Plan of Territorial Coordination (PTC) which constitutes the link between the territorial Regional policies and the local Town Planning Plans. It identifies the territorial resources and fixes the objectives of territorial planning on a provincial level, particularly concerning: principles for the respect of natural resources, prescriptions on the environmental and landscape priorities, public interventions of provincial competence (main roads, lifelines, etc.). The PTC gives indications and sets bonds for the preparation of the municipal Town Planning Plan (PRGC);
- The Communal Administration draws up the Town Planning Plan (PRGC) which represents the planning instrument with which the communal territory is managed. It contains the detailed indications for urbanistic and infrastructural development of the communal territory and of the environmental and landscape priorities.

The preparation of these territorial plans is carried out analysing risk conditions of the territory and these are presented in detail in the local administrative Town Planning Plan, following the prescriptions given by DCR 94 - 12/2/85.

Decree of Regional Council (DCR) 230 - 21/6/94 "Measures to prevent hydraulic risk" constitutes a fundamental law in the hydraulic risk protection of urbanized areas. It aims to the conservation of the public interest, particularly the prevention of damages produced by phenomena of flooding and stagnation.

The Decree fixes boundaries of hydraulically homogeneous areas in relation to certain distances from the rivers concerning the construction of buildings and the management of the Town Planning Plan by establishing prescriptions, restrictions and directives.

In detail, the construction of buildings and other interventions that require public authorizations are subjected to different types of hydraulic risk limitations, which consist in the following respect areas parallel to the torrent bed:

- A1 area - comprehends the torrent bed and its banks, if present, plus a buffer area 10 meters wide on each side. In this area, any kind of intervention of construction of new buildings or morphological changes is forbidden. The only permitted interventions are hydraulic works, crossing structures, water derivations, etc. that do not increase the hydraulic risk conditions of the torrent bed;
- A2 area – only for torrents with a width larger than 10 meters. These are additional areas, outer to the A1 area and running along each side of the torrent, that have a width equal to the one of the torrent bed with a maximum of 100 meters. In these areas, new buildings and structures can be carried out only if the hydraulic safety is certified (the law does not specify any return time flooding period for the hydrological-hydraulic analysis of these areas).

Concerning, instead, the preparation or modification of Town Planning Plans, the law fixes an A1 area identical to the one above and a B area, only for river courses that present particular problems of hydraulic risk, defined as follows:

- B area - an external area to the A1 area, that includes surfaces along each side of the water course that have an elevation lower than 2 meters above the brink of the torrent levee (or external foot of artificial banks) with a maximum extension of 300 meters width. In this area, the Town Planning Plan requires that the construction of new buildings and structures can be made only if the hydraulic safety is certified by carrying out a hydrological-hydraulic analysis of the torrent considering a return time flooding period of, at least, 100 years. Concerning the preparation of new Town Planning Plans, for the hydraulic safety of that territory, a 200 years return time period must be considered.

Regarding the hydraulic risk of the areas outside the previous limits, the Regional Decree establishes the following four different hydraulic risk levels, on the basis of the morphological safety of territory and the occurrence of historical flood events, that must be considered in the preparation of municipal Town Planning Plans:

- Level 1 irrelevant risk
  Areas on hills and mountains that have the following characteristics:
  a) no record of flood events;
  b) elevation higher than 2 meters above the brink of the torrent levee (or external foot of artificial banks).
  - no measures are required for the reduction of hydraulic risk.

- Level 2: low risk
  Floodplain areas that have the following characteristics:
  a) no record of flood events;
  b) elevation higher than 2 meters above the brink of the torrent levee (or external foot of artificial banks).
  - no measures are required for the reduction of hydraulic risk.

- Level 3: medium risk
  Flood plain areas that have either one or the other of the following characteristics:
  a) record of flood events;
  b) elevation lower than 2 meters above the brink of the torrent levee (or external foot of artificial banks).
  - reduction of hydraulic risk is required, although without the definition of specific measures.

- Level 4: high risk
  Flood plain areas that have both of the following characteristics:
  a) record of flood events;
  b) elevation lower than 2 meters above the brink of the torrent levee (or external foot of artificial banks).
  - specific measures must be taken for the reduction of hydraulic risk risk considering a return time period of 100 years.

Decree of Regional Council (DCR) 94 - 12/2/85 "Geological investigations for town-planning" concerns the geological-techniques investigations necessary to the planning action in urban areas.

In particular, a detailed analysis of the geological, geomorphological, hydrogeological, slope and flooding (see DCR 230 - 21/6/94) aspects of the communal territory must be carried out, in order to identify the hazard conditions, to be mapped in scale 1:5 000.

Comparing land use destinations and hazard conditions of the territory, the degree of risk must be evaluated and mapped in a scale 1:5 000. Norms, limitations, conditionings and prescriptions for carrying out the interventions foreseen by the PRGC are guided by these maps.

2.2.4.4 Portugal

The first urban areas subject to a planning process appeared in the 30's. The main concerns were first the planning of urban areas but, nowadays, the planning initiatives are considered in a larger spatial scale. Thus, the policy related to planning defines three categories of planning instruments: Regional Territorial Management Plans (PROT), Special Territorial Management Plans (PEOT) and Municipal Territorial Management Plans (PMOT).

The Regional Territorial Management Plans (PROT) (Figure 2.2.4.4 a) were instituted by Decree-Law 338/83 of 20 July, amended by DL 176-A/88, DL 367/90, DL 249/94 and DL 309/95. They are instruments with normative and pragmatic character and they have the objective of promoting the characterization and harmonious development of different parts of territory.

The elaboration of this kind of plans is associated with the necessity of co-ordination of Municipal Master Plans (PDM) and definition of management strategies at a regional scale.

The Special Territorial Management Plans (PEOT) are plans refering to special protected areas, classified reservoirs and coastal zones such as is refered in Decree-Law 151/95, 24 July, amended by DL 5/96. The mentioned areas have specific features that require special management measures.

Decree-Law 309/93 regulates the Coastal Zones Management Plans (POOC-Figure 2.2.4.4 b).

Decree–Law 2/88 of 20 January regulates the Reservoirs Management Plans (POA -Figure 2.2.4.4 c).

Decree–Law 19/93 of 23 January regulates the Protected Areas Management Plans (POAP).

The Municipal Territorial Management Plans (PMOT) are regulated by Decree-Law 69/90, of 2 March, amended by DL 211/92 and DL 155/97, consider the Municipal Master Plans (PDM), the Urban Plans (PU) and Detailing Plans (PP). These plans define the occupation, alteration and use of land in the areas encompassed by each one of them.

The Municipal Master Plans (PDM) (Figure 2.2.4.4 d) are instruments of landscape administration and they have as objective the regulation of land use and occupation of the respective municipality. In the past, municipalities have not dedicated much attention to the harmful occupation of the flood plain areas and many serious problems have developed, as a direct consequence of the lacking experience on land use planning. This situation is changing in a fast way: Municipalities are now required to prepare and update periodically a Municipal Master Plan (PDM) and flood affected areas must be explicitly considered (e.g., Decree-Law 364/98).

Decree-Law 364/98 of 21 November establishes the obligation for the Municipalities to elaborate, for their PMOT's a map with all the floodable areas, within the urban order, at a maximum scale of 1:5 000. For this purpose, all the official or public services are required to provide the available information freely. Those maps have to show explicitly the area covered by the largest known flood, at least, since 1967. In the cases where the 100-year flood levels are known, from the corresponding PBH or from any other source, these should be marked. When no flood level limit is known, a 100-meter wide band on each side of the river banks is considered restricted area, i.e., all the construction requirement processes in this area have to include a justification that safety of people and properties is not jeopardized by the required project.

All the official permissions respecting urbanization plans within the floodplain limits should mention this fact. The municipalities have a period of 18 months maximum to adjust their PMOT's in accordance with this law.

The Law 48/98 of 11 August, recently published, establishes the bases of landscape management and urbanism policy.

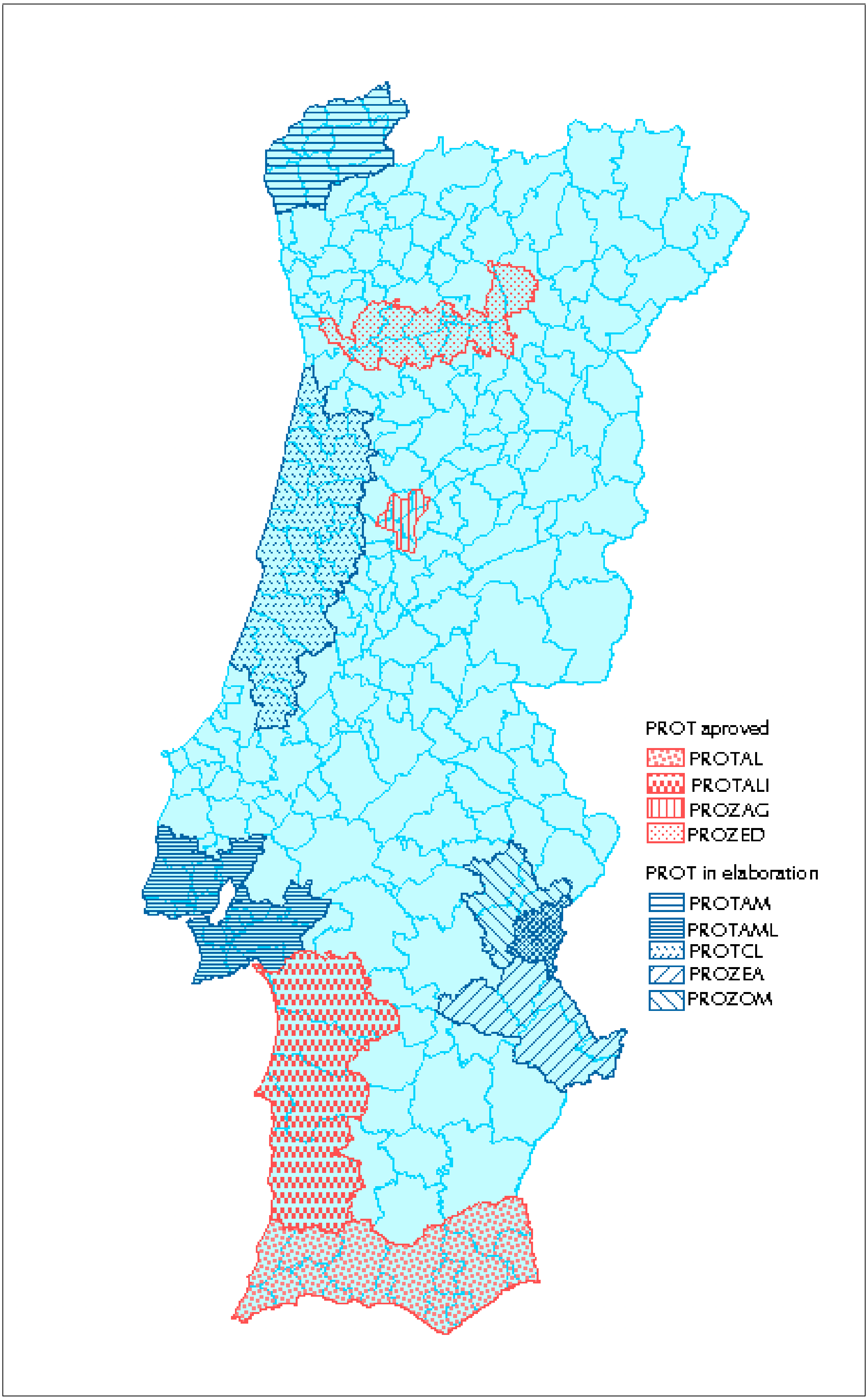


Figure 2.2.4.4 a – Regional Territorial Management Plans (PROT's) in Portugal (October 1998)

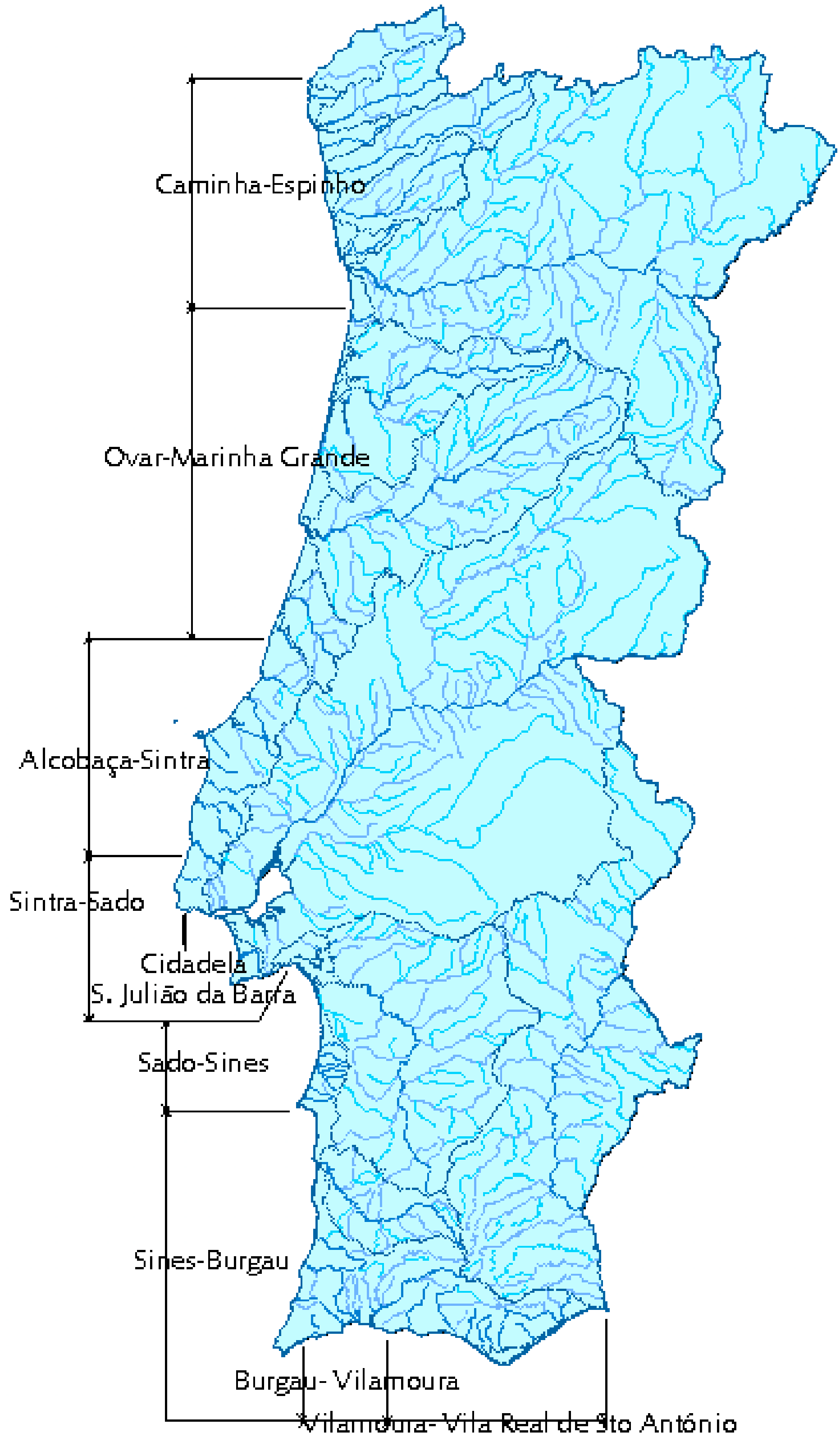


Figure 2.2.4.4 b – Coastal Zones Management Plans (POOC's) in Portugal (October 1998)

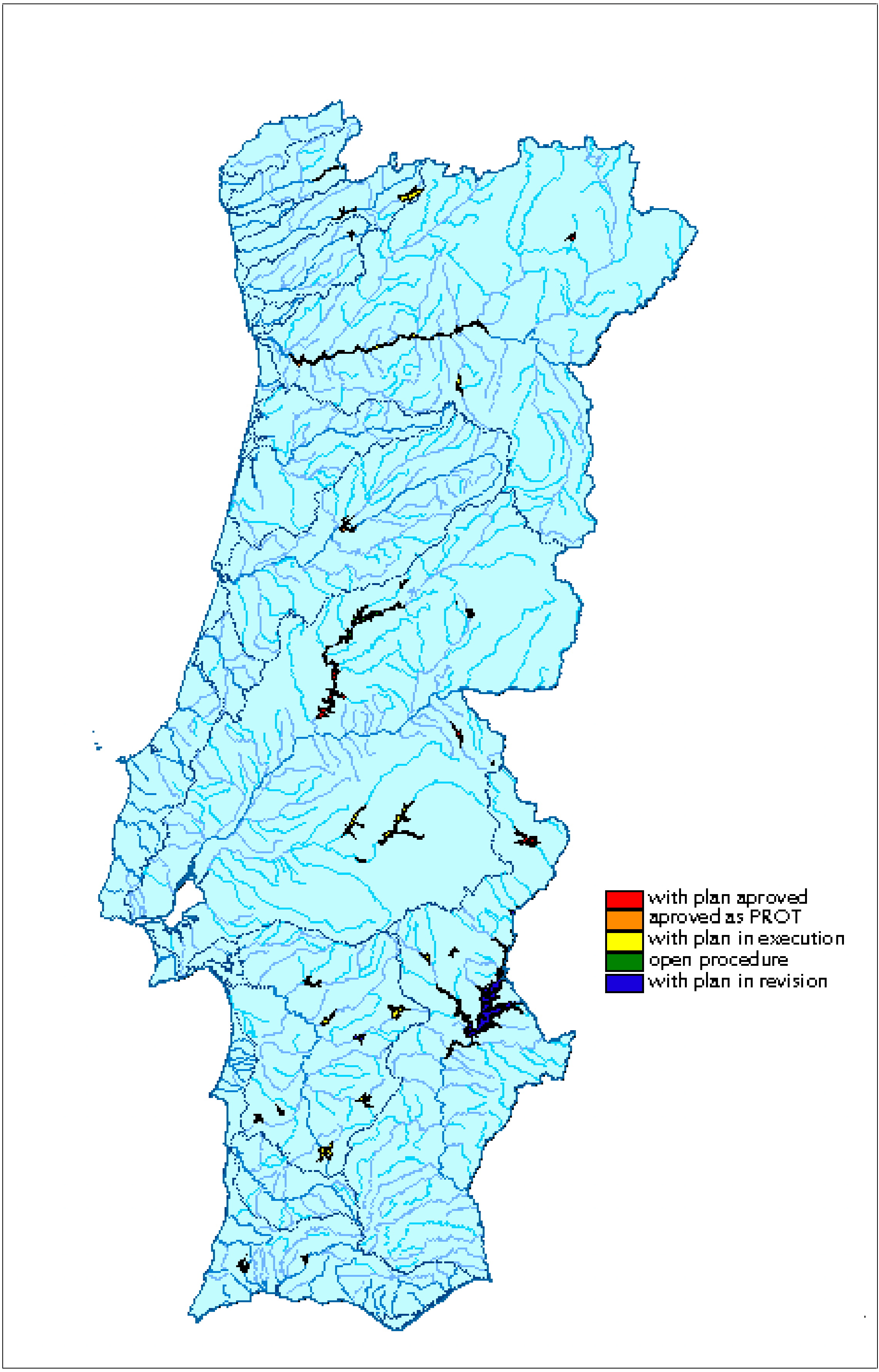


Figure 2.2.4.4 c – Reservoirs Management Plan (POA's) in Portugal (October 1998)

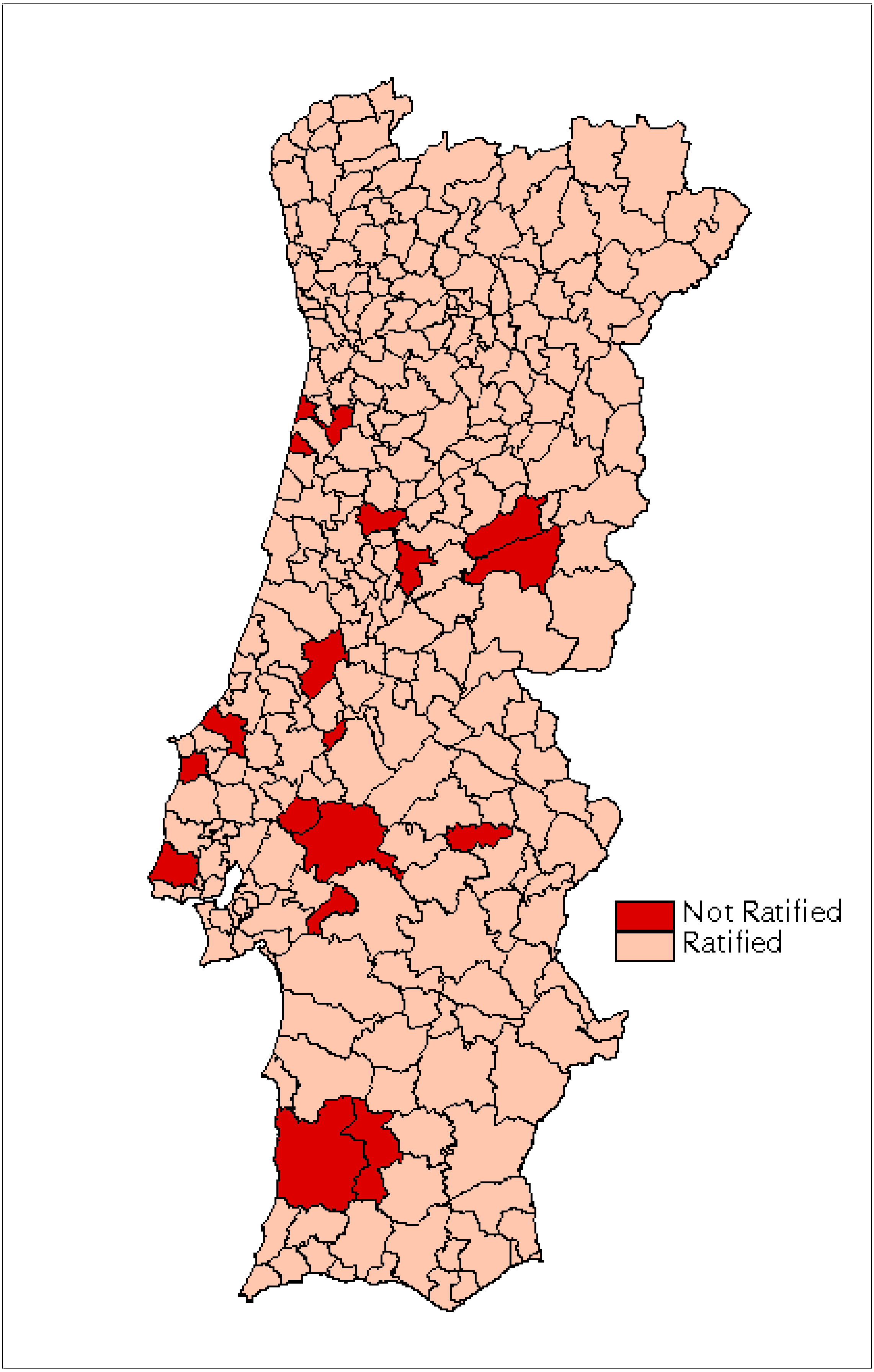


Figure 2.2.4.4 d – Municipal Master Plans (PDM's) in Portugal (October 1998)

2.2.5 Civil Protection Legislation

2.2.5.1 Austria (Styria)

To date, the concept of Civil Protection as such is not included in the Austrian federal constitution.
It was integrated into Civil Defence, constituting part of Overall National Defence, which is, of course regulated in the federal constitution.

Article 10 of the federal constitution, containing essential regulations on the allocation of competencies and resting the federal level with legislative and executive powers, will be amended to comprise the concept of Civil Protection, integrating it with the federal level's competence.

The Styrian Civil Protection Act of 16 March 1999 focusses on the prevention and action against disasters. Its contents can be summarized in the following points:

- Civil Protection tasks;
- Distribution of competences between relevant authorities;
- Preliminary measures (general civil protection plans/alert and intervention plans for enterprises and plants with particularly high risk potential);
- Direction of civil protection intervention and organization of training and continuous training;
- Civil protection drills;
- Issuing of directives by the regional government so as to achieve coherent and consistent implementation of preliminary measures;
- Regulation of assistance in the field of civil protection (disaster relief and preparation for action against disaster / other types of intervention in the field of civil protection);
- Definition of citizen duties in the event of disaster;
- Costs (linked to the implementation of the measures / indemnities for people who are obliged to give assistance (= indemnities for third persons);
- Definition of the role for public security authorities.

Preliminary measures for prevention and action against disasters have to be devised at the regional level, at the level of every political district and for each commune. In particular, relevant authorities have to:

1. prepare and enforce:
   - civil protection plans and
   - alert and intervention plans for enterprises and plants with particularly high risk potential;
2. direct civil protection intervention and focus on relevant traning and continuous training;
3. guarantee rapid alert to organizations that are involved in protection through proper organizational measures and keep the necessary equipment ready for use;
4. carry out an adequate number of civil protection drills and exercises with the participation of all forces involved in civil protection;
5. provide psycho-social assistance.

The regional government has to issue directives to ensure coherent and consistent implementation of preliminary measures. The Land of Styria has worked out a civil protection plan for flood events. This plan has the following contents:

- legal foundation;
- immediate measures;
- capabilities of the regional warning center and the fire brigades;
- assistance;
- rules of behaviour for citizens;
- information on damages;
- subsidies.

2.2.5.2 Italy (Tuscany)

National Law 225/92 - 24/2/1992 "Institution of the National Service of the Civil Protection" establishes the National Service of the Civil Protection in order to protect the integrity of life, goods, installations and environment from damages or risk of damages deriving from natural adversities, catastrophes and other calamitous events.

In addition to the helping phase and the overcoming of the emergency, the norm contemplates the "prediction" of events and the "prevention" to avoid or reduce the entity of the damages and of the aspects closely connected with the expected events.

For such reason, the Bureau of Civil Protection prearranges the national programs for prediction and prevention of the different hypothesis of risk typologies, the national programs for aid organization and the plans for carrying out of the necessary emergency measures.

The preparation of prediction plans for identification of the potentially existing risk conditions is entrusted to the most important national scientific and technological Institutions.

On the basis of National Law 225/92, Regional Law 42 - 10/6/96 "Discipline of the activities of Civil Protection" fixes the criteria to develop the regional planning of the activities of civil protection by means of the preparation of Plans of prediction, prevention, and emergency. With the first two plans, the Law highlights the necessity to operate towards the prediction and prevention of the calamitous events, identifying and studying the phenomena that generate the conditions of risk in order to characterize models or modes of evaluation of dangerous situations, preventive methodologies for mitigation of these eventualities and their representation in thematic maps.

The collection of territorial information and the preparation of prediction and prevention plans is carried out respecting the competence assigned by the laws in force to the National and Regional Offices working on soil defence (e.g. River Basin Authority, etc.). Local Authorities (Provincial, Inter-communal and Communal) play an important role in the collection and updating of risk conditions on their territory.

On the basis of the territorial data gathered for the preparation of prediction and prevention plans, the Regional Administration of Tuscany prepares the regional plan of emergency, that foresees the following main tasks:

- fixing criteria for management of emergency phases;
- identification of human and structural resources that can be employed during the emergency phases;
- preparation of logistic and operative structures for the emergency;
- preparation of networks for the communications during emergency.

To this regard, the Regional Admistration of Tuscany is working on the creation of an information network that makes use of Internet as a means for communicating and distributing information (see Section 3.2.6)

The territorial management plans made by the River Basin Authority and by the Regional Administration (PIT see Regional Law 5/95) must be conform to the indication of the provisional risk maps prepared by provisional regional plan of risks.

In addition to the regional civil protection plans, each local administration (Provinces and Communes) must prepare prediction, prevention and emergency plans according to the regional indications.

2.2.5.3 Portugal

Emergency plans are prepared at all levels (national, regional and local) under the responsibility of SNPC, SRPC and SMPC (see Section 2.1.2.3), in accordance with guidelines provided by the National Commission for Civil Protection (intergovernmental technical body for co-ordination of Civil Protection activities). Thus, they are classified accordingly to the territorial levels they cover, as national, regional, district and municipal; and to the risks they tackle with, as general (all risks) and specific (one risk).

National and regional plans are approved, respectively, by the Portuguese Government Cabinet and by the Governments of Autonomous Regions. District and Municipal plans are approved by the National Commission for Civil Protection.

In regards of the Organic Law for Civil Protection, the National Emergency Plan (PNE) was worked out by the SNPC through 1992-1993 and approved by Deliberation of the Portuguese Cabinet of September 1, 1994. The SNPC is responsible for the development of plans and policies, co-ordination and control of emergency response.

2.3 CONCLUSIONS

2.3.1 Summary of the Institutional and Legislative Framework

The three following tables summarize legislative competences in relation to the institutional framework in the partner countries, in a schematic way, in order to compare the different situations (Tables 2.3.1 a, b and c). The tables are constructed by crossing information from Section 2.1 on the columns with the matters dealt with in Section 2.2 on the rows.

Table 2.3.1 a - Legislative competences in relation to the Administrative levels in Austria (Styria)

Administrative level		**River Basin Plan**	**Agriculture and Forestry Management**	**Ecology and Environment**	**Land Use and Urban Planning**	**Civil Protection**
National	Ministry of Agriculture and Forestry	Technical and financial coordination (Water Act and Water Construction Promotion Act) Issue of directives and instructions	Identification of danger zones, management of forestry covered areas			
Regional	Regional Government	Planning actions on base of the ministerial indications Issue of decrees	Issue of decrees Preservation of water-resources, protection of soil	Regulation of environmental safeguard, landscape protection	Working out of development programmes, evaluating of relevant measures, authority of planning activities of the communes	Issue of directives to ensure the implementation of preliminary measures
District	District Administration	Issue of decrees	Issue of decrees			
Local	Commune				Local development framework, land use plan, construction plan	

Table 2.3.1 b - Legislative competences in relation to the Administrative levels in Italy (Tuscany)

Administrative level		River Basin Plan	Agriculture and Forestry Management	Ecology and Environment	Land Use and Urban Planning	Civil Protection
National	Ministry of Enviroment	Delimitation of catchments of national and inter-regional interest and establishment the procedures for the preparation of Basin Plan		Delimits National Parks and defines the guidelines for the management of state and regional protected areas. Defines the guidelines for the co-ordination of the regional legislative activity concerning the criteria for the preparation of hydraulic and forestry maintenance actions		
	Ministry of Interior					Programs for the prevision and prevention of risk conditions, Programs for aid organization and the plans for the carrying out of the necessary emergency measures
National/Regional	River Basin Authority	Preparation of Basin Plan that studies and programs the actions and prescriptions for land use management and for the hydraulic defence of the territory			Identifies prescriptions and constraints on the territorial planning of the regional and local Public Administrations	
	Park Authority	Must be consulted for interventions in protected area		Must be consulted for interventions in protected area	Must be consulted for interventions in protected area	
Regional	Regional Administration	Delimitation of catchments of regional interest and establishment of Basin Plan procedures	Approval and co-ordination of the "Directions of Principle and Forestry Police"	Rules and principles about soil defence action according to the use of bioengineering structures	Prepares the PIT (Plan of territorial direction)	Prepares the Regional Plan of prevision, prevention, and emergency
Local	Provincial Administration		Manages the hydrogeological bond and proposes and applies "Directions of Principle and Forestry Police" after approval by Regional Administration		According to the PIT prepares the PTC (Plan of Territorial Co-ordination)	Prepares the provincial prevision, prevention and emergency plans according to the regional indications
	Land-Reclamation Syndicate Consortium of Mountain Communes	According to the Basin Plan, lays out a Plan of Reclamation that defines interventions under the competence of Land-Reclamation Syndicate or Consortium of Mountain Communes.	Planning, construction, management, and maintenance of the public hydraulic-forestry interventions on torrents and mountainsides			
	Communes	In the preparation and modification of the Town Planning Plans must respect the prescriptions, restrictions and directives imposed by the Basin Plan of the River Basin Authority			According to the PIT and PTC prepares the PRGC (Town Planning Plan)	Prepares the local prevision, prevention and emergency plans according to the regional and provincial indications

Table 2.3.1 c – Legislative competences in relation to the Administrative levels in Portugal

Administrative Level		River Basin Plans	Agriculture and Forestry Management	Ecology and Environment	Land Use and Urban Planning	Civil Protection
National	Ministry of the Environment	Preparation of National Water Plan and the River Basin Plans of Minho, Douro, Tejo and Guadiana		Preparation of Protected Areas Management Plans (POAP) Preparation of National Ecology Reserve (REN)	Preparation of Coastal Zones Management Plans (POOC) Preparation of Reservoir Management Plans (POA)	
	Ministry of Agriculture, Rural Development and Fishing		Preparation of National Agricultural Reserve (RAN)			
	National Water Council	Supervision of water resources policy				
	National Service for Civil Protection					Programs for prediction and prevention of risk conditions; programs for aid organizations; Programs for carrying out of the necessary emergency measures. Preparation of prevention related to major accidents, disaster or calamity at national level.
Regional	Regional Services for Civil Protection					Preparation of prevision, prevention and emergency plans according to the guidelines provided by the National Comission for Civil Protection
	River Basin Council (CBH)	Supervision of River Basin Plans				
	Regional Directorates of the Ministry of Environment	Preparation of the River Basin Plans of Lima, Cávado, Ave, Leça, Vouga, Mondego, Lis, Oeste creeks, Sado, Mira and Algarve creeks				
	Regional Coordinating Commission				Preparation of Regional Territorial Management Plans (PROT)	
Local	Municipalities		Preparation of Forestry Intervention Municipal Plans (PMIF)	Delimitation of National Ecology Reserve (REN)	Preparation of Municipal Territorial Management Plans (PMOT)	Preparation of prediction, prevention and emergency plans, according to the guidelines provided by the National Comission for Civil Protection
	Communes				Garden and Street Maintenance	

2.3.2 Optimal Level of Coordination

The institutional framework for flood management is a complex issue, due to its "cross-horizontal" character, involving different sectors and levels of decision and action (Saraiva et al. 1993). In all partner countries, responsibilities are distributed among central, regional and local administrative and political levels. The following Table 2.3.2 identifies a suitable set of range of decision-making levels for various activities that need co-ordinating:

Table 2.3.2 - Decision-making levels (adopted from Kraemer 1995)

Priority	Topics	Local	Sub-Regional	Multi-Regional and Regional	National	Internat.	European Union	Continental	Global
1	Flood Defence	■	■	■	■	■			
2	Groundwater Protection	■	■	■	■	■	■		
3	Water Quality				■	■	■		
4	Water Supply	■	■	■					
5	Emission Standards			■	■	■	■		
6	Sewerage	■	■	■					
7	River Basins	■	■	■	■	■			
8	Water Maintenance	■	■	■	■				
9	Habitat Protection	■	■	■	■	■	■	■	■
10	Hydropower	■	■	■	■				
11	Leisure Use	■	■	■	■				
12	Administrative Procedures	■	■	■	■	■	■	■	■

In the various European countries, some of the terms used in the above Table have different definitions and uses. This must be taken into account when dealing with the various levels.

Since the natural water cycle is indivisible not only in the geographical but also in the functional sense, all activities relating to water management must harmonize with one another. Even if it is clear that a vertical co-ordination of water management activities will always be necessary, the question still remains at which level a horizontal co-ordination of water management functions can be attained most easily and effectively.

This kind of integration is possible only where both functions are located at the same level (usually local, NUT IV-V), where the legal framework is broadly similar. There is a number of water management functions which, depending on circumstances, can be carried out effectively at local or municipal level. Among them are (local) habitat protection, (local) flood control and the maintenance of (minor) water courses. The co-ordination of these functions at local level is facilitated by the comparatively small number of actors which, as a rule, also dispose of a relatively good knowledge of local conditions. In addition, the direct participation of water users as well as democratic control is quite possible at this level. Considerable municipal involvement in water management follows logically from the application of the subsidiarity principle, as does an important role for local associations for water management and services. For this purpose, associations of municipalities exist in almost all of European countries (Kraemer 1995).

The same applies to activities which water users can carry out as their own responsibility and their own effort. As a rule, this will include the maintenance of water courses and flow control of small water courses. In this case, there is normally an economic self-interest of riparian landowners and water users. However, the nature of the legal framework and supervisory procedures for such activities must safeguard the overall requirements of nature conservation and habitat protection in the decision-making process.

Account must be taken of the need, on the one hand, to bring together the required expert knowledge when determining a suitable level for the implementation of co-ordination mechanisms. Otherwise, the implementation and enforcement of regulations adopted at more central levels could not effectively take place. This requirement usually counts in favour of larger units. On the other hand, one must ensure that the necessary local knowledge is also available, otherwise, problems at local level could not effectively be solved. This requirement usually works in favour of smaller units. In consequence, a balance has to be found depending on the specific circumstances in each case.

In this context, river basins can provide a basis for territorial definitions where they seem suitable given their territorial size. In cases where river basins are either too large or too small, the vertical and horizontal integration of the various functions can only be guaranteed through institutional mechanisms for co-ordination and co-operation (Kraemer 1995).

In Europe, where river basin authorities have been established, there are two contradictory philosophies in the establishment of co-ordination and co-operation mechanisms at river basin level: either the establishment of sovereign statutory authorities or the establishment of river basin commissions by the regions concerned.

The establishment of sovereign statutory authorities by central government first took place at the beginning of the 2Oth Century in the Ruhr area in Germany for some tributaries to the Rhine and was continued with the creation of the French river basin authorities, the “Agences de l'Eau”. The Regional Water Authorities, which existed in England until the privatization of the water industry there in 1989, were also centrally established statutory authorities. Sovereign statutory authorities have been set up also in Italy with the state law 183/89 for the large national and regional river basins.

The other way towards an improved co-ordination of water management activities is the establishment of joint river basin commissions by the regions concerned. In contrast to river basin authorities, these are not established "from the top", but through voluntary co-operation within a contractual framework. River basin commissions are not financed through taxes or charges but through contributions. The budgets of commissions can be much smaller than would be the case with sovereign statutory authorities. This is because the objectives of commissions are essentially limited to the co-ordination of activities and no important, cost-intensive measures are undertaken by a commission itself (Kraemer 1995).

On the basis of experience of the participant countries, river basin authorities represent the best co-ordinating and operative structure for the hydraulic management of the national and regional basins (large surfaces), while river basin commissions, that are characterized by a much lower degree of centralization and essentially leave more decision-making power at a lower level, could be identified for medium-small size basins.

3 PRINCIPLES AND GUIDELINES FOR FLASH FLOOD PREVENTION

There are two types of measures to reduce flood damages (U.S. Army Corps of Engineers 1985): structural interventions, involving structures that promote the reduction of one or several flood features, such as the flood area and the river flow, and non-structural interventions, encompassing preventive or adaptative actions that promote the reduction of risk from changing the damage susceptibility to losses of socio-economical activities in the risk areas.

Geographical Information System (GIS) and other computer graphic techniques, within an interdisciplinary environment, are powerful tools not only for river basin and flood plain management but also for facilitating the dialogue with decision-makers, interest groups, and the public in general.

The approach to the solution of problems connected to the risk of flash floods requires a logical succession of actions that aim towards:

- identification of the risk conditions and of the causes that determine them by carrying out detailed studies of the basin;
- definition of the non structural and structural interventions to resolve the existing problems.

Concerning the study of small medium basins, the methodology defined by project PREMO ("Action towards environmental protection of areas subjected to flood risks" – 1998) is here proposed and illustrated using a scheme that considers objectives, scope and technical execution for each theme analyzed.

3.1 METHODOLOGY FOR THE STUDY OF A SMALL-MEDIUM BASIN

The guidelines, which drive the proposed methodological framework for the study of small-medium basin, are represented by a logic sequence of actions to put in practice step by step:

1) Data inventory - Analysis of the collected information;
2) Diagnosis of the hazard conditions;
3) Proposed interventions;
4) Post Project Analysis.

The proposed methodology is an operative tool that can iteratively improve the knowledge of the characteristics of basins, in order to identify the best defence interventions for reduction of the hydraulic risk.

3.1.1 Data Inventory (Thematic Maps – Legend and Scale Typology)

On the basis of the physiographic and hydraulic characteristics of basins that have been defined in the Introduction of this Monograph, the scale 1:25 000 is the best way to represent, in a organic way, the territorial aspects. Larger scales, 1:10 000 or 1:5 000, should be useful to make a detailed representation of a specific situation (erosional phenomena, sites of interventions, hydraulic risks, etc.) or to analyse very small basins.

3.1.1.1 - Biophysical Data

3.1.1.1.1 - Spatial Data
E.g., topography, physiography, meteorology (e.g., wind, temperature, humidity, solar radiation and orientation), hydrology (e.g, precipitation, evapotranspiration, infiltration and groundwater), geology, hydrogeology, soils, land use.

3.1.1.1.2 - Temporal Data
E.g., climate, rainfall, flow, water levels.

3.1.1.1.3 - Others
E.g., historical references and cultural values, sensitive areas.

3.1.1.2 - Socio-Economic Data
Socio-economic data are usually based on censuses and refer to land value, urban development, population trends, economic growth, public services and facilities, natural features and constraints.

3.1.1.3 – Legislation
E.g., laws, directives, regulations.

3.1.1.4 - Perception Data
E.g., questionnaires, polls.

3.1.2 - Analysis (Drainage Basin Characteristics)

3.1.2.1 - History, Socio-Economy and Environment

3.1.2.1.1 - Socio-Economic Characterization

Objectives
- Identification of the important and peculiar socio-economic features of the studied area (population, real estate, economic activities, typology of the actual settlements and urban planning development, etc.);
- Historical analysis and determination of the socio-economic trends with respect to the highlighted aspects;
- Preview of potential future socio-economic scenarios (short-long-term) related with the existence of socio-economic development plans for the basin;
- Selection of guidelines for the socio-economic planning, taking into consideration the hydraulic and hydrogeological risks;
- Promotion of public participation, in order to: a) sponsor a mechanism for exchange of information; b) provide a source of information on local values; and c) establish the credibility of the planning and assessment process.

Scope
- The entire basin;
- Particular sub-basins;
- Urbanized areas.

Technical Execution
- Analysis of all the socio-economic historical information collected both in the Public (Local, Regional Administrations, State Statistical Agencies, Public Libraries, Museums, etc.) and Private Offices (Private Libraries, etc.), and identification of the socio-economic evolution of the basin;
- Analysis of the present socio-economic conditions and trends on the basis of censuses of the population and of the agricultural and commercial activities (State Statistical Agencies, Chambers of Commerce, etc.);
- Analysis of the territorial management plans (Local, Regional Management Plans, etc.), in order to highlight the guidelines of the socio-economic development of the territory;
- Definition of the general framework for public participation (observations and principles, participation levels, identification of the publics, implementation of the corresponding programs, conflict management and dispute resolution rules);
- Use of questionnaire methods;
- Choice of the pertinent descriptive thematic maps;
- Elaboration of a technical report with guidelines for the socio-economic territorial planning taking into consideration the hydraulic and hydrogeological risks.

3.1.2.1.2 - Water Resources

Objectives
- Identification and quantification of the available water resources within the basin and specification of the political- and operative-managing structures;
- Quantification of the water use by human activities with respect to the total quantity of resources in the global water balance of the basin;
- Analysis of the compatibility between the water resources and the calculated water exploitations;
- Estimate of the most important typologies of water uses and of the existing wastes with respect to potential polluting events;

- Identification of the percentage of water resources subjected to de-pollution processes and recycling;
- Formulation of guidelines for the rearrangement of the management scheme for the water resources.

Scope
- The entire basin;
- Particular sub-basins;
- Urbanized areas.

Technical Execution
- Determination of the mean annual hydrologic balance through the calculation of the water quantities entering and leaving the basin (rainfall, groundwater, runoff, evapotranspiration, etc.), on the basis of the meteorological data collected and processed (see also Runoff and Drainage Network 3.1.2.2.2 and Hydrogeology section 3.1.2.2.4);
- Analysis of the information regarding the exploitation of surface and underground (springs, wells, etc.) water resources and determination of the entity and typology of use of the resources exploited by each water management office (local administrations, private aqueducts, etc.);
- Determination of the renewable and potentially exploitable water resources through the definition of the dynamics of both surface and underground waters (see also Runoff and Drainage Network 3.1.2.2.2 and Hydrogeology Section 3.1.2.2.4) and comparison with the exploited water calculated in the previous point;
- Drawing up of thematic maps to represent the collected data, at the necessary scales;
- Elaboration of a technical report with guidelines for rearrangement of the water management system.

3.1.2.1.3 - Environment

Objectives
- Identification of the general and peculiar environmental conditions of the studied area (water, air, soils, flora, fauna, etc.);
- Ecological characterization of the river courses;
- Identification of the prevalent and potential pollution sources and of the efficacy of the existing de-pollution structures;
- Territorial zoning with respect to environmental vulnerability;
- Protection of the important ecological aspects from the prevalent and potential pollution-deterioration phenomena;
- Prediction of future environmental conditions subsequent to a potential disastrous polluting event;
- Preservation of important historic, cultural, and natural landmarks;
- Prediction and assessment of impacts on the cultural environment (e.g., historic sites, buildings, and antiquities);
- Protection and enhancement of the cultural environment;
- Description of the existing landscape and prediction and assessment of potential visual impacts resulting from possible project types.

Scope
- The entire basin;
- Urbanized areas;
- Areas with a high environmental value.

Technical Execution
- Identification of the environmental conditions of the basin and of the water courses through the analysis of water, air, soil, etc. and of the floral-faunal aspects from records of the Public Offices responsible for the environmental issues (Health and Environmental Offices, Universities, etc.);
- Location and characterization of the prevalent and potential pollution sources from records of the Public Offices (Health and Environmental Offices, Chambers of Commerce, etc.) and field surveys;
- Evaluation of the pollution-source hazards with respect to typology, extension, and life span of the prevalent or potential polluting substances, and definition of the vulnerability of the basin with respect to the physiography of the territory (see also Hydrogeology Section: 3.1.2.2.4);

- Identification of the areas with a high ecological value and their relationship with the existing pollution sources in order to detect signs of degradation phenomena;
- Location of the existing wastewater and elaboration of chemical analyses of water done by Health and Environmental Offices, etc.;
- Location of the existing de-pollution structures, determination of the total volume of recycled water and comparison with the total entity of the wastewaters;
- Determination of the qualitative-quantitative environmental evolution of the studied area with respect to relevant polluting events that occurred in the past and prediction of future short- and long term trends;
- Historical and archeological observations and survey work by qualified professionals;
- Choice of some maps, in a detailed scale, to represent the collected data;
- Elaboration of a technical report.

3.1.2.1.4 - Administrative and Legislative Aspects

Objectives
- Identification of the administrative boundaries within the basin, regarding State, Regional, Provincial and Communal limits;
- Identification of the Public Offices that are responsible for the territory management and, in particular, for the hydraulic, forestry, hydrogeological-defence and environmental areas;
- Analysis of the State and Regional Laws regarding territorial management (planning, hydraulic defence, hydrogeological features, environmental protection, etc.);
- Analysis of the different competencies of each Law and identification of contradictions, overlaps, insufficiencies and failures in the existing legislative scheme;
- Proposals for rearrangements of the legislative scheme, especially as regards the hydraulic and hydrogeological defences, with respect to the physical limits of the drainage basin;
- Proposals for rearrangement of the Public Offices that are responsible for the territory management and, in particular, for the hydraulic, forestry and hydrogeological defences.

Scope
- The entire basin;
- Particular sub-basins;
- Urbanized areas.

Technical Execution
- Identification of the administrative boundaries (State, Regional, Communal limits) through the observation of detailed and updated maps and in consultation with the competent offices;
- Research of the Laws, Regulations and Executive Orders in force in the basin through the collection of information from Public Offices, bibliographical sources, etc.;
- Identification, on the basis of the indication given by the Laws and by Administrative Offices, of the Public Bodies that are responsible for the territory management and of their competencies, especially as regards the hydraulic, forestry and hydrogeological defences;
- Verification of the effectiveness of the Laws in force with respect to the hydraulic, hydrogeological and environmental defences for the basin;
- Selection of one or more maps to represent the competence limits of each Law and of the Public Bodies responsible for the territory management and identification of failures and contradictions of the legislative-management scheme for the basin;
- Elaboration of a technical report.

3.1.2.1.5 - Historical Calamitous Events

Objectives
- Identification of typology, intensity and location of the historical major floods and hydrogeological (landslides, erosion) disastrous events that have occurred in the studied area;
- Analysis of quantitative data regarding the past hydraulic and hydrogeological disastrous events (water discharges and levels, height and intensity of the rainfalls, duration of the flood events, landslide types, involved surfaces, etc.);

- Mean temporal distribution of the identified events and correlation with the typology of the rainfalls responsible for the hydraulic and hydrogeological disasters;
- Data analysis of the areas, structures, population and damages involved, and quantification of the total damages caused by the hydraulic and hydrogeological phenomena;
- Consequences of the disastrous events (pollution of groundwater, morphological changes, changes of the river bed, etc.);
- Preparation of a database, using GIS, to collect disastrous event data and updating of this database.

Scope
- The entire basin;
- Areas, identified on the basis of historical information, involved by a high hydraulic or hydrogeological hazard;
- Along the river and water courses and locally in the areas involved by hydrogeological instabilities.

Technical Execution
- Research of the qualitative-quantitative data of disastrous events through records of the Public Offices responsible for the territory management (Public Administrations, Civil Engineers, Civil Protection Agencies, Land-Reclamation Syndicates, etc.);
- Analysis of the pluviometrical, river discharge and hydrogeological instability data from records of the Public Offices that are responsible for the territory management (Hydrographic Bureaus, Land-Reclamation Syndicates, etc.) and their correlations;
- Analysis of the information concerning the damages caused to population, structures and environment (records from Public Administrations, Health and Environmental Offices, etc.) and estimation of the total costs for rearrangement of the areas involved in hydraulic and hydrogeological disastrous events (Local, Regional Administrations, etc.);
- Drawing up of one or more maps (for different aspects), in order to represent the collected data, at the necessary scales;
- Selection of a descriptive form with the various aspects of the analyzed phenomena (date, typology, structures involved, damages, etc.) and preparation-updating of the database;
- Elaboration of a technical report.

3.1.2.2 - Physical Characteristics

3.1.2.2.1 - Meteorology and Climate

Objectives
- Characterization of the general climatic features of the hydrographic basin (rainfall, snow, temperature, wind, solar radiation and orientation, etc.);
- Identification of the mean annual regimes of the meteorological data, in particular, for rainfall;
- Identification of the extreme meteorological events;
- Identification of the typologies of the meteorological events that have caused calamitous events in the past and definition of the mean values (total height, intensity, etc.) that may cause or favor hydraulic or hydrogeological risk conditions;
- Fitting of a meteorological recording network that can also be used to alert the population and prepare civil protection actions.

Scope
- The entire basin and adjacent areas;
- The entire basin;
- Particular sub-basins.

Technical Execution
- Analysis of the meteorological-climatic data collected in the competent offices (public and private): nature of precipitation (rain, snow, sleet), evapotranspiration and interception, rainfall intensity, duration, areal and time distributions, and direction of the storm movements;
- Determination of the mean annual regimes of the basin by interpolation of the data of the nearest existing stations in small basins that do not have recording stations inside the hydrographic boundaries;
- Analysis of the extreme meteorological events and their statistical processing in order to define the expected values versus return period data;
- Analysis of the historical meteorological-climatic events that have caused floods and hydrogeological instability and determination of their typology (intensity, duration, extension, season, etc.);
- Elaboration of isohyetal (equal precipitation contour) maps for different periods (e.g., 10 min, 1 h, 6 h, 12 h, 24 h);
- Elaboration of depth (or intensity), area, duration and frequency curves or relationships;
- Drawing up of one or more maps to represent the collected data, at the necessary scales, in particular, as regards the meteorological-climatic events that may generate hydraulic and hydrogeological hazards;
- Elaboration of a technical report.

3.1.2.2.2 – Runoff and Drainage Network

Objectives
- Identification of the most important characteristics of the hydrographic network with respect to the geomorphologic features of the basin, its recent evolution (Quaternary) in terms of the regional drainage system and human impact;
- Characterization of the mean annual regime of discharges and specification of the extreme measured and calculated discharge values;
- Identification of the river dynamics aspects (erosion, solid transport, sedimentation, aggradation, characteristics of the alluvial sediments, etc.);
- Verification of the existing hydraulic works, planned actions, and efficacy of the existing structures;
- Identification of the risk conditions generated by the dynamics of the torrents (erosion areas, decrease of the flow sections caused by the aggradation of the torrent beds, etc.).

Scope
- The entire basin;
- Along the torrents;
- Urbanized areas close to the torrent beds.

Technical Execution
- Definition of the geometrical features of the hydrographic network (geometry of the network, length and slope of the torrent beds, Norton indexes, etc.) through the analysis of detailed geographic maps;
- Preparation of cross sections of the water courses in order to represent the different types of flow sections existing along the torrent beds (incised, braided, etc.);
- Analysis of the discharge data collected from the competent Public Offices (Hydrographic Bureaus, Land-Reclamation Syndicates, etc.), in order to define the mean annual regime of the torrent. Specification of the extreme discharge data and their statistical processing to define the expected discharge values with respect to the return time periods;
- In the case of lack of available discharge recording stations, definition of the extreme discharge values using an appropriate hydraulic model to determine the discharge values from pluviometrical data, on the basis of statistical analysis of the rainfall of the basin calculated for different return time periods;
- Detailed surveys along the important water courses, in order to identify the erosion, transport rate and sedimentation phenomena. Parallel survey of the existing hydraulic works and verification of their efficacy;
- Singling out of the torrent stretches with hazard situations as regards the erosion phenomena, that can generate landslides and breaking of the hydraulic defence structures, and sedimentation-aggradation phenomena, that may decrease the hydraulic sections;

- Determination of the mean annual hydrologic balance through the calculation of the water quantities entering and leaving the basin (rainfall, groundwater, runoff, evapotranspiration, etc.), on the basis of the meteorological and climatic data collected and processed (see also Hydrogeology Section: 3.1.2.2.4);
- Analysis of the information regarding the exploitation of surface and underground (springs, wells, etc.) water resources and determination of the entity and typology of use of the resources exploited by each Water Management Office (local administrations, private aqueducts, etc.);
- Determination of the renewable and potentially exploitable water resources through the definition of the dynamics of both the surface and underground waters (see also Hydrogeology Section: 3.1.2.2.4);
- Formulation of one or more maps to represent the collected data, at the necessary scales;
- Elaboration of a technical report.

3.1.2.2.3 – Geology and Geomorphology

Objectives

- Identification of the general and peculiar morphological features of the examined area (landslides, paleo-landslides, terraced surfaces, etc.);
- Identification of both the relict and present morphological agents concerning, in particular, river dynamics and mountainside stability;
- Determination of the morphological parameters, slopes, and typical longitudinal profiles;
- Determination of the geomorphologic evolution of the studied area as regards in particular the recent changes of the basin (Pliocene-Quaternary);
- Qualitative estimation of the intensity, importance and extension of the active geomorphologic phenomena within the studied basin;
- Identification of the main characteristics of the outcropping geological formations (lithology, age, fractures, weathering, etc.);
- Attitude and tectonic structure of the outcropping geological formations and drafting of geological underground sections.

Scope

- The entire basin;
- Particular sub-basins;
- Detailed localized investigations.

Technical Execution

- Analysis of bibliographical publications and studies done in the same area, their updating and revision through interpretation and analysis of stereoscopic aerial photos, direct surveys in the basin, etc.;
- In the case of lack of preliminary studies, carrying out of a new geological and geomorphologic survey of the basin through the analysis of stereoscopic aerial photos, direct surveys, localized geological investigations, etc.;
- Formulation of thematic maps, in order to represent the collected data;
- Drafting of geological and structural subterraneous sections;
- Description of the morphologic features that present a relevant importance as regards the hydraulic and hydrogeological hazards of the studied area;
- Elaboration of a technical report.

3.1.2.2.4 - Hydrogeology

Objectives

- Identification of the important hydrogeological characteristics of the basin (permeability of the outcropping geological formations, hydrogeological watershed, etc.);
- Definition of the main features regarding the groundwater circulation (infiltration areas, springs, wells, etc.);
- Calculation of the total balance of the water resources of the basin and of the hydrogeological regime of the underground water;
- Definition of the renewable and potentially exploitable water resources;

- Identification of the chemical composition of the groundwater with respect to the chemical composition of the rocky substratum and to incidental human pollution.

Scope
- The entire basin and adjacent areas;
- The entire basin;
- Particular sub-basins.

Technical Execution
- Analysis of the geological maps, identification of the fracture scheme of the rocky substratum, through stereoscopic analyses of aerial photos, and identification of karst phenomena,
- Collection of localized information (wells, permeability tests, granulometry analyses, etc.), in order to define the hydrogeological characteristics of the geological outcropping formations and identification of the reloading and drainage areas of the groundwater;
- Description of the confined and unconfined groundwater systems, their relationships with surface streams and lakes, since mutual influences can occur, and their use within the studied basin;
- Determination of the dynamics of the groundwater and aquifer transmissivity through the analysis of information with respect to the spatial distribution of the springs, well measurement of the groundwater level both during the minimum and maximum levels and calculation of the total groundwater stored volume;
- Determination of the groundwater regime through the measurement of the well water levels during the year and of the spring discharges, in order to calculate the exhaustion function of the groundwater resource and determination of the renewable resources;
- Location of the most important pumping-reloading zone of the groundwater both for drinkable and industrial use and definition of the interference of these areas in the natural dynamics of the underground water;
- Chemical characterization of the groundwater through the collection of chemical analyses of water from records of the competent public offices;
- Formulation of thematic maps to represent the collected data;
- Elaboration of a technical report.

3.1.2.2.5 – Soil Erodibility[4],

Although soil resistance to erosion depends in part on topographic position, slope steepness, and the amount of man-made disturbances, the properties of the soil are the most important factors. They include soil texture, aggregate stability, shear strength, infiltration capacity, and organic and chemical content. Soil type and conditions (temperature, soil moisture, soil structure, soil flora and fauna) control infiltration, surface storage, soil water and groundwater storage.

Objectives
- Identification of the different soil types and their characteristics (soil texture, aggregate stability, shear strength, infiltration capacity, and organic and chemical content);
- Definition of soil aspects with respect to determination of hydrological parameters (e.g., Curve Number) in order to make a hydraulic characterization of the basin,
- Identification of the land use changes occurred in the past and correlation with the erosional phenomena;
- Prediction of the future changes of land use, in particular, as regards the formation of erosive hazard situations (agricultural practice, forestry harvest activities, etc.);
- Identification of land use management guidelines directed to reduction of the erosional risk.

Scope
- The entire basin;
- Particular sub-basins.

[4] Erodibility defines the sensitiveness of the soil to both detachment and transport.

Technical Execution

- Analysis of the existing soil maps in the competent offices (public and private);
- Updating of the most recent data regarding soils or realization of new surveys and analysis of aerial photos, etc.;
- Analysis of soil maps, with the dominant soil types, in terms of erodibility;
- Identification of peculiar areas in terms of soil erodibility;
- Formulation of thematic maps to represent the analyzed data;
- Elaboration of technical report with guidelines for territorial management aimed at protection against erosional risk.

3.1.2.2.6 – Land Use

Objectives

- Definition of the different patterns (form and density), controls and values of land use existing in the basin with respect to determination of hydrological parameters (e.g., Curve Number) in order to make a hydraulic characterization of the basin,
- Classification of the land capability as a method of assessing the extent to which limitations such as erosion risk, soil depth, wetness and climate hinder the use that can be made of the land;
- Identification of the land use changes occurred in the past and correlation with the alluvial and hydrogeological instability phenomena;
- Prediction of the future changes of land use, in particular, as regards the determination of hydraulic hazard situations (urban development, forestry harvest activities, etc.);
- Identification of land use management guidelines directed to reduction of the hydraulic and hydrogeological risk.

Scope

- The entire basin;
- Particular sub-basins;
- Hilly and mountainous areas.

Technical Execution

- Analysis of the existing land use maps in the competent offices (public and private);
- Updating of the most recent data regarding land use or realization of new surveys through stereoscopic analysis of aerial photos, direct ground surveys, etc.;
- Identification of the most important changes through the comparison between recent or updated cartographies and older land use maps;
- Analysis of territorial management plans (forestry plans, re-forestation plans, etc.), in order to verify the compatibility of the planned actions for decrease of hydraulic and hydrogeological risks;
- Formulation of thematic maps, in order to represent the collected data;
- Elaboration of a technical report with guidelines for territorial management aiming towards protection against hydraulic and hydrogeological risks.

3.1.2.2.7 - Hydraulics

Objectives

- Determination of the catchment yield[5] and flood routing along the main streams of the basin;
- Determination of the specific erosion, sediment yield, and transport, i.e., the sediment routing along the main streams of the basin;
- Determination of extreme events and flood areas;
- Identification of remarkable transversal and longitudinal sections of the river bed;
- Implementation of a monitoring system for the hydraulic and morphological aspects.

[5] Catchment yield refers to the volume of water available from a stream at a given location over a specified period of time.

Scope

- The entire basin;
- Particular sub-basins;
- Selected reaches.

Technical Execution

- Identification of the significant sub-catchment runoffs, existing channel width adjustments and flow regulation works;
- Hydraulic and hydrological modelling[6] for runoff, sediment production and flood routing (including physical foundations of fluvial process responses, analytical basis, model selection, simulations, tests and calibrations);
- Characterization of the historical floods[7] (peak flow rate or flood discharge, flood elevation, flood volume[8], flood duration[9], and flood frequency);
- Determination of flood discharges and water surface profiles for 2- to 500-year return periods;
- Determination of channel conveyances, flood areas and critical hydraulic sections.

3.1.3 - Diagnosis (Identification of the Main Existing Problems and Associated Risks)

3.1.3.1 - Landslide Risks

Objectives

- Identification of the areas involved by morphological instability (geological and geomorphologic maps);
- Classification of the intensities of the instability hazards;
- Identification of the prevalent and potential involvement of buildings, lifelines, roads, bounds of the main valley, economic activities, etc. by landslide phenomena and quantification of damages;
- Identification, on the basis of different surveyed geomorphologic hazards situations, of guidelines for definition of structural and non-structural measures for reduction of landslide risks of the basin;
- Identification of general guidelines for territorial management in order to reduce the geomorphologic risk;
- Identification of guidelines for preparation of general and detailed civil protection plans.

Scope

- The entire basin;
- Particular sub-basins;
- Localized landslides.

Technical Execution

- Analysis of the geological and morphological maps[10], in order to identify, localize and characterize (intensity, surface, typology, etc.) prevalent and potential morphologically unstable areas. Updating of the Geological and Geomorphologic Maps through stereoscopic analyses of aerial photos, ground surveys, etc.;
- Identification, on the basis of intensity and unfavourable local conditions (groundwater circulation, erosion, etc.), of hazard classes through the preparation of an evaluation scheme of the landslides surveyed in the basin;
- Identification of the prevalent or potential damages produced to the involved structures by landslides through the preparation of an evaluation scheme (number, typology, intensity of damages, etc.) on the basis of geomorphologic unstable conditions;
- Comparison between the hazard and the prevalent and potential damages, in order to define the risk conditions of the studied area;

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[6] Modelling refers to relationships between the real system, such as a basin, and its model.

[7] A flood can be defined as a flow that overtops the banks of a river or a stream.

[8] Flood volume is the volume of flood above the base discharge.

[9] It may be based on observations or predicted by methods of flood routing.

[10] A geomorphological map shows the form of the land surface, the properties of the soils and rocks beneath the surface, and the kind and magnitude of the geomorphological processes at work.

- Preparation of a risk map;
- Elaboration of a technical report concerning the typology of defence actions and the preparation of Civil Protection guidelines.

3.1.3.2 - Erosion Risks

Objectives

- Identification of the main (mechanical) processes of erosion: rainsplash erosion, overland flow, subsurface flow, rill erosion, gully erosion, mass movements, wind erosion (Morgan 1986);
- Determination of the soil loss tolerance, i.e., the maximum acceptable rate of erosion, and estimation of the prevalent and potential erosion risk conditions of the basin;
- Classification of the intensity of erosion hazards and identification of the areas involved by erosion phenomena and mass transports;
- Identification of the prevalent and potential influence of the erosion phenomena on existing structures, agricultural activities, solid transport, etc.;
- Identification, on the basis of different surveyed erosion hazard situations, of guidelines for definition of structural and non-structural measures for reduction of the risk conditions;
- Division of the basin into sub-regions, similar in their degree and kind of erosion risk;
- Study of the effects of slope and plant cover on erosion;
- Identification of general guidelines for territorial management, in order to reduce erosion risk;
- Identification of guidelines for preparation of general and detailed Civil Protection plans.

Scope

- The entire basin;
- Particular sub-basins;
- Areas with localized erosion phenomena.

Technical Execution

Since erosion risk is closely related to the vegetation cover (and therefore to land use), soil erosion surveys often form part of a broader land resources study, and may be carried out at several scales (from reconnaissance to detailed levels);

Because of the similarity of content in the studies of soil erosion and geomorphology, it seems logical to seek a method for a dynamic approach to erosion survey in the various systems of geomorphological mapping. Usually, soil erosion is shown in morpho-conservation maps, where slope steepness, slope shape, present land use, areas of rill and gully erosion, and areas of mass movement are shown (Morgan 1996). As much detail as possible is shown on a single map but, to avoid clutter, overlays are recommended for erosivity, soils and slope steepness.

- Analysis of Geological and Morphological Maps, in order to identify, localize and characterize (intensity, surface, typology, etc.) prevalent and potential surface (mountainsides) and linear (torrent beds) erosion phenomena. Updating of Geological and Geomorphologic Maps through stereoscopic analyses of aerial photos, ground surveys, etc.;
- Identification, on the basis of intensity and unfavorable local conditions (slope, lack of defence works, vegetal covering, etc.), of hazard classes, through preparation of an evaluation scheme of the erosion phenomena surveyed in the basin;
- Identification of the damages produced to the involved structures and to the territory, by the erosion phenomena through the preparation of an evaluation scheme (number, typology, intensity of damages);
- Comparison between hazard and prevalent or potential damage, in order to define the risk conditions of the studied area, through the preparation of an evaluation scheme, on the basis of the surveyed erosion phenomena;
- Use of indexes of erosion intensity, e.g., drainage density[11] and drainage texture[12] (or source-point density or gully density);

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[11] Defined as the length of streams per unit area.

[12] Defined as the number of first-order streams per unit area.

- Elaboration of a simple scoring system (e.g., on a scale from 1 to 5) for rating erosion risk (or soil loss), with respect to erosivity, erodibility, slope, ground cover, and human occupation (density and type of settlement). The five factor scores are summed to give a total score, which is compared with an arbitrarily chosen classification system to categorize areas of low, moderate and high erosion risks. The scores are mapped and areas of similar risk delineated;
- Estimation of the rate or quantity of soil eroded (ton ha^{-1} $year^{-1}$) through, e.g., the "Universal Soil-Loss Equation" (Wischmeier and Smith 1962);
- Preparation of a risk map;
- Elaboration of a technical report with general indications concerning the typology of defence actions and preparation of Civil Protection guidelines;

3.1.3.3 - Flood Risks

Objectives

- Delimitation of the areas affected by flood events and with problems connected to difficulties in the drainage of surface waters;
- Definition of the intensity of the alluvial phenomena (return period, water height, time of permanence, energy of the flood stream, etc.);
- Quantification of the population and delimitation of the structures involved by flood events and estimation of prevalent-potential damages;
- Assessment of the magnitude and frequency of the flood interference[13] with human activities;
- Estimation of the prevalent and potential risks caused by the flood events in the basin;
- Identification, on the basis of the different hydraulic hazard situations surveyed, of guidelines for structural- and non-structural measures for reduction of risk conditions;
- Identification of general guidelines for territorial management, in order to reduce hydraulic risk;
- Identification of guidelines for preparation of general and detailed Civil Protection plans.

Scope

- The entire basin;
- Particular sub-basins;
- Urbanized areas close to the water courses.

Technical Execution

- Identification, on the basis of the hydraulic modelling of the basin, of critical cross sections (see Hydraulics Section: 3.1.2.2.7), historical flood events, inefficiency of the existing hydraulic works, and delimitation of the prevalent and potential areas subjected to flooding with respect to the return period;
- Analysis, on the basis of population, actual and expected land use, of the potential damages with respect to the characteristic aspects of alluvial phenomena (return period, water height, time of permanence, energy of the flood stream, etc.);
- Comparison between the flood events and their potential damages, in order to define the risk conditions of the studied area;
- Preparation of a risk map;
- Elaboration of a technical report concerning the typology of defence actions and the preparation of Civil Protection guidelines.

3.1.3.4 - Sensitive Areas

Objectives

- Delimitation of the areas and definition of the resources (water, soil, etc.) potentially involved by one or more environmental risks following a flood event;
- Evaluation of the short- and long-term damages caused to the environment and to human activities and identification of the type, time and costs for the environmental rearrangement;
- Estimation of the potential environmental risks of the basin;

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[13] Measured in terms of actual or potential economic losses and danger of human lives.

- Identification, on the basis of the potential environmental hazard situations, of guidelines for definition of structural and non-structural actions for reduction of risks in the basin;
- Identification of general guidelines for territorial management, in order to reduce environmental risk in the basin;
- Identification of guidelines for preparation of general and detailed Civil Protection plans.

Scope
- The entire basin;
- Particular sub-basins;
- Urbanized areas.

Technical Execution
- Analysis of information about the location and typology of all the potential pollution sources and comparison with the areas affected by geomorphologic, hydraulic and erosion risks in order to identify the potential polluting sources during calamitous events;
- Definition of hazard classes of the polluting substances through the preparation of an evaluation scheme on the basis of the characteristics of the elements that can potentially be dispersed in the basin (typology, quantity, residence and decay time);
- Qualitative-quantitative analysis, on the basis of the population as well as the actual and future land use, of the potential damage with respect to the characteristic aspects of polluting phenomena (intensity, duration, residence time and de-pollution costs);
- Comparison between the potential polluting events and their potential damages, in order to define the risk conditions of the studied area through the preparation of an evaluation scheme on the basis of the characteristics of the prevalent and potential polluting phenomena;
- Preparation of a risk map with respect to the highlighted risk conditions;
- Elaboration of a technical report with the typology of defence actions and the preparation of Civil Protection guidelines.

3.1.3.5 - Vulnerability Zoning

Objectives
- Delimitation of the areas affected by one or more of the existing risk conditions (hydraulic, geomorphologic and erosion risks);
- Comparison of the importance of each risk condition and definition of an evaluation scheme for the global zoning of the risk degree of the basin;
- Estimation of the global risk conditions in the basin;
- Identification, on the basis of the hazard situations surveyed, of guidelines for definition of structural- and non-structural measures for reduction of risks in the basin;
- Identification of general guidelines for territorial management, in order to reduce the global risk the basin;
- Identification of guidelines for preparation of general and detailed Civil Protection plans.

Scope
- The entire basin;
- Particular sub-basins;
- Urbanized areas.

Technical Execution
- On the basis of the information regarding the typology and geographic distribution of the different risk conditions, delimitation of the areas involved by one or more risk conditions;
- Definition of an evaluation scheme of the different risk conditions existing in the basin assigning the maximum risk degree to the zone involved by more than one risk condition and a lower value to the areas involved by just one risk condition. The estimation of the degree of risk to be assigned to each risk condition must be done on the basis of the rapidity of the calamitous event (and perhaps other parameters such as extension, intensity) with respect to the preparation of Civil Protection measures;
- Preparation of a global risk map with respect to the highlighted risk conditions;
- Elaboration of a technical report concerning the typology of defence actions and the preparation of Civil Protection guidelines.

3.1.4 Geographical Information System (GIS)

3.1.4.1 Introduction

A Geographical Information System (GIS) (Figure 3.1.4.1 a) is a computer-based tool for capturing, storing, checking, integrating, manipulating, analysing and displaying data related to positions on the Earth's surface. Typically, a GIS is used for handling maps of one kind or another. These may be represented as several different layers where each layer holds data about a particular kind of feature. Each feature is linked to a position on the graphical image of a map. Layers of data are organized to be studied and to perform statistical analysis. Uses are primarily government related, town planning, local authority and public utility management, environmental resources management, engineering, business, marketing, and distribution.

A working GIS integrates five key components: hardware, software, data, people, and methods:

- Geographical Information System software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations. It provides the functions and tools needed to operate with the geographic information;
- Key software components are tools for the input and manipulation of geographic information, a database management system (DBMS), tools that support geographic query, analysis and visualization, and a graphical user interface (GUI) for easy access tools;
- Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider. A GIS will integrate spatial data with other data resources such as a DBMS;
- GIS technology is valueless without the people who manage the system and develop plans for its application to the real world problems. GIS users range from technical specialists, who design and maintain the system, to those who use it to help them perform their everyday work;
- A successful GIS operates according to a well-designed plan and business rules, which are the models and operating unique to each organization.

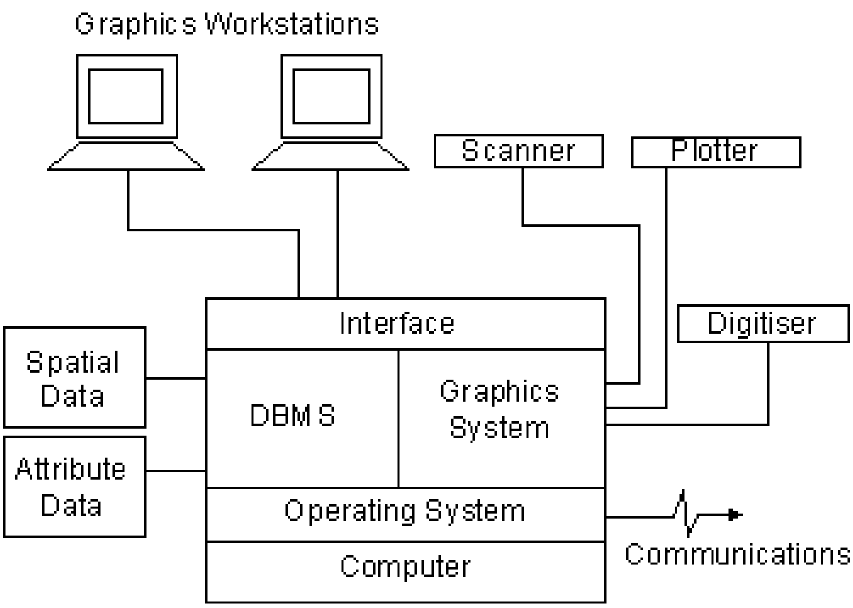

Figure 3.1.4.1 a – The physical components of a GIS
(adapted from the Association for Geographic Information)

3.1.4.2 How GIS Works

A GIS stores information as a collection of thematic layers that can be linked together by geography. This simple but powerful and versatile concept has proven invaluable for solving many real-world problems.

Geographic information contains either an explicit geographic reference, such as latitude and longitude, a national grid coordinate, or an implicit reference (as an address, zip code, census tract name, forest stand identifier, or road name).

3.1.4.3 Vector and Raster Models

Geographic information systems work with two fundamentally different types of geographic models: the “vector model” and the “raster model”. Modern GIS’s are able to handle both models.

Vector Model is an abstraction of the real world where positional data are represented in the form of cartesian coordinates. In vector data, the basic units of spatial information are points (such as a bore hole), lines (such as roads and rivers) and polygons (such as river catchments). Then, e.g., a line is a collection of related points, and a polygon is a collection of related lines. Vector data may or may not possess topological relationships. The vector model is rather useful for describing continuously varying features such as soil type or accessibility costs.

Raster Model is an abstraction of the real world where spatial data is expressed as a matrix of cells or pixels - the smallest unit of information available in an image or raster map (Figure 3.1.4.3 a), with spatial position implicit in the ordering of the pixels. With the raster data model, spatial data are not continuous but divided into discrete units. This makes raster data particularly suitable for certain types of spatial operation, e.g., overlays or area calculations. Unlike vector data however, there are no implicit topological relationships.

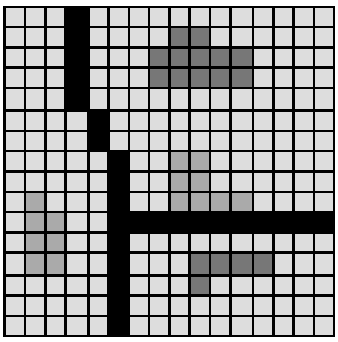

Figure 3.1.4.3 a – Raster model pixels

3.1.4.4 GIS Tasks

General purpose GIS’s perform essentially five tasks:

a) Input
b) Manipulation
c) Management
d) Query and Analysis
e) Visualization.

Before geographic data can be used in a GIS, it must be converted into a suitable digital format. The process of converting data from paper maps into computer files is called digitizing. Modern GIS technology can automate this process fully for large projects using a scanning technology; smaller jobs may require some manual digitizing (using a digitizing table). Nowadays, many geographic data already exist in GIS compatible formats.

Data types required for a particular GIS project need to be transformed in some way to make them compatible with our system. For example, when geographic information is available at different scales, it must be transformed to the same scale before it can be integrated. This process may be a temporary transformation, for display purposes, or a permanent transformation, required for analysis.

For small GIS projects it may be sufficient to store geographic information as simples files. However, when data volumes become large and the number of data users becomes larger, it is better to use a database management system (DBMS) to help store, organize and manage data.

There are rather different designs of DBMSs, but, in GIS, the relational design has been the most useful. In the relational design, data are stored conceptually as a collection of tables, where common fields in different tables are used to link them together.

Geographical Information System provides both simple point-and-click query capabilities and sophisticated analysis tools, in order to provide timely information to managers and analysts alike. GIS technology really comes into its own when used to analyze geographic data to look for patterns and trends and to undertake "what if" scenarios.

Modern GISs have many powerful analytical tools, but two of them - proximity analysis and overlay analysis - are especially important.

To answer to questions like "how many houses lie within 100 m of this water main?", GIS technology uses a process called "buffering" which determines the proximity relationship between features.

The integration of different data layers involves a process called "overlay". At its simplest, it can be a visual operation, but analytical operations require one or more data layers to be joined physically. This overlay, or spatial join, can integrate data on soils, slope, vegetation, or land ownership.

For many types of geographic operation the end result is best visualized as a map or graph. Maps are very efficient at storing and communicating geographic information. While cartographers have created maps for millennia, GIS provides new and exciting tools to extend the art and science of cartography. Map displays can be interacted with reports, three-dimensional views, photographic images and other outputs, such a multimedia.

3.1.4.5 Related Technologies

Geographical Information Systems are closely related to several other types of information systems, but it is the ability to manipulate and analyze geographic data that sets GIS technology apart. Although there are no fast rules on how to classify information systems, the following discussion should help us to differentiate GIS from desktop mapping, computer-aided design (CAD), remote sensing, database management system (DBMS) and global positioning system (GPS) technologies.

A desktop mapping system uses the map metaphor to organize data and user interaction. The focus of such systems is the creation of maps: the map is the database. Most desktop mapping systems have more limited data management, spatial analysis and customization capabilities. Desktop mapping systems operate on desktop computers such as PCs, Macintosh's and smaller UNIX workstations.

Computer-aided design (CAD) systems evolved to create designs and plans of buildings and infrastructure. This activity required that components of fixed characteristics in order to be assembled to create the whole structure. CAD systems require few rules to specify how components can be assembled and limited analytical capabilities. These systems have been extended to support maps but, typically, have limited utility for managing and analyzing large geographic databases.

Remote sensing is the art and science of making measurements of the planet earth using sensors, such as aerospace cameras, global positioning system (GPS) receivers, or other devices. These sensors collect data in the form of images and provide specialized capabilities for manipulating, analyzing and visualizing those images. Lacking strong geographic data management and analytical operations they can not be called true GIS.

Database management systems are specialized in the storage and management of all types of data, including geographic data. DBMSs are optimized to store and retrieve data and many GISs rely on them for this purpose. They do not have the analytic and visualization tools common to GIS.

3.1.4.6 What can GIS do for Flood Prevention

The ability of GIS to search databases and perform geographic queries has saved many companies millions of euros. GISs have helped to: a) decrease the time taken to answer population requests, b) find land suitable for development, c) search for relationships among crops, soils and climate or to locate breaks in hydraulic systems.

Many organizations that have implemented a GIS have found that one of its main benefits is improving the management of their own organization and resources. Because GISs have the ability to link data sets together by geography, they facilitate interdepartmental information sharing and communication: by creating a shared database one department can benefit from the work of another - data can be collected once and used many times.

The old adage "better information leads to better decisions" is as true for GIS as it is for other information systems. However, a GIS is not an automated decision making system but it can be used to support the decision-making process. GIS technology has been used to assist in tasks such as presenting information at planning inquiries, helping resolve territorial disputes, and siting pylons in such a way as to minimize visual intrusion. The information can be presented succinctly and clearly in the form of a map and accompanying report, allowing decision makers to focus on the real issues. GIS products can be produced quickly, multiple scenarios can be evaluated efficiently.

Maps have a special place in GIS, since the process of making maps with GIS is much more flexible than the traditional manual or automated cartography approaches. It begins with database creation: existing paper maps can be digitized and computer-compatible information can be translated into the GIS. The GIS-based cartographic database can be both continuous and scale free. Map products can then be created centered on any location, at any scale, and showing selected information symbolized effectively to highlight specific characteristics.

3.1.4.7 Geographical Information Classification

In this project, geographical data are divided into three types:

- Graphical data (maps)**:** object's graphical representation, in vectorial or raster format;
- Alphanumeric data (tables): valor attribution to graphical data;
- Multimedia data (map images, satellite and aerial photographs, photographs, documents, etc.).

The classification of geographical information themes must consider the existing relations between them (Figure 3.1.4.7):

- Context data: they are used only with descriptive purposes, where detail and accuracy does not affect the results or the consistency of the overall datasets; this information is not used to build new data or to spatial analysis;
- Structural data: they are not directly an object of calculations or spatial analysis but they assure the consistency of all datasets and can also be used as an alphanumerical aggregation data base and as a base for the definition of new boundaries;
- Inventory data: it is the class associated to objects that should be described exhaustively, without generalization by omission;
- Support data: they are used to perform calculations and spatial analysis and have direct influence in the results; the characteristics of support data are subject of option, balanced according to the intended characteristics of the resulting data;
- Derived data: they result from analysis or statements and are not directly a subject of option; the characteristics of derived data are defined at support data and procedure levels, or they are just stated that way without any possibility modification.

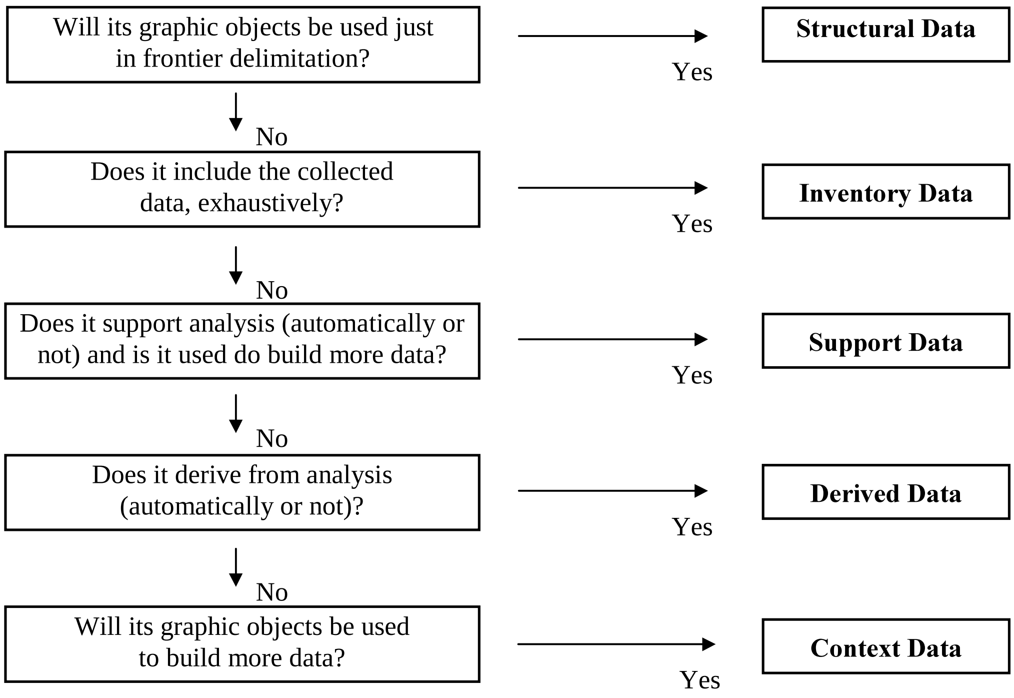

Figure 3.1.4.7 – Classification of information according to its cartographic use

3.1.5 Research Needs for Floods

The flood hazard is created by the excess of water but also by the loads of sediment and chemicals associated with the highest water discharges. Some activities, like deforestation, irrigation, industrialization and urbanization, when practiced in watersheds without careful consideration of their primary and secondary effects, can be devastating for downstream populations. Much of the main mechanisms causing floods are already known as are some of the relationships between the geophysical, atmospheric, hydraulic and hydrologic conditions of flood-prone systems. Still, more needs to be learned before losses due to floods can be successfully curtailed especially where structural and non-structural mitigation measures is the main concern.

Much research and has been generated on water resources management and on the flood hazard, covering a wide range of topics and disciplines. Hereinafter, only three topics on the flood hazard will be briefly discussed, forecasting, estimating probability, and flood plain management (Sabadell 1995).

Forecasting floods is essential for forewarning and planning and, contrary to droughts where long-term forecasting is important, the short-term forecast is of great consequence as is real-time forecast in the case of flash floods. During the past half century many efforts have gone into developing timely warning systems based generally on storm activity, precipitation, runoff and stream flow. Even if much advance has been made to date, results have been uneven, with researchers generally agreeing on that our best skills are on "how to route floods" and the poorest on "what to route" for riverine floods.

It has been pointed out also that in studying hydraulic and hydrologic flooding, where the former represents floods caused by failure of structures or flow stage changes by the sediment load, and the latter pertains to flooding due to rainfall, snow and icemelt, or a combination of them, research has been preeminent on hydrologic floods and especially on the development of precipitation-runoff models.

Examples of research areas that should receive increased attention are: development of in-situ and remote instrumentation and of methods for designing improved and new monitoring networks that can survive floods and other related hazards; improving and developing data acquisition systems and GIS including maps, data bases and spatial-temporal analyses; development of techniques for imagery and data management; assessment of the impacts of land use changes on flood plains and floods; improving precipitation prediction models; integrating physiographic and ecological characteristics of watersheds into flood forecasting models.

Estimation of probabilities of floods has been for several decades and continues to be a very active area of research. In general terms, flood frequency is estimated by using hydrologic data to produce probability statements, maps and other products for purposes of design and planning. The body of literature produced is impressive and many approaches have been used, for example: deterministic or stochastic, using real and synthetic storms, transforming precipitation into flood, and transposing storms from one basin to another.

To date, research results have been good but not entirely satisfactory especially in the modelling of extreme floods and for risk assessment. The availability of quality data in the necessary amount is still a problem, especially for historical data. Several tools have been developed to deal with hydrologic uncertainty, e.g., Monte Carlo simulation, as it has been done for increasing the information available, e.g., Bayesian analysis, but, in this area as in many others related to flood, substantive research efforts are still necessary.

For flood plain management, gaining knowledge in the regional hydrologic modelling of rainfall-runoff, in the erosion and transport processes together with the regional analysis of statistical frequency and magnitude of flood occurrence; a better understanding of the river basin topography, surface and soil storage capacity and of flood plain geomorphology; an improved knowledge of the flood plain ecology and the means to maintain biodiversity in the face of flood plain development; the development of new and improved watershed models; and a better understanding of the economic, legal, social and political constraints and opportunities in flood plain management can provide the capabilities and tools needed for improving the mitigation of the flood hazard (Sabadell 1995).

3.1.6 Conclusions

The following scheme (Figure 3.1.6) is based on a succession of steps which consist in the preliminary collection of data regarding territorial aspects of the basin, analysis of the information gathered, diagnosis of existing risk conditions and singling out of the general typology of intervention for mitigating and/or solving the existing problems. The first phase of application of this methodology must further be followed by a successive analysis (Post-Project Analysis) regarding:

a) evaluation of the benefits produced by the accomplishment of the protection and defence actions set up;
b) revision of the bindings force of the law about land use - territorial planning;
c) model validation by comparing predicted and measured values.

1) DATA INVENTORY AND ANALYSIS

HISTORY SOCIO-ECONOMY ENVIRONMENT	METEOROLOGY AND CLIMATE	RUNOFF AND DRAINAGE NETWORK	GEOLOGY AND GEOMORPHOLOGY
HYDROGEOLOGY	SOILS	LAND USE	HYDRAULICS

2) DIAGNOSIS

LANDSLIDE RISKS	RETENTION AND RECHARGE AREAS	EROSION RISKS	FLOOD RISKS
AGRICULTURAL AND FOREST LAND	URBAN DEVELOPMENT AND PRESSURES	SENSITIVE AREAS	VULNERABILITY ZONING

3) PROPOSED ACTIONS (see Sections 3.2 and 3.3)

NON-STRUCTURAL INTERVENTIONS	RISK ACCEPTANCE	Toleration strategies	- Evaluation of risk; - Civil protection and response systems (emergency measures involve protection, evacuation, risk emergency services); - Insurance against damage caused by floods.
	RISK REDUCTION	Prevention strategies	Basin Area Management: - Delimitation of flood areas and securing of flood plains; - Flood areas regulation (national, international and european legislation, Regional Land Use Plans, Local Director Plans, construction restrictions and contracts, planning use and soil using actions); - Financial measures for rehousing and use conversion; - Management of Agricultural, Forestry and Ecological Areas.
		Attenuation strategies	- Reduction of discharge through natural retention; - Flood prediction (involves flood forecasting, flood warning and flood alert); - Public information, education and public consciousness campaigns.
STRUCTURAL INTERVENTIONS	SHORT-LONG TERM		- Passive Flood Control; - Active Flood Control (Retention Basins); - River Training Works; - River Corridor Enhancement Rehabilitation and Restoration; - Agricultural and Forestry Measures.

4) POST PROJECT ANALYSIS (see Chapter 5)

Figure 3.1.6 - Methodology Scheme for the Protection of Small-Medium Basins Prone to Flash Floods

3.2 NON-STRUCTURAL INTERVENTIONS

3.2.1 Introduction

Extreme flash floods strongly affect natural and constructed environments. Floods, avalanches and mudslides are a threat to the valleys of mountainous regions, whereas long-lasting high water can jeopardize settlements and areas of economic relevance in the planes. Due to this situation, agricultural land and sites for industrial exploitation are scarcely available, whereas the quest for building land becomes more and more pressing, leading to intrusion into flood plains. This trend will continue into the future.

Very early, measures for the protection of valley floors against floods were adopted in many countries, so as to favour settlement. Reports of serious damage to villages and objects caused by catastrophical floods, however, demonstrate that it is impossible to achieve absolute protection against such events and that intervention has sometimes even worsened the situation further downstream because of the elimination of natural retention surfaces and the ensuing acceleration of flood waves.

Governments have recognized that the public cannot respond to, recover from nor prevent this kind of major disaster without the help of local, state, national and international special agencies and programs (Correia et al., 1993). To address these needs, legislation and executive orders have been issued and implemented, and some actions taken during the last decades.

State governments have instituted flood plain management plans and are also responsible for emergency preparedness and response, protection of natural resources and environmental quality and economic development. Some of the activities carried out at the regional level are: acquisition and relocation, building of levees, flood plain mapping and flood plain protection projects, and drought relief programs.

It should be noted that, in many nations, governments respond to natural hazards in two modes: the "active" mode immediately after a disaster, and the "passive" mode in between disasters. Quick responses and high priorities characterize the first manner of action, and low priority and slow-to-no-action illustrate the second. Governmental efforts are in general concentrated on emergency response and on recovery. Of late though, the importance of mitigation has been growing (Correia et al., 1993).

Examining the records for worldwide natural catastrophes it can be concluded that hydrologic extremes have affected and continue to strike many more lives and livelihoods than earthquakes and severe wind combined. In the United States (Berga 1988), disasters related to water have produced about 60% of the life and economic losses caused by all the federally declared disasters during the last three decades. Trends in that country seem also to indicate that life losses are declining because of good warning systems and other adopted mitigation measures, but that economic losses are increasing because of the growing population and economic activities living in areas of raising risk.

Research on floods now engage a significant number of disciplines ranging from meteorology to hydrology, soil mechanics, fluid dynamics, engineering, agriculture and forestry, social sciences, geology, computer science, and economics to name only a few. It should be noted that water resources administrators and policy makers separate the management of water resources under normal and under extreme conditions into different sets of planning and implementation actions even if they have emergency response responsibilities.

Structural means have long and massively been employed to reduce flood problems in Europe. These kind of measures have generally been well accepted by residents and localities. Nevertheless, they have their limits.

Therefore, along with active measures (structural interventions), the water management ensures protection against floods through passive measures (non-structural interventions), i.e., measures that, in the long run, will render active intervention often unnecessary, which has also favourable effects on the national economies.

Because of a growing body of knowledge, prevention measures are being developed and adopted all over the world in an increasing number, e.g., building codes, flood insurance, warning and monitoring systems, retrofitting of buildings and structures.

Non-structural interventions involve several alternatives, from land use planning to constructions and structure management codes, soil management and acquisition policies, insurance, perception and awareness, public information actions, emergency systems and post-catastrophe recovery.

Reducing flood damages involves different kinds of non-structural measures:

Risk Acceptance

- **Toleration Strategies:**

- Evaluation of risk;
- Civil protection and response systems (emergency measures involve protection, evacuation, hazard emergency services);
- Insurance against damage caused by floods.

Risk Reduction:

- **Prevention Strategies:**

  Basin area management:

  - Delimitation of flood areas and securing of flood plains. This is achieved by enclosing flood catchment areas and ensuring that they are exploited only for activities that are compatible with the water regime as envisaged in regional policy prescriptions and in the provisions for the identification of new building land. This is to preserve and improve flood discharge and bed load transport so as to head off later remedying intervention;
  - Flood areas regulation (national, international and european legislation, Regional Land Use Plans, Local Director Plans, construction restrictions and contracts, planning use and soil using actions);
  - Financial measures for rehousing and use conversion;
  - Management of agricultural, forestry and ecological areas.

- **Attenuation Strategies:**

  - Reduction of discharge through natural retention;
  - Flood prediction (involves flood forecasting, flood warning and flood alert);
  - Public information, education and public consciousness campaigns.

In an effort to slow escalating flood losses and to reduce mounting expenditures for structural protective works and because of concerns over their environmental costs, State and local policy should favor non-structural alternatives to protection works.

3.2.2 Basin Area Management

The interest of an integrated water basin management, particularly, land use control in floodplain areas, is not only to reduce damage from floods but also to attain social objectives and to focus on the conservation and preservation of floodplain environments. In this way, land use control and planning may be a tool to reduce vulnerability of floods but also to develop a "sustainable" approach to basin management. Structural measures cannot reach these objectives if they are used alone.

The success in the management of flood areas depends on the selection of suitable measures, based on flood characteristics, physical and morphological characteristics of flood areas, economical and social conditions, political and environmental conditioning or flood control works planning.

3.2.2.1 Urban Development Safeguards

The pressure exerted by high population density and the unsustainable transport situation have lead to considerable increasing of runoff in urban areas. Very often, the chaotic development of constructions leads to dramatic worsening of the flood problem. The present studies on flow patterns provide the basis for the protection of endangered settlements and objects against flood risk, but they also help to identify priority areas that should be kept clear from constructions both for future active intervention (for example, the construction of a flood retention basin) and passive flood control purposes.

From the experiences of PREMO ’98 partner countries, the definition of hydraulic risk conditions is based on the precise determination of the areas subject to flooding as a function of hydrologic-hydraulic criteria. The solutions adopted in each country are next synthetically described:

In Austria, in order to avoid later planning and construction errors, the results of run-off evaluations are generally included in regional development programmes and in the land use and construction plans of the various municipalities. According to the Act on Water Right (WRG 1959), the limits of flood catchment areas have to be defined and any intervention within the 30-year return time period (HQ_{30}) flooding zone requires special authorization (amendment of July 1, 1990). Against this background, since 1990 the Water Management Section of Styria has started to outline the HQ_{30} and HQ_{100} flooding areas, mainly along longer sections of water courses. Knowledge of the limits of flood run-off areas relating to a specific HQ not only provides the basis for the control of nearby communities, but also enables authorities to keep these areas clear of constructions in order to preserve flow retention, thereby curbing flood peaks, and avoid harmful effects on the lower course.

Among the water management objectives contained in the directives to the Federal Hydraulic Engineering Administration (RIWA-T) there is the securing of flood catchment areas: territories lying within the HQ_{100} boundaries, which have to be kept clear of constructions, are located and marked as water management priority areas in order to avoid harmful consequences on the maximum flood discharge flow, with particular respect to combination effects caused by human intervention. They are then registered in the Land Use Plans of every municipality, as envisaged in the Regional Policy Act (ROG 1974). This way of securing land coincides with the traditional method of “passive flood control”, whereby flood catchment areas are to be kept clear of constructions in order to avoid long-lasting damage (non-commercial use of land for the public benefit, as stated in the ROG). The ROG and the Styrian Building Act establish that valuable building land has to be free from flood risk.

In Tuscany (Italy), the D.C.R. 230/94 gives indications concerning the preparation of Town Planning Plans and in particular distinguishes the following areas of hydraulic respect:

- A1 area - comprehends the torrent bed and its banks, if present, plus a lateral area 10 meters wide on each side. Modifications of the Town Planning Plan for the construction of new buildings or morphological changes are forbidden. Hydraulic protective works, crossing structures, water derivation, etc., that do not increase the hydraulic risk conditions are permitted.
- B area - an external area to the A1 area, that includes surfaces along each side of the water course that have an elevation lower than 2 meters above the brink of the torrent levee (or external foot of artificial banks) with a maximum extension of 300 meters of width. Application of the Town Planning Plan indications can be made if only the hydraulic safety is certified by the carrying out of hydrological-hydraulic analysis of the torrent with a return time period, at least, of 100 years. While concerning the preparation of new Town Planning Plans or their modification, the hydraulic safety of territory for 200 years return time must be proved.

Concerning the hydraulic risk of the areas outside the previous limits, the Regional Decree establishes the following four different hydraulic risk levels on the basis of the morphological safety of territory and the occurrence of historical flood events:

- irrelevant - elevated areas and no historical flood events;
- low - flat areas and no historical flood events;
- medium - flat areas or historical flood events;
- high - flat areas and recurrent flood events.

In the areas that have a medium and high level of risk, specific hydraulic studies that define the HQ_{100} and HQ_{200} limits must be considered in the preparation of municipal Town Planning Plans.

In Portugal, the Water Institute (INAG) is the main agency responsible for the prosecution of water resources policies, including flood management and co-ordination of civil operations. Basin Plans, currently under development, will consider, according to Decree-Law 45/94, a: i) diagnosis including identification of risk areas and situations; ii) a proposal of measures to regulation and flood control, as well as physical, financial and institutional programming of the proposed actions. The National Water Plan, according to the same Decree-Law, must include measures for co-ordination of the several Basin Plans and for co-ordination of these and the other sectorial and land use plans as well as its co-ordination with Spain management of international basins.

The Municipal Master Plans (PDM) are relevant planning instruments that combine public utility reserves determined by the National Agricultural Reserve (RAN), the National Ecological Reserve (REN) and the public water domain.

The Decree-Law 468/71 defines the concept of public water domain; the 100-year flood is considered as the basis for defining the adjacent area - where construction is subject to licensing by the water authority. Decree-Law 89/87, an extension of Decree-Law 468/71, still considers HQ_{100} as the basis for defining the adjacent area which is subject to strict regulation with respect to construction, namely the consideration of a non-edificanti zone.

Portuguese legislation concerning the adoption of non-structural measures has been deficiently applied; in many situations, the Municipal Master Plans (PDM's) simply ignore the delimitation of flood risk areas. It is important that PDM's and other planning instruments consider the identification of risk and adjacent areas, harmonizing these areas with urban shapes and guaranteeing appropriate safety levels.

Decree-Law 364/98 requires the elaboration of a floodable area map for all the municipalities containing urban centres affected by floods, at least since 1967, and that do not have adjacent classified zones according to Decree-Law 468/71. This map must include, inside the urban perimeter, the areas affected by the highest known flood. When higher level flood occurs, or when Water Basin Plans or other studies allow the definition of the 100-year flood, municipalities must proceed to the alteration of the floodable areas boundary line. Municipalities have 18 months to change their Municipal Territorial Management Plans (PMOT) inside the highest known flood limit or the 100 meter buffer, if the highest flood limit is unknown. Any project, to be approved, must prove, through appropriate study, that it does not set up a risk to people and goods safety.

PMOT's must include the areas mentioned by Decree-Law 364/98 and their regulations must establish the necessary restrictions to minimize flood risk, including, in the urban areas, specific norms for construction, protection and draining systems, measures for the maintenance and recuperation of the soil permeability conditions and, in the future urban potential areas, the interdiction or the regulation of construction.

Comparison of the situations in these three countries highlights the homogeneity of the criteria for determination of hydraulic risk conditions of the territory. In fact, all of them consider the definition of return time periods as the most useful tool. They represent the reference point for delimiting areas subjected to flooding (Austria – Portugal) or for determining conditions of inadequacy of the hydrographical network, defining the areas subjected to flooding on the basis of geometric and morphologic criteria (Tuscany).

Hydraulic studies on entire basins are necessary to determine flood risk areas; these should be mapped on a detailed scale (1:5 000 – 1:10 000 is sufficient in most cases). It is also important to map areas that have already been flooded, since the comparison can eventually turn out useful to verify the resulting areas.

Delimitation of these areas is therefore a pre-requisite to correctly lay out urban development and land use plans. Only then the limitations (laws and regulations) on soil use can be proposed, that is, as a function of ascertained risk conditions.

Return time periods associated with risk conditions are usually determined as a function of two situations: recurrent risk (HQ 25-30 years) and a sporadic or exceptional risk (HQ 100-200 years).

Particular attention should be placed on the consideration of hydraulic risk conditions connected to possible structural failures of artificial banks of rivers and canals causing concentrated water flows. In such eventualities, even if the discharge capacity of these hydraulic sections has been calculated for long return time period flooding, adjacent areas still have an elevated risk that is not easy to evaluate. Even though the prediction of this type of phenomena is difficult, certain measures can be taken, such as fixing certain distances from artificial banks for buildings and infrastructures, which would at least reduce risk to people and things.

Artificial basins can also represent a flood risk, in fact, the potential hazard of a dam is usually high, involving an extensive area located downstream. In view of this fact, for example, the portuguese government has assumed a higher commitment as regards the responsibility for protecting the populations that are likely to be affected by dam-break accidents. Thus, the "Regulamento de Segurança de Barragens -

RSB" (Portuguese Regulations for Safety of Dams) was published in 1990, which has led to a significant improvement in the analysis and safety of dams in Portugal.

Comunitary Directives 85/337, 96/61 and 97/11 regarding envirnmental impact analysis include large dams among the type of works on which to carry out risk assessment, especially considering the possibility of dam break.

Some countries consider as dangerous dams only the large dams according to the International Committee on Large Dams (ICOLD) definition or, even, larger dams. But, as a rule, small dams are also included in the safety programs.

Table 3.2.2.1 gives a general idea (not exhaustive) on how legislations consider this subject. The definition of H, height of the dam, varies from country to country. Sometimes, the required values of H and Vt (reservoir capacity) are cumulative, other times they are alternative. Furthermore, legislation may vary in federal states and be subjected to updates and other conditions.

Table 3.2.2.1 - Minimum values of H and for Vt, that imply special safety measures

Source	**H (m)**	**Vt (m^3)**
ICOLD	15	1 000 000
Austria	15	500 000
Italy [14]	10	100 000
Portugal	-	100 000
Finland	3	-
Norway	4	500 000
Sweden	5	50 000
Switzerland	10	50 000
United Kingdom	-	25 000
USA and Canada	7,6	62 000

Small values of H and Vt are not a guarantee of no danger to downstream people. Each case should be examined, even in an expedite way.

In the light of comparison of the different experiences, the Styrian one represents straight-forward and rational way of concieving urban development safeguards. Flood catchment areas are well defined and special permits must be issued for interventions in the HQ_{30} flooding zone. Since 1990, flood plains corresponding to HQ_{30} and HQ_{100} events have been marked out over extensive river segments.

Knowledge of the extension of flood runoff areas referring to specific HQ values not only provides the basis for the protection of endangered settlement areas (HQ_{100}) but it is also fundamental to make sure that construction activity does not take place in these specific areas so as to maintain flow retention and curbe flood peaks. Thus, HQ_{100} events have to be outlined and kept clear of contructions to prevent harmful consequences on maximum flood discharge flow, especially with respect to possible combination effects. These areas are known as hydraulic engineering priority zones.

According to the provisions envisaged in the Federal Directives on the Promotion of Hydraulic Engineering Works (Water Promotion Act), protection of settlements and transport ways should be guaranteed against an HQ_{100} event. When this risk limit is not possible to be reached, the lowering to a security level corresponding to an event recurring every 30 years (HQ_{30}) is exceptionally accepted.

These directives do not envisage special protection measures for agricultural land and forests. For privates, they assume their own risk and will have no financial aid.

To this end, the Styrian Regional Policy Act (ROG 1974) envisages that flood plains be indicated in each communal land use plan. This land enclosure procedure can be regarded as the traditional ”passive flood

[14] Limits that imply carrying out of environmental impact analysis.

control” method, i.e. to keep flood discharge areas clear of buildings so as to head off the need for remedying intervention (and uneconomic use of public money) at a later time.

Another important condition is that the recommendations of hydraulic engineering experts on passive flood control be complied with in regional development programmes and construction plans. The ROG and the Styrian Building Act both prescribe that valuable building land must in any case be free from flood risk.

In the framework of the studies on water flow carried out by the water management, proposals concerning general measures for the protection against floods of endangered objects and settlements are also made. A crucial aspect is the early securing of areas for flood control purposes, so as to have them available in emergency situations. To this end, territories that are particularly suitable for water retention or that are necessary to build earth dams or dikes are singled out and marked as ”devoted to special purposes”, which is also reflected in the land use plans. Such procedures are known as “land securing measures”.

The aim of water management to preserve natural retention areas and improve their state is in contrast with the desire to employ them for industrial, economic, agricultural, settlement and transport purposes. Hence exploitation conflicts are bound to arise.

The objective of ”keeping flood catchment areas clear of constructions” is not yet envisaged either in the Water Act or in the Regional Policy Act. In practice, however, the studies on water run-off are often taken into consideration by local authorities. A very effective instrument in this context is provided by the conditions established by the Federal Hydraulic Engineering Management for the granting of subsidies and envisaged in the Act on the Promotion of Hydraulic Engineering Works. According to these provisions, denial of subsidies for the implementation of flood control measures is possible.

According to the provisions of the RIWA-T, flood control measures or any other intervention entailing reduction of the retention surface of a flood plain can only be subsidized if compensation measures are adopted. Flood control measures for the protection of settlements and objects located in an HQ_{30} flooding zone, that were built after July 1st , 1990 or for which building permit was issued after this date, are no longer subsidized.

Depending on the standard of available technical support, the fulfilment of technical project requirements is often associated with morpho-environmental evaluation of the water course and its banks and, occasionally, description of the forms of exploitation of the surrounding land.

If regional planning authorities can prove the existence of interests transcending the mere local level, the water management may intervene to secure areas from flood risk and provide compensation for the loss of flood retention surfaces.

Along with the identification of the flood plains that are involved in HQ_{30} and HQ_{100} events, water management authorities draw up danger-zone maps for river regulation and torrent control interventions. On the danger-zone maps, the surfaces that are not suited for settlement and transport purposes are marked in red. The flooding area that is comprised between the encircling line of the red zone and that of the HQ_{100} zone is known as “yellow danger zone”. Here, floods can cause damage to constructions. In the areas beyond the yellow zone, residual risk cannot be excluded.

The study of flow patterns is the first step towards the outlining of a comprehensive picture of the various water courses. This is synthesized in water-course conservation programmes. The second step then is the definition of water management and environmental objectives and the working out of measures to protect both water courses and their surrounding land.

3.2.2.2 Management of Agricultural, Forestry and Ecological Areas

In Styria, the objectives of water management no longer include the protection of agricultural land against floods. Recently, the problem of extensive soil erosion in the fields and consequent sedimentation of fine grained material in water courses has become more and more pressing. Deposition of fine material is not only a cause of reduced water flow in the main river channel but it also considerably worsens water quality (nutrients, pesticides) and impairs the ecologic function of the water course. Only rarely it is possible to influence cultivation practices. Therefore, the water management is mainly focussing on the creation of lateral bank strips (min. 5-10m on each bank), functioning as buffer zones against intensive agricultural exploitation, and as sedimentation reservoirs along lateral branches.

In Italy the existing national law, RDL 3267/23, has long since been an efficient safeguard against erosion and landslide risks in hill and mountain territories by establishing particular restrictions of land use to extended areas, carefully delimited on maps, that present the so called hydrogeological risk. In Tuscany, Regional Law 1/90 has gone further by establishing that all of the woods of the region, even if not delimited by RDL 3267/23, are subject to the “Directions of Principle and Forestry Police” enforced on a provincial level. The indications contained in the law regulate the use of woods as regards the way of cutting, the transformation of woods and pastures into cultivated land and provide that any movement of terrain must be authorized by the Provincial Administration. These two laws are the only measures that limit extensive soil erosion and the consequent sedimentation of fine-grained material in water courses.

Other general indications concerning management of agricultural, forestry and ecological areas directed towards soil erosion reduction and flood prevention are given by the Basin Plans defined by the River Basin Authorities (National Law 183/89 and Regional Law 91/98).

In Portugal, Decree-Law 196/89, modified by Decree-Law 274/92, defines the legal regime for the National Agricultural Reserve (RAN). The National Agricultural Reserve aims to protect the best agricultural soils, delimiting areas according to its soil use capacity. The RAN is an important planning instrument concerning floods, since it includes a great number of soils located in flood-plain areas. RAN legal regime allows the extension or overlapping of water domain, contributing to establish non-structural measures to flood protection.

The legal regime for the National Ecological Reserve (REN), defined by Decree-Law 93/90, derived from European directives, may be considered as regulatory instruments contributing to the ecological preservation of water resources. The REN aims to be a "biophysical and diversified structure to assure ecosystems protection and the continuity of the biological processes, necessary for an adequate framework for human activities, by limiting the use of areas with specific ecological characteristics". REN includes floodplains, freshwater areas and areas with large maximum infiltration rates and with steep slopes. Concerning flood control, it includes flood risk areas, river springs protection and areas with large erosion risk rates.

This review of the legislative instruments for management of agricultural, forestry and ecological areas existing in Austria, Italy and Portugal puts in evidence that regulation regarding this matter is rather limited. Nevertheless, it is generally recognized that the correct management of agricultural, forestry and ecological areas can have a primary role in the reduction of surface runoff and can sensibly modify the entity of the flood event. For this reason, an action of setting up detailed regulations on a european level for the correct management of these areas from the hydrogeological point of view can constitute a base for protection from hydraulic risk. To this purpose, certain forms of incentives to farmers and people operating in the forestry sector could be sought in analogy of the already existing regulations in these activities (EEC Reg. 2078/92 and 2080/92).

It is important to underline the need to take into account particular criteria of management of agricultural areas when thinking of possible specific communitary regulations:

- favouring utilizations of agricultural land that induce infiltration of water in the soil (for example, certain types of soil tillage, increase of the organic fraction, etc.);
- favouring the maintenance of agricultural layouts that reduce the phenomena of erosion and solid transport (crosswise tillage, grass covering, etc.);
- development of small scale drainage networks of superficial water that can prolong concentration time of rain water (holding of water in the ground);

- favouring utilizations of agricultural land that maintain the soil covered during the whole year (by means of right successions of cultivations).

For pasture areas it is instead necessary to:
- regulate the density of animals as a function of the availability of resources.

Management of forestry areas must:

- favour a sustainable use of the woods taking its multifunctional nature into account (productive, protective, recreational, ecologic, landscape functions);
- maintain stability of woods from the ecologic point of view (mixed woods, woods of different age, etc.);
- favour the increase in area of wooded surfaces.

Ecological areas should:
- include lateral bank strips along river and torrent beds functioning as buffer zones against intensive agricultural exploitation, and as sedimentation reservoirs along lateral branches such as those implemented in the Styrian water management and to be considered analogous to the Portuguese REN areas;
- not be isolated but be connected between each other by the enhancement of river corridors which represent the main, and sometimes the only, ecological corridors (see Section 3.3.4).

The indications mentioned above should be included in plans and regulations for correct management of agricultural and forestry territories to be implemented on the basin scale. However, long time periods are expected for these measures to have a significant effect of surface runoff reduction and reduce the sediment discarge along the streams.

3.2.3 Flood Insurance Policies

In Styria (Austria), insurance against flood damage is to be conceived as an integral part of the risk acceptance. Since high population density in the danger zones suggests that potential damage is very extensive, difficulties may arise in the analysis and evaluation of the different risk factors.

The water management must in any case be ready to face an increase in the number of insurance policies against flood damage in the next few years. This could, however, have the undesirable effect of intensifying settlement in flood plains because potential damage would be covered by the insurance.

An interesting experience with this respect (U. Rosenthal et al., 1997) exists today in France by a scheme that was devised by a law of 1982. It has the characteristics of a voluntary private insurance, though non specific for this type of damage, but on the other hand it is also State organized. A central fund for insurance for the risks caused by natural disasters is guaranteed by the State to the benefit of insurance companies, and it is activated only with the declaration of “state of natural disaster” issued by an interminesterial order according to a strict procedure. The premiums are set as a percentage of reference premium and not, as it is usually the case, according to the potential value of the damage. The scheme has worked pretty well even though in the last years, due to the recurrent floods, perplexities have arised as to the economic sustainability of the system.

Until now, in Italy, insurance policies against damages caused by natural disasters had not been considered. After the flood event that occurred in Campania (Southern Italy), in the Spring of 1998, the Government began to discuss the possibility of using this instrument in areas subjected to risks.

One publication of the Regione Toscana (ANPA-ARPAT, 1998) puts forth a formula to calculate the risk in a certain area as a function of the return time of the disaster event and the duration of the insurance policy:

$$P = [\ 1-(1-1/T)^{L}]\ x\ 100$$

where: P = probability of risk (%); T = return time (years); L = duration of policy (years).

For example, for a flood event with a return time period of 200 years and for an insurance policy that lasts 10 years, there subsists a probability of risk of 4,9%. However, up to this date, no news are registered of Italian insurance companies that are in the process of stipulating insurance policies against natural disasters.

The agricultural activity is more exposed to risk than any other economical activity and among these, meteorological risks have a very important role. In Portugal, Decree-Law 395/79 of 21 September, reviewed by Decree-Law 283/90 of 18 September, created the crop insurance to guarantee farmers profit stability. Decree-Law 326/95 of 5 December establishes an Integrated Protection System against Climatic Aleatorities composed by a crop insurance, a disaster found and a damage compensation. Crop insurance is an agricultural investment incentive and contributes to guarantee farmers profit stability, and also works as an agricultural policy instrument in view of a correct crop planning. It warrantees the defence of fire, ray, explosion and hail risks and, as complementary insurance, tornado, rainfall, frost and fall of snow risks (see Section 2.2.2.4).

On the basis of the various experiences it results that the system of insurance policies applied only on local level is far too expensive both for insurance companies and for private and public entities. However, a mandatory national or European insurance fund against natural hazards could spread costs and follow the concept of joint sharing of burdens.

3.2.4 Financial Support (to Individuals and to Local Communities)

In Austria, the financial support (Water Construction Promotion Act) for the construction of structural interventions is shared among the different administrative levels. The total amount is divided by the state, regional and local administrations.

The following tables describe possible financial burden-sharing for the planning and buiding phases (table 3.2.4.a) and for the maintenance phase (table 3.2.4 b):

Table 3.2.4 a - Financial support for planning and building in Austria (Styria)

Projects	Federal means (%)	Regional means (%)	Applicants (%)
Intervention in the interest of applicants	30 – 60	30 – 40	10 – 40
Nationwide federal rivers and border rivers	90 – 100	0	0 - 10

Table 3.2.4 b - Financial support for maintenance in Austria (Styria)

Maintenance	Federal means (%)	Regional means (%)	Applicants (%)
Intervention in the interest of applicants	33 (1/3)	33 (1/3)	33 (1/3)
Nationwide federal rivers and border rivers	90 – 100	0	0 - 10

Private contributions are required by the authorities for the construction of structural interventions that give a direct benefit to one or more private owners.

Directives on funding are also channelled in the elimination of risk conditions through the application of the following actions:

- Transfer of land exploitation activities to safe areas;
- Acquisition, by public administrations, of areas frequently subjected to floods.

Policy is able to reduce or eliminate the source of risk, in order to prevent the recurrent expenditures for the damages of business and private settlements.

In Italy, the basic rules on funding of hydraulic works of public interest is regulated by the still standing Royal Decree 523 that dates back to 1904. Since the onset of Regional Administrations in 1972, several Italian Regions have partially updated these rules, and Tuscany has done so with Regional Laws 34 of 1994 and 91 of 1998.

Royal Decree 523 classifies interventions on rivers courses belonging to five distinct categories of decreasing importance which determine who is to provide funds for the interventions and who must maintain them:

1st category - hydraulic works that have as object the conservation of riverbeds of rivers that run along national boundaries. The State finances them and pays entirely for their maintenance.

2nd category - works along embanked rivers and along their tributaries if they are embanked, as well as new channelling, deviation of river courses and related works. Their funding is 50% paid for by the State, 12,5% by the Provincial Administration/s, and 37,5% by Public bodies of lower levels. Their maintenance is provided for among the same subjects and in the same proportions.

3rd category - all works along water courses, not comprised in the first two categories, and that have at least one of the following objectives:

- defend railways, major road systems and other important works of public interest;
- improvement of the regime of water courses that already have works of the 1st or 2nd category;
- prevent any flooding, overflowing, bank erosion and sedimentation that can cause damage to the territory and to settlements, or produce bogging of agricultural grounds.

Their funding is 50% paid for by the State, 10% by the Provincial Administration/s, 10% by the Communal Administration/s and the remaining 30% by a consortium of private landowners which receive the benefits. Maintenance is entirely paid for by the consortium of private landowners.

4th category - works having to do with riverbed improvement and containment of waters within rivers and torrents, that are not comprised in the previous categories. Such works are paid for by the Land Reclamation Syndicate or Consortium of Mountain Communes that operates in the area, who are responsible for their maintenance as well. In the case that these works are declared compulsory by means of a Ministry Decree, the State can participate with a maximum of 1/3 of the expenditure, and Provincial Administrations with no less than 1/6 of the total cost.

5th category - works that provide the defence of settlements against erosion and landslides. Funding is partly provided by Communal Administration/s and partly by the private landowners as a function of the benefits they receive. In cases where the financial burden to the Administration/s is too high, the State can participate with a maximum of 1/3 of the expenditure.

Regarding maintenance of other hydraulic works along urbanized stretches which are not classified according to R.D. 523/1904, Communal Administrations must carry the financial burden according to the most recent rules established by Regional Law 91/1998.

Insofar land reclamation is concerned (see Section 2.2.1.2), according to Regional Law 34/1994, the programme of the Regional Administration of Tuscany determines the entity of private contribution for new works of land reclamation of public interest, which in any case must not exceed 25% of the total cost. Instead, new works of land reclamation of private interest can be funded up to 35% of the total cost by the Regional Administration, and up to 70% in areas included within the hydrogeological bond, in mountain areas and in less-favoured areas (Council Directive 75/268/EEC). Maintenance of these works are entirely paid for by private landowners through the mechanism of benefit and is carried out by the Land Reclamation Syndicate or Consortium of Mountain Communes which operate in the specific area.

Financial support is foreseen after the occurrence of flood disasters in order to aid both private owners and public structures. In these cases, National and Regional Administrations usually promulgate specific laws for the economic contributions, in order to limit private and public economic losses. These laws foresee both an economic contribution or a reduction of fiscal drag. The economic contribution is fixed by law on the basis of the certified damages. Because of the recurrence of flood, the payment of economic contribution after each disaster requires a great expenditures of public resources by the administrations

In Portugal, no standard procedure has been put in practice, so far. As a general rule, two municipalities will benefit of a greater support than one. On the other hand, if individuals have a private flood prevention project and want to get some financial aid, they should include it in some other project for primary (agriculture or forestry) or secondary (industry or commerce) activities. As before, a group of citizens will have a financial support greater than the case of a single private. The emergency cases are dealt on a “ad hoc” basis.

3.2.5 Risk Perception, Public Awareness and Participation

In the area of perception and public awareness of risk affected areas, a significant effort has been made in relation to public involvement in civil protection measures. How individuals and social groups behave in face of flood occurrence and how they perceive this kind of risk is an investigation area of social sciences, which tries to understand the natural tendency of populations to reoccupy areas exposed to natural catastrophes. This analysis can be included in the human geography, sociology and psychology fields, which studies conducted to the General Hazards Coping Theory (Burton, Kates and White, 1978), also known as the leading paradigm on the natural hazards investigation. According to Fordham (1992) this theory considers three postulates:

- the apparent irrational behaviour of those who live in the river bed and persist on their location, due to a low level of risk perception;
- the variations on the perception could be explained by its physical characteristics, importance and recent occurrence, as well as by each individual personality;
- the choice of the kind of adjustment depends on the risk perception, the alternatives and the experiences lived by individuals.

Human perception and response to natural hazards can be understood not only by individual cognitive processes but also by the social and cultural framing involved in the perception process, as well as the choices and restrictions that affect the individual and the community decisions concerning adjustment and adaptation. Adjustment to floods depends on institutional and social restrictions to the process, personal and social characteristics, ethics, faith and attitudes that influence on the decision process as well as the decision process itself (which is the origin of the choices taken to minimize the effects of the risk).

Non-governmental organizations (NGO’s), like Red Cross, have charted missions and activities in the area of natural disasters response and mitigation. The NGO's and, more generally, the public and private organizations involved in natural hazards mitigation carry out some form of education.

The European Union should see all these activities, international as well as domestic, as a key for opening up new opportunities for improving the capabilities for coping with natural disasters by all the populations at risk regardless of their economic conditions and available resources. Building a world-wide network for technical assistance and information, developing methods for appropriate technology and knowledge transfer, and coordinating public and private organizations and activities are certainly some of the European Union main objectives.

3.2.5.1 Austria (Styria)

The objectives of the water management can only be achieved if they are explained to decision-makers and citizens at an early stage. The increasing request for information in modern societies has rendered decision-making processes more transparent. As a consequence of this fact, conscience raising among the public can lead to successful implementation of water management measures. Furthermore, the achievements of the administration are more widely acknowledged, leading to an increased acceptance of the new norms. The desire for more transparency in planning is fulfilled by the water management of Styria in the following ways:

The Hydrography Section, which deals with the analysis of the hydrological cycle, constantly releases up to date information on the Internet, providing accessible data to a large number of people. Everyone can find on the Internet data concerning the level of groundwaters, flood events, overviews of average rainfall over many years as well as deviations from the average.

In addition, information is published concerning protected groundwaters and relevant areas, a register of Styrian springs and karsthydrogeological studies on drinking water supply so as to attract more attention on the qualitative and quantitative aspects of drinking water in Styria and to focus public awareness on the need to protect it. A supply plan for Styria, describing the present offer and analysing demand, including emergency supply, is being worked out.

In the field of waste water disposal situation, reports (the so-called Styrian waste water management plan) are regularly issued thanks to the support of a GIS. The issuing of technical directives on waste water and the working out of fundamental principles relating to waste water management enable to compare different disposal solutions from an environmental and economic point of view. Reports and studies on alternative waste water disposal measures and booklets on specific technical aspects are being constantly published as well as reports on the disposal of communal sewage sludge by the Water Management Division of the Styrian Regional Government .

In the field of protection hydraulic engineering, brochures and folders are published, dealing mainly with the planning and extension of greater flood control projects. Here, aspects concerning specific segments as well as general overviews of the various water systems can be found. Technical collaboration with the Water Ecology Section is always sought.

When more extensive interventions have to be carried out, environmental planning experts and construction monitoring are always involved. Moreover, as a rule, implementation follows intensive public information campaigns based, for example, on the publication of a brochure describing the type of intervention, information to citizens and, in particular, people living along the water course and information shields on the site of the works. To enhance public acceptance, revegetation actions are carried out in collaboration with schools. An important contribution to the activity of Public Relations (PR) are conferences and seminars on subjects such as flood control, bioengineering, water ecology, water care and water preservation. In addition, water management employees are members of numerous committees and workgroups throughout Austria.
The water management section is working for the creation of a data network named ”Waterland Styria” (*Wasserland Steiermark*). The aim of this project is to gather results from studies, analyses and projects on water courses and related issues and to give a wide public access to this information material by releasing it on the Internet. The apex of the water management’s PR and information activity is reached yearly on March 22nd on the occasion of the World Water Day, which the Styrian water management celebrates with conferences, exhibitions and actions to raise public awareness on water-related questions.

3.2.5.2 Italy (Tuscany)

Only in the last years, initiatives to sensitize the population as regards the eventuality of a risk condition have developed significantly.

A series of initiatives have been set up consisting of information campaigns in mass media and in schools, thanks to the state and regional laws that have institutionalized the civil protection service, aiming to bring to the public knowledge the behavior to be followed in case of natural calamities of various types.

Futhermore, in the last years, periodical drills to simulate procedures to be adopted in case of natural calamities have been organized involving the actors interested in the civil protection machine.

As for public participation to the decisions regarding the activities of public administrations and therefore also as a matter of hydraulic risk, the national legislation in force (142/90, 241/90) promotes voluntary associations and organisms of citizen participation that can give their contribuition in decision-making processes of territorial management, rendering these processes more transparent.

In particular, before their actual adoption, all decisions regarding territorial management must be made public to any subject interested and these can eventually make any observations that must by law be taken into consideration and valued before the definitive approval of any administrative act.

For example, the lay out of management plans formulated by Basin Authorities, Land Reclamation Syndicates, as well as the Town Planning Plans (PRGC), etc., must be preventively undergo through vision and analysis of public and private subjects.

3.2.5.3 Portugal

In Portugal, one of the Agencies of the Ministry of Environment, the Institute for Environmental Promotion (IPAMB) is responsible for promoting environmental awareness and interfacing with NGO's. Also, professional, technical and scientific NGO's, in their fields of activity, have an important role in public awareness of water issues and have been considered (Water Resources, Environment, Water Treatment, Law, Journalism, etc.).

The Framework Law of the Environment (Law 11/87) states clearly the mechanisms for public participation in environment related matters, where water resources are an important part. Recent legislation related to planning activities create the River Basin Councils, in which relevant segments of the public participate. In fact, water resource associations, professional associations, environmental protection NGO's and interest groups have a seat in these councils.

The Law for Environmental Protection (Law 10/87) establishes the framework for the environmental NGO's officially recognized as "social partners" that must be consulted in all relevant situations, namely, when legislation is prepared or modified.

There are other relevant forms of public participation in water management procedures. It is the case of public audits and consultation required by the legislation on environmental impact assessment. Some licensing activity also requires a previous public consultation.

The right of access to non-classified information is regulated by Law 65/93, based on Directive 90/313/EEC. This law is also relevant to promote public participation and awareness.

The laws consider Environmental and Consumer NGO's and, at the same time, allow groups of citizens to organize themselves for protection of environmental resources, endangered species, or special places with specific problems or conditions. These laws also create conditions for a more efficient public participation. Environmental and consumer associations also have specific rights under the new Code for Administrative Procedures, approved in 1991.

The environmental protection associations have an important role in the protection and conservation of water systems, as they recognize how important water systems are for environmental protection. These associations participate in the National Water Council and in many River Basin Councils.

The highest level of NGO's participation takes place at the Social and Economic Council (CES). This Council is an interface body between governmental and non-governmental organizations, in which the most important policies are debated and amendments are proposed. All relevant interest groups, including environmental protection associations, agriculture, industry, tourism and trade confederations, as well as labor unions, participate in this council. Only recently, environmental issues started being analyzed by this high level council.

3.2.6 Monitoring ,Warning and Response Systems (MWRS)

Early Warning Systems are one type of non-structural measure, concerned with providing information to potential flood victims on the basis of which they can react with flood-mitigating actions. In addition, such forecasting and warning systems generally have an element which gives advice to those potentially suffering from flooding, in the form of what actions they should take to minimize losses (Penning – Rowsell and Fordham 1994).

Because of different physical, cultural, economic, and institutional circumstances and experiences, countries in the European Union have developed Monitoring ,Warning and Response Systems (MWRS) to different levels. When different circumstances are taken into account, comparison of the different experiences of countries provides important opportunities for improving practice and policies. This may be achieved by highlighting common problems, pooling knowledge and identifying the most effective systems and best practices which might be transported fruitfully from one country to another.

Economic activity increase and population growth has intensified flood plain use and rising flood loss potential. There is also growing recognition among public, environmental groups and engineers of the adverse environmental impacts of some structural flood control measures. Therefore, alternative non-structural measures are being employed, namely MWRS.

On occasions, also, structural solutions to flood hazards are technically or economically infeasible and therefore reliance is placed on MWRS. Where flood dikes or embankments are used, these only provide protection to a given standard limit, so that complementary MWRS are necessary. Lastly demands are often made for new or improved MWRS in the post-disaster phase.

MWRS have therefore become an important means of modifying the vulnerability of communities to flood hazards in both unprotected areas and protected zones with residual flood risks.

Vulnerability to flood hazards is created by a combination of many variables, including those concerned with human activities and those concerned with the physical nature of the location of those activities; the latter includes the nature of the fluvial flood event itself. Therefore, vulnerability can be represented in a very general way in the equation below, which includes an element of the character of the flood itself (the flood characteristics), also both the human characteristics of those in the flood prone area and the nature of the response to those flooded by society at large(Penning – Rowsell and Fordham 1994):

Vulnerability = f (flood characteristics, warning characteristics, response characteristics, socio-economic characteristics, property and infrastructure characteristics).

This is, of course, an oversimplification, and we need to calibrate the above equation by breaking down, analyzing and quantifying its constituent elements.

Warning and response are interconnected, as indeed are all other variables. The time taken for assistance to arrive will affect the vulnerability of the most vulnerable in the flood-affected community. Swift response can save lives and reduce the health impacts of the flood on its victims, as well as helping to save damage (especially to heritage values in that art treasures may be saved from total damage if they are quickly removed from the flood waters).

In addition, the amount of response (assistants, police, military personnel, observers, media, donations, etc.) will affect the degree of response, if not the quality. This includes the so-often forgotten long-term response system, which affects the way in which the community returns to a normal state of affairs. In this respect, the dependence is growing upon flood forecasting, warning and response systems .

Flood forecasting has improved with enhanced hydrometric and telemetric data collection networks, with the spread of weather radars and with the use of electronic data analysis and numerical forecasting.

Flash flood forecasting is based on weather forecast, essentially on high precipitation levels foreseen on the area, on hydrological forecast, considering registered precipitation and/or hydrometrical levels, or on the combination of both techniques.

Forecasting data can be acquired by different ways:

- observation posts (meteorological or hydrometrical) allowing automatic data collection and radio or phone transmission (radio transmission is preferable considering weather conditions);
- radar for rainfall analysis;
- satellites for precipitation estimate;
- quantitative rainfall foreknowledge (empirical, statistical or with numerical methods).

Flood forecasting is a difficult problem to meteorologists and hydrologists considering the short period available to realize a prevision; organization is the answer to success, involving different administrative levels and different knowledge fields. Furthermore, due to the spatial contraction of the meteoric events that give rise to flash floods in medium and small size basins, the meteorological monitoring system must be set up with sufficient density of stations.

Conceptual Questions and Guides

The initial research on MWRS has been guided by a generic conceptual model of flood forecasting, flood warning dissemination and flood response. The main components of this model are forecasting, warning and response. Information is either formal or intrisic, that is, when it is part of the MWRS and incorporating "official" warnings of floods; or informal or extrincic, involving "unofficial" warnings used by flood plain users. There also important feedback loops in the initial model. A complementary guiding conceptual model is Lazarus's (1966) stress model (Table 3.2.6 a). In this model, stress is a function of the challenge or demand of the event (i.e., the flood).

Table 3.2.6 a - Lazarus's (1966) stress model

CHALLENGE	MWRS	ADAPTATION
Flood Characteristics:	**Preferred System Components:**	**Individual/Social Response:**
rate of rise	minimum 2 hours warning	prevent water intrusion
depth	behavioral advice	raise property contents
velocity	updated messages	evacuate
duration	pre-flood event information	shelter
sediment load	limit "false" warnings	activate flood control measures
contamination		

Technically, an emergency plan must consider six situations: warning, alert, activation, operation, deactivation and report, and cleaning and repair:

- warning: the meteorological service warns that it is possible that critical levels of rainfall occur over one specific area if a certain meteorological situation develops as predictable;
- alert: control level personnel is warned that flood may occur; the equipment is verified and the operational personnel is contacted. No panic must be established.
- activation: operational personnel is on duty and the equipment and provisions are placed at the service places;
- operation: the emergency operations are performed as planed (traffic deviation, preventive evacuation of population, vehicle removal and rescue operations);
- deactivation and report: pick up material and return to normal activities;
- prepare the report of different activities and the general report;
- change action plan if necessary;
- cleaning and repair: proceed if necessary.

The measurement of MWRS effectiveness

An important question concerns how the effectiveness of a MWRS might be measured. There is a variety of possibilities, ranging from technical measures to economic measures and consumer satisfaction as expressed by flood zone users. The central problem with MWRS is that the benefits are not automatically delivered once a flood forecasting system has been established. The formulation of flood warning messages is not straightforward, and raises a series of problems which are central to risk communication. Furthermore, physical flood-producing factors may combine to produce rapid responses of flooding to rainfall, making warning dissemination problematic. In practice, making MWRS work effectively can prove to be a complicated process involving regular feeedback and concerted interagency cooperation and learning over time.

Flood early warning systems are real-time event reporting systems that consist of remote gaging sites with radio repeater sites to transmit information (e.g., water level, rainfall) to a base station. The overall system is used to collect, transport, and analyze data, and make a flood forecast in order to maximize the warning time to occupants in the flood plain. Some remote stations have both rainfall and streamflow gages. Automatic repeater stations, located between the remote stations and the base station, receive data from the remote stations, check the data for validity, and transmit the data to the base station. Incoming radio signals are transformed from radio analog form to digital format and are forwarded to the base station computer through a communications port. After data quality checks are made, the data are formatted and filed on either hard or floppy disk media. Once the data filing is complete, the information can be displayed or saved for analysis.

Data collection, processing and management can be performed in computer centers on site, in a regional center, or in few centers on different levels (from the site itself to the local, regional or state level), depending on the accepted organization.

The values of registered phenomena and their development trends versus time are first signs for undertaking the adequate measures and reduction of possible consequences. Depending on possible endangering risks, the responsible group or person will decide on the procedure to prevent or stop unfavorable phenomenon or process. Due to different circumstances, these measures are often very limited. In the case that the final results are uncertain, i.e., that it is very difficult to govern the arisen situation, it is most important to inform people who live in the downstream areas on these safety problems. It is a way to prepare them to undertake first measures for implementation of the emergency action plans. This information should be presented in a such way to exclude the possibility of panic in the population (Table 3.2.6 b).

Table 3.2.6 b - Danger level and operational measures

Danger Level	Operational Measures
1	Increase state of alarm readiness
2	Full state of alarm readiness - Partial Evacuation
3	Evacuation

Preparations

These include: a) planning, b) installation of the required alarming equipment, and c) organizational measures for ensuring the evacuation of the people.

a) Planning
The first step is to determine the potentially submerged area in case of a flood. Because the amount and extend of the flood are not known in advance, one assumes the most adverse condition. On the basis of the results of these computations, the local authorities have to establish an evacuation plan that will be distributed to the population. This document has to include the meaning of the various acoustic signals given by the sirens and instructions on how the population has to behave when hearing such signals. The evacuation plan also indicates the limits of the potentially submerged area, the escape ways or escape directions corresponding to the various sectors, the meeting points, and the traffic regulation.

b) Equipment

General alarm is an alarming process which urges the population to listen to the radio. Behavior instructions are then given by the radio stations. The alarm signal to evacuate the population out of the potentially submerged area is given by sirens in the localities. The water alarm sirens are triggered directly from the local center by the local authority. In the case this center cannot be put into operation or the authorities cannot reach the site in due time, fixed or mobile stand-by posts must be provided. Under normal conditions, the water alarm system is in stand-by mode. The water alarm sirens are locked to avoid unwanted triggering. When needed, at least at danger level 2, water alarm sirens will be unlocked.

c) Organizational Measures
The municipalities shall provide for planning and preparing the evacuation including evacuation plans, hosting centers, traffic control, and preparation of all needed equipment. They are also required to inform the population on the ongoing events, to issue the behavior instructions in case of alarm as well as reminders on the meaning of the various acoustic signals. In case of emergency, it is their duty to mobilize the personnel in charge of triggering the general alarm sirens.

Technical Advances

a) Automation

There has been a growing demand for automatic monitoring systems capable of operation in often remote and hostile environments with minimum maintenance. However, the fully automated measurement of selected components of the hydrological cycle poses great technical difficulties. In one sense, records derived from automatic systems are often regarded as being inherently more reliable and accurate than manually gathered data, but the two types of data collection should be regarded as being complementary.

b) Remote Sensing

The increasing sophistication of hydrological data collection means that it is often too expensive to install land-based equipment that could meet all the demands. One solution is to use remote sensing to gather data on continental scales. Remotely sensed data are increasingly used to forecast and monitor impending hydrological hazards such as big storms. Snow cover, surface heights, water vapor content of the atmosphere, vegetation distribution and soil moisture may all be sensed using telemetric systems which monitor and transmit data from a distant source. Remote sensing has largely overcome the limitation of point data by allowing the integration, at least of some variables, on a spatial scale more suited to heterogeneous basin processes.

As with automatic systems, a word of caution is needed. Usually some form of ground truth is required in order to calibrate satellite or radar signals. Satellite equipment also has a finite life and may be replaced by equipment with different specifications. In practice, much time must be spent in calibration and inter-comparisons in order to be certain that any differences in the data are real and not a function of the instruments or of the data-gathering process.

Geostationary satellites orbiting the earth at an altitude of about 35 000 km above the equator provide imagery both day and night. The satellite imagery helps provide estimates of the location, size, and intensity of a local storm and its surrounding environment.

Also specially equipped aircrafts can be used for operational reconnaissance. Pilots fly aircraft into the core of a local storm to meausure wind, pressure, temperature, and humidity as well as to provide an accurate location of the center path of the storm.

Storms can also be monitored by hand-based Doppler weather radars. They can provide detailed information on storm wind fields and their changes. Local offices will then be able to provide more accurate short-term warning for floods.

3.2.6.1 Austria (Styria)

The setting up of the first remote monitoring station of the Hydrographic Service in Styria dates back to 1968. At that time, ten external stations could be contacted by radio. Because of international obligations, however, these stations had to be located along the rivers Mur and Raab as well as the lower courses of their main tributaries. Thus, information on the upper segments of their respective catchment basins could not be provided.

In 1984, the seat of the Hydrographic Service was transferred. On this occasion, the remote monitoring system, which by that time had already become obsolete, was replaced by a computer-based one. This has both allowed to widen the stations' network and to gather information also on other parameters such as rainfall and air temperature. Furthermore, it is now possible to process data on the computer.

The recorded values are collected from the various stations at regular intervals via telephone or radio. For radio-connected stations, calls are made at half-hour intervals, but these can be reduced to 15 or even 5 minutes in case of flood. Telephonically connected stations are called once a day in normal circumstances, whereas in case of flood the interval may be reduced to 30 minutes. Manual connection is possible at any time for both systems.

A second device has been installed in the Styrian Warning Centre (LWZ). This warning station is active every day around the clock. Furthermore, certain stations release data relating to the preceding three days on a special server for information and download.

In case the internally established security levels are surpassed, the alert service of the Hydrographic Centre is activated to warn bordering countries (Slovenia and Hungary) and alert relevant authorities at home (telephone, fax, e-mail).

The present network includes 26 run-off and 40 rainfall remote monitoring stations.

In view of the further expansion of the system, one future objective is to create a databank by linking all institutions having remote monitoring stations, with particular reference to electricity-producing enterprises in the valley of Enns river and the rainfall and temperature monitoring network of the Air Quality Monitoring. Links to the Styrian energy company STEWEAG have already been established.

A project started in 1993 is trying to connect also the weather radar of the Federal Bureau for Civilian Aviation (Austrocontrol). This enables to follow the real time development and intensity of rainfalls across the country.

In 1999, a new visualization system was ordered, which will provide a more effective overview of observed values (flood and rainfall).

In 1998 and 1999, two new, partially computer-based, flood forecast prototypes were presented, to be employed in the valleys of the Sulm and of the Mürz (both tributaries of the Murz). These systems would enable to forecast and evaluate the dimensions of greater flood events up to six hours in advance. At the same time, flood plans have been worked out for these areas, which enable to outline the extension of danger zones immediately, according to measured or forecasted flood values. Thereby, preventive action can be taken.

3.2.6.2 Italy (Tuscany)

The weather forecasts are the first step to predict the occurrence of storms that could produce alluvial events. In Tuscany, this function is performed by several Public bodies (State Hydrographic and Marigraphic Service, ARSIA-Regional Agrometeorological Service of Tuscany, etc.) that inform the Prefects (who represents the State government on the provincial level) about the potential risk conditions. Then, the Prefects give warning to the other Public Bodies that are in charge of public safety (Fire Brigade, Municipal Police, Mayor, etc.).

During a meteoric event, control of streams is carried out by all the Offices that are in charge of the management and control of water courses (Civil Engineering Corps, Land Reclamation Syndicates, Consortium of Montain Communes). They monitor the water level in the channels and warn the overcoming of warning levels. During the last decades, the monitoring action is performed also by technological instruments, located along the streams, that allow to control flood events in real time.

The definition of warning level is ruled by Royal Decree 2669 of December 9th , 1937. This decree foresees that, for each water course of classes I and II (defined by Royal Decree 523 of July 25th , 1904) that represent the major national and international rivers, the Head Engineer of each river stretch identifies the location of hydrometers and their warning level.

The technical procedure that fixes the warning level is not specified in the Royal Decree. Usually, it is identified on the basis of the hydraulic and morphological characteristics of the river bed, structures located along that river reach and experience. The identification of this level is not fixed with homogenous hydraulic criteria. For this reason, this warning level varies from river to river and along the same water course.

In the last few years, warning systems have been set up by Land Reclamation Syndicates, Consortium of Montain Communes, etc., also along the water courses of small-medium size basins (water courses of classes III, IV, and V).

Also, in these cases, the identification of warning discharge level is defined by the staff that is in charge of the control and management of each small-medium size basin, on the basis of criteria that depend on local conditions and on the necessity to set up civil protection procedures. Sometimes, two or more warning levels are fixed.

In both cases (big and medium-small size basins), when the flood level exceeds the warning level (levels), the staff in charge must alert the civil protection structure in order to take all the necessary measures to avoid risk for population. In particular, they warn the Local Authorities (Mayors) that provide the preparation of all the necessary civil protection measures. When flood events are calamitous or involve many Local Municipalities, Mayors have to give warning to the Provincial, Regional or State Civil Protection structures in order to face the emergency.

Emergency planning requires a census of human and material resources and of the facilities in the area in order to acquire a homogeneous and organic overview of the knowledge acquired in relation to the area and the population affected by risks and calamities.

Much attention must be dedicated to disseminating information with two main objectives: one is operational and concerns the management of emergencies, and the other is to inform and sensitize the population with regard to the foreseeable risk scenarios in the area.

Both objectives can be attained through the creation of a regional information system that should be a reference for a network for transmitting and sharing information regarding civil protection.

To this regard, the Regional Admistration of Tuscany is working on the creation of an information network that makes use of Internet as a means for communicating and distributing information. The reference point is the Website of the Regional Government, Civil Protection Sector, that performs several functions at various levels.

The first of these functions is to provide a civil protection data bank - with access limited to institutions - that can be consulted and updated by remote computers. The advantages of Net-based data archive management permit real-time updates and diffusion of information at relatively low costs.

The second function of the Website is to provide information to the public through a series of Web pages that describe the activities of the Regional Government, the most important information concerning civil protection plans, risks and vulnerability of the area along with guidelines on what to do in case of an emergency.

The civil protection database not only makes it possible for various agencies to share all the available information, but it also stimulates cooperation among them to safeguard the well-being of the population, to mitigate the risk and limit damage.

Another significant aspect is the need for an instrument to provide for real time information updates. This makes the tool truly effective and operational, especially during the initial phases of an emergency when it is essential to have a network connection among national, regional and local agencies and authorities to coordinate aid.

The electronic archive for entering information about civil protection contains all the information useful to the operational organizations and agencies that must take action during calamities. The following data entry cards have been prepared:

- Supra-provincial organizations;
- Provinces;
- Municipalities;
- Health Care and Aid;
- Volunteer Organizations;
- Radio Communications;
- Shelter Facilities;
- Collection and Sorting Areas;
- Material Stores;
- Resources;
- Fire Department;
- Cispel (the federation of municipally managed or owned organizations and bodies).

Each agency is asked to share information concerning its organization, headquarters, staff, materials and equipment available for emergencies, with the names and contact points of the persons in charge of sectors, logistics and emergency management (shelters for the population and emergency workers, road access, etc.)

The archive is designed specifically for the Civil Protection officers of the various operational organizations throughout the region. The database can also be used by all public and private institutions which, upon authorization from the coordinator for Civil Protection of the Tuscan Regional Government, can access it or add useful information.

The database was developed in the Simple Query Language (SQL). The consultation and updating interface consists of a series of active (asp) pages that can be accessed via MS I.E. 4.0 or superior Internet Browsers. By entering the password and ID, the database at central headquarters can be accessed via an Internet connection.

The work plan also provides for the possibility of connecting the database to a geographical information system (GIS) through specific fields (U.T.M or Gauss-Boaga coordinates and the organization's identification code) that were entered on the cards of the organizations considered suitable for geo-referencing (Resources, Collection and Sorting Areas, Material Stores, Health Care and Aid).

In case of an emergency, the user connects with the database in the consultation mode and can obtain the required information quickly. Modern computer and telecommunications technologies eliminate the need for fixed headquarters for the network connection, making it possible to use mobile equipment that is very useful in emergencies.

In addition to consultation, the database can be used to enter information. The guiding philosophy for data entry must be the "quality" rather than the quantity of the information.

The Web pages consist of three main sections: regulations, territory, and actions. The regulations section will contain information on regional regulations, plans and programs and regional Civil Protection bodies. The section concerning the territory will contain information about areas exposed to seismic, hydraulic, hydrogeological, industrial and fire risks, with appropriate summaries and maps. The third section will focus on actions in progress and information on implementation status through the electronic publication of various regulatory documents.

3.2.6.3 Portugal

There are not many systems for Flood Forecast and Warning in Portugal. In Tagus River, there is a simple method for flood forecasting. In Douro River, the Electrical Utility (EDP) is also performing some flood forecasting and warning, since this river became a cascade of reservoirs operated so far by the same EDP (Correia et al. 1993).

Crucial to the prediction of flood in real time is the accurate prediction of rainfall rate.

In Portugal, the Surveillance and Warning System (SVAC) is a computer system that collects and makes available useful data to support entities, such as civil protection, port authorities and firemen, working with flood risk situations. The Surveillance and Warning System, SVAC, began its work in the 95/96 Winter, including data from three hydrometrical stations in the Tagus basin (Tramagal, Almourol and Ómnias) and dam data provided by EDP (for the portuguese basin) and by the Tagus Hydrographic Confederation (for the spanish basin). During 1996, six more stations were automatized in other basins and, in 1997, SVAC increased its number of stations to seventeen. Nowadays, the system disposes thirty-six automatic stations and fifty-seven dams (out of which, 25 are automatic).

Collecting data from hydrometrical and udometrical stations requires Hydra and Rainbow software respectively, completely designed by INAG technicians. Hydra software collects data continuously, which warrants actualized data every ten minutes; this data allows the estimation of water depth and flow. Rainbow software collects data from udometrical stations every fifteen minutes, organizing daily files containing minute to minute data for each station.

It is important that flood forecasting expands, specially on small basins where flash floods are more significant; there are already some udometric stations on small Tagus basins, North of Lisbon (Trancão, Rio Grande da Pipa and Alenquer), to feed rainfall-flow modelling.

The application of radar technology in meteorology is being developed since radar became available, about 40 years ago. In Portugal, the Water Institute is working with the Meteorology Institute in the operational exploitation of the Meteorological Radar Station of Lisbon/Airport since 1988.

3.2.7 Concluding Remarks and Recommendations

From past disasters we have learned that people can cope with floods and can plan effectively for the rescue, relief, and recovery activities; that structures and buildings can be designed and built to withstand and survive strong physical abuses; that technologies exist to select safer building sites; that each event has its own spatial, temporal, characteristics which can be measured and monitored by increasingly accurate systems.

Planning should be:

- global, based on a joint approach of the technical, economic, environmental and institutional aspects;
- rational, aiming at an optimal use of several sources for the satisfaction of all needs;
- integrated, coordinating the interfaces with the planning activities of the various sectors:
- participatory, involving the economic agents and the affected populations and aiming at a large consensus.

On the other hand, we have to improve and increase our knowledge about:

- regional identification, assessment, management and communication of flood risks;
- full social, economic and political consequences of hydrologic disasters;

- health and ecological consequences of extreme floods;
- development of effective hydrologic hazards mitigation measures and secondary effects of mitigation on the environmental and social systems;
- capabilities and methods for integrating hydrologic hazards knowledge into the water resources development, management and economic uses of watersheds;
- development and adoption of better and new systems for the transfer of hydrologic hazards knowledge to water resources managers.

3.3 STRUCTURAL INTERVENTIONS

The term structural intervention comprehends different typologies of works that can be put in practice both along the river courses and on the slopes of the basin.

This class groups the interventions that require the construction of works involving directly the evolution and downflow of flood events.

Structural interventions for the solution of hydraulic problems in basins subjected to hydraulic risk conditions are of two types:

- Interventions for the flood control (localized interventions);
- Interventions for the reduction of flood peak (territorial interventions).

The former type aims at the control of flood peaks through the planning of interventions that permits to contain the surplus of water (e.g. artificial embankments, retention basins, etc.) while the latter try to reduce or delay the runoff of meteoric water in order to lengthen the concentration time of the river basin and reduce the peak of the flood events.

Construction of structural interventions usually have represented, up to today, the easier way to gain the hydraulic protection of territory. This philosophy has driven the choice of many public authorities and decision makers during the last decades. The development of constructive techniques and materials has favoured the planning of different typologies of interventions that are able to be applied in almost all morphological and hydraulic situations.

On the other hand, these interventions can interfere with natural hydraulic and ecological aspects of the river dynamics, in fact, wrong application of structural works usually produces a significant change in the river dynamics and in the environmental characteristics of natural river courses. Their application is usually able to solve local hydraulic problems but frequently they can produce new problems or the increase of the existing ones along the upstream and/or downstream portion of the hydrographic network. Therefore, application of new structural interventions for flood control need to take into consideration all the effective and potential interference with the hydraulic and environmental characteristics of the river bed.

In the last decades, the development of bioengineering works has guaranteed the environmental and ecological respect of the river and torrent habitats. They have been largely applied especially in the upper portion of the hydraulic network in the hilly and mountainous areas.

Interventions for the reduction of flood peaks (agriculture and forest management) require territorial planning at the scale of entire drainage basins. Though their application is more difficult because of the large surfaces involved and of the long time needed to reach a significant efficiency, it would however guarantee the hydrogeological defence of territory more efficiently in the long run.

Thus, the preparation of territorial plans for the entire basin concerning agricultural, forestry and urbanistic development, and in particular, the identification and application of the best techniques for agriculture and forest cultivation that permit to increase the storage of meteoric water in the soil and in the vegetal covering should be the guiding strategy for long term prevention of floods and hydrogeological instability.

In the following pages, an overview of the different typology of structural interventions is made, starting from the interventions for flood control (localized interventions) and concluding with interventions for reduction of flood peaks (territorial interventions).

3.3.1 Passive Flood Control

Though passive flood control fit into interventions that could be considered as "non structural" ones, decisions linked to management of areas along river courses imply changes/control of land use subjected to recurrent flooding by adapting and transferring cultivations, acquisition of land and structures, etc.. Since these interventions require investments and, sometimes, few structural interventions, their inclusion in this Chapter is preferred.

Objectives

The expression "passive flood control" refers to the avoidance of actions that increase flood discharge. Instead of focussing on the building of structures, investments are devoted to:

- adapt cultivations in the neighbourhood of water courses to the event of excess discharge considering the resistance and susceptibility to damage of different crops;
- transfer local cultivations to safe areas;
- acquire land and structures which are more frequently subjected to floods.

The fostering of natural flood retention is not merely devoted to flood control; actually, it is an aspect of the interdisciplinary management of land and water resources, aimed at preserving and improving general environmental conditions. Examples of natural flood areas are shown in Figures 3.3.1 a and 3.3.1 b.

The main objectives of passive flood control actions are the following:

- availability of flood discharge areas;
- upkeep and creation of retention zones;
- improvement of the ecological function;
- ground water enrichment;
- water conservation (reduction of toxic emissions);
- reduction of upkeep and servicing operations;
- water retention in the landscape (sponge function);
- avoidance of interventions on the natural equilibrium.

Measures

Effective water retention is based on the following prerequisites (Riedl & Gockel 1996):

- safeguard of available low land run-off zones, covered by woods, coppice and grassland;
- development of forms of cultivation suitable for the local conditions in river plains;
- no further construction undertakings in the flood plains;
- restoration of retention areas through withdrawal and displacement of dams as well as reactivation of old arms;
- preservation of nature-like trenches, nature-friendly development of already trained water systems.

The above-mentioned prerequisites prove useful when there are effective retention mechanisms in the area. Among them: structures that have the ability to slow down run-off, soils with high storage capacity, enough room to allow evapotranspiration and seepage.

Figure 3.3.1 a – Natural flood areas of the Lafnitz river

Figure 3.3.1 b – Natural flood areas of the Lafnitz river

Passive flood control in Austria

According to the provisions envisaged in the Act on Water Right (WRG 1959), the limits of flood catchment areas have to be defined and any intervention within the HQ_{30} flooding zone requires special permit. With this background, since 1990 the Water Management Section FA 3a has started to outline the HQ_{30} and HQ_{100} flooding areas, mainly along the major rivers. Knowledge of the limits of flood areas related to a specific HQ not only provides the basis for the control of nearby communities, but also enables authorities to keep these areas clear of constructions in order to preserve flow retention, thereby curbing flood peaks, and avoid harmful effects on the lower course (see Section 3.2.2.1).

One of the water management objectives contained in the directives of the Federal Hydraulic Engineering Administration (RIWA-T) is the securing of flood catchment areas: territories lying within the HQ_{100} boundaries, which have to be kept clear of constructions, are located and marked as water management priority areas in order to avoid harmful consequences on the maximum flood discharge flow, with particular respect to combination effects caused by human intervention. They are then registered in the Land Use Plans of every municipality, as envisaged in the Regional Policy Act (ROG 1974). This way of securing land coincides with the traditional method of “passive flood control”, whereby flood catchment areas are to be kept clear of constructions in order to avoid long-lasting damage (non-commercial use of land for public benefit, as stated in the ROG). The ROG and the Styrian Building Act establish that valuable building land has to be free from flood risk.

In the framework of the studies on water flow carried out on behalf of Fachabteilung 3a – Wasserwirtschaft (Water Management Division), proposals concerning general measures for the protection of endangered objects and settlements against floods are also developed. A crucial aspect is the early securing of areas for flood control purposes, so as to have them available in emergency situations. To this end, territories that are particularly suitable for water retention or that are necessary to build earth dams or walls are singled out and marked as “devoted to special purposes”, which is also reflected in the Land Use Plans. This, too, is a measure to secure areas.

The water management objective of preserving natural retention areas and improving their state contrasts with the desire to employ them for industrial, economic, agricultural, urbanization and communication purposes. Hence, exploitation conflicts are bound to arise. Such measures as depositions and embankments enable to secure areas against floods in a relatively economical way, provided the effects on flood run-off are proved to be minimal.

The water management objective of keeping the flood catchment areas clear of constructions is not yet envisaged by law. In practice, however, the studies on water run-off are often taken into consideration by local authorities and indeed they make up the foundation of their regional plans.

A decisive role is played by the conditions established by the Federal Hydraulic Engineering Administration for the granting of subsidies and envisaged in the Act for the Promotion of Hydraulic Engineering Works. As an example, in Figure 3.3.1.c., the borders of HQ_{30} and HQ_{100} areas are shown with proposal of protection measures.

Figure available as a separate file

Figure 3.3.1 c – Protection measures proposed by the Federal Hydraulic Engineering Administration

Framework of the "Z-Procedure"

Procedures for land consolidation are initiated by every single federal territory through the issuing of regulations. These procedures are aimed at removing deficiencies within agricultural structures, but are more and more frequently being used also for swift implementation of plans of territorial intervention that are of public interest, especially the building of transport infrastructures (e.g. by-pass roads). The land consolidation ("Z") procedure offers many advantages to the plan implementing body:

- time-consuming, conflict-laden individual land acquisition negotiations can be avoided: the acquisition price is established on the grounds of an expert's report and negotiated with the group of landowners; the acquisition runs under the "Z" and it is performed by the agricultural authorities;
- loss of land borne by a community avoids penalizing single economic units: by buying plots that are on sale in the area and consolidating them through the Z-procedure where necessary, authorities can avoid to take away land from single owners, whose possessions lie in the area of intervention but who cannot sell them because their living depends on them;
- land can be made available by establishing a share principle rather than expropriating: the above advantages hold true also if there are no plots on sale in the area. In this case, it is not the few directly involved landowners who have to give up their possessions for public interest; in fact, the burden is shared by all people having properties in the area covered by the Z-scheme;
- implementation through agricultural authorities saves money and reduces bureaucracies, surveying work (partition plans, surveying and demarcation). The registration of the reorganized public water domain in the land register or cadastre is carried out by the agricultural authorities, although an agreement on the sharing of costs ensuing from the Z-procedure can be reached with the plan-implementing body;
- integral land consolidation supports passive flood control: the Z-procedure brings about a re-organization of land and has profound influence on its management, which not only favours passive flood control, but also fosters sustainable agricultural practices in the whole valley.

3.3.2 Active Flood Control (Retention Basins)

Dams, and especially flood mitigation dams, play an important role in the reduction of the damages due to the floods, always coordinated and complemented by other non-structural solutions in the floodplain zones.

But also, dams suppose a hazard: an environmental risk in their interaction with nature and a hazard for the downstream population, due to their potential failure. That is why Dam Safety is a basic concept and a determinate question to be taken into account in the dam design, in its construction, and during the long life that these structures have.

Urbanization increases both the volume and the velocity of runoff, and efforts have been made in urban areas to offset these effects. Storm water retention basins provide one means of managing storm water. A storm water retention basin can range from as simple a structure as the backwater effect behind a highway or road culvert, up to a large reservoir with sophisticated control devices.

Runoff can be held for a short period of time before releasing it to the natural water course, or it can be held in storage facilities for a considerable length of time, for aesthetic, agricultural, consumptive, or other uses[15]. The water might never be discharged to a natural water course, but instead be consumed by plants, evaporation, or infiltration into the ground. Retention facilities generally do not significantly reduce the total volume of surface runoff, but simply reduce peak flow rates by redistributing the flow hydrograph.

On-site retention is distinguished from downstream retention by its proximity to the upper end of a basin and its use of small retention facilities as opposed to the larger dams normally associated with downstream retention and larger water basins.

The concept of retaining runoff and releasing it at a regulated rate is an important principle in storm water management. In areas having appreciable topographic relief, retention storage attenuates peak flow rates and the high kinetic energy of surface runoff. Such flow attenuation can reduce soil erosion and the amounts of contaminants of various kinds that are assimilated and transported by runoff from land, pavements, and other surfaces. Several different methods exist for the retention of storm water, including underground storage, storage in basins and ponds, parking lot storage, and rooftop retention.

A reservoir may be a single-purpose structure, such as for flood control, or it may be a multiple-purpose reservoir. Until the mid-twentieth century, schemes were relatively unsophisticated and were commonly operated as single-use systems but there has been a marked tendency in the world over the past 30 years for planned regulation of riverflows.

3.3.2.1 Primary Variables

The primary variables to be determined in a reservoir design are the location and height of the dam, the storage capacity in the reservoir, the elevation and capacity of the spillway, and the capacity and mode of operation of the discharge works.

There are several considerations involved in the design of storm water retention facilities. These are: (1) selection of a design rainfall event, (2) volume of storage needed, (3) maximum permitted release rate, (4) pollution control and (5) design of the outlet works for releasing the retained water.

Several flow simulation models such as the known HEC-1 model (U.S.A.C.E. 1981) can be used to perform reservoir routing to check the adequacy of retention basin designs. This is

[15] Although the term “detention” is sometimes used for the first case and the term “retention” for the second one, in this report the distinction is not made because a perfect correspondence of these terms, in the languages of the countries participating to project PREMO ’98, does not exist.

generally well illustrated by comparing the outflow hydrographs from those retention ponds with the corresponding inflow hydrographs for various flow volumes. There can be some uncertainty, especially for short periods of historical data.

Hydrologic design of a reservoir involves the determination of the location and elevation of the dam, calculation of its surface storage area-capacity curve for present and future conditions, and determination of its service life, or period of years during which the reservoir will be adequate.

To determine the storage-area curve, the surface area A_j is determined by measurement on a topographic map of the area enclosed within the contour line at elevation hj. The horizontal slice of storage between elevations h_j and h_{j+1} has an average area of $(A_j + A_{j+1})/2$ and a thickness of $h_{j+1} - h_j$, so the storage at the upper level $_{j+1}$ is:

$$S_{j+1} = S_j + [(h_{j+1} - h_j)(A_j + A_{j+1})/2]$$

where Sj is the storage at the lower level j of the slice.

The storage-area curve so computed corresponds to the topographic conditions when the reservoir is first constructed. After the reservoir has been in use for some years, its storage-area curve may be modified by sedimentation in the reservoir, which can reduce both the storage and the area for a given water surface elevation. Specific studies are needed at each site to determine the rate of sedimentation and how the deposited sediment is distributed within the reservoir.

3.3.2.2 On the Main River Course

Introduction

Flood retention installations may contribute significantly to reduce the danger of floods. They are designed to replace run-off accelerating measures or at least to reduce them to a minimum. Apart from their economic and technical aspects, protective hydraulic installations should also safeguard and improve the ecological function of flowing waters.

Existing structures have to be adapted to the most recent state-of-the-art. The necessary public funding is provided for within the framework of the Hydraulic Structures Promotion Act, in Styria (Austria). The technical and safety-related aspects are taken care by Basin Surveillants. Basin Overseers are responsible for maintenance.

In principle, flood retention installations have to be designed in such a way that minimum intervention is required in case of a flood event of a certain return period in the lower reach of a river, perhaps even allowing its renaturalization. To achieve this, the bottom outlet is reduced to a certain cross section to ensure that the maximum permissible discharge quantity is not exceeded.

It is part of the planning task to study different design versions as regards basin size and the extent of measures in the lower course and in which way they are to be combined. The solution should be optimized not only with regard to its economic and technological feasibility but also in view to securing and improving the ecological function of the water. In the ideal case, this means that the selected retention measures could make possible compensations in the lower reach, e.g. by revitalization of older control structures.

Measures and components

Hydrological Bases of Design

The hydrological bases of design have a major influence on the reliability and economic efficiency of a retention basin. If basin capacity or spillway are undersized, the protective effect of the installation as well as its safety will be challenged. Oversized installations require more financial means that could be employed more meaningfully elsewhere for flood protection. Also, the bigger the installation is the more severe its impacts are on ecology, and thus the limits of what can be reached.

The hydrological bases of design require great care. The task should be handled by recognized and experienced hydrologists, but also be coordinated at a Regional level, at least in case of medium-size installations.

Hydraulic and Constructional Bases

The most important structures required for operation of a retention basin are the bottom outlet, the spillway, the bypass as well as the energy conversion facilities necessary for these installations. Additional structures may be provided, e.g. for exploitation of water power, low water replenishment, irrigation or other purposes. Hydraulic dimensioning of the operating facilities of a retention basin is similar to that of dams for hydroelectric power stations and must follow the relevant laws of pipe and free-surface hydraulics.

Measures Related to Soil Mechanics

The choice of a check dam for retention basin is determined by the condition of the subsoil, the topography and the height of the structure. It is important that geologists and experts in soil mechanics be involved right from the beginning.

Check dams may change the groundwater situation. Calculations and studies in this respect are indispensable, especially in case of installations with permanent lakes. Constructional criteria have also to be applied to all operating structures, such as bottom outlets spillways, energy conversion and rake installations.

Ecological Aspects

The type and extent of changes in water ecology are closely related to the respective project. The least changes occur when only a dam is constructed and no further hydraulic measures are taken on the stream outside the dam area. In this case, the water´s ecology is primarily interfered by the interruption of the ecological continuum (caused by the bottom outlet) of the flowing water. However, these negative effects can be minimized by designing the bottom outlet accordingly.

Other influent factors are sediment accumulation in the retention basin during floods as well as the changed channel-shaping forces of floods downstream the basin. At any rate and wherever possible, the construction of retention installations should be accompanied by ecological compensating measures.

The most dramatic changes in the biocenosis of waters occur when permanent lakes are constructed due to the associated habitat transformation and the barrier effect caused by the monk-like design of the bottom outlet. Due to the longer residence time of the water in the permanent lake, effects must be expected on the water condition and quality as well as on the species pattern. Therefore, whenever the construction of a permanent lake is considered, the problem of limnological development and successional use has to be analyzed in addition to the question of integrating a newly created element into the natural landscape, and predictions have to be made as to the water’s ecology.

Economic Analysis

The manifold effects of flood retention basins on economy, ecology, regional policy and society should by studied carefully by way of analysis in the early project phase. According to the Technical Guidelines of the Federal Ministry of Agriculture and Forestry (Austria), the so-called cost-benefit study is mandatory as economic analysis for river works whose project cost exceed $2x10^6$ Euros.

Practice has shown that economic analysis may be valuable also for projects whose costs are lower. However, extent of and expenditures for such studies should be commensurate with the size of the object.

Involvement of the population is of great importance for several reasons:

- it is vital that the population be informed about the planning concept at an early stage;
- suggestions and reservations put forth by the population help to define timely and more precisely the problems associated with the planning concept;
- projects that can rely on broad consensus have a better chance of being implemented.

In the course of economic analyses, the flood protection objectives to be achieved are specified in more detail. Consideration of various design options is encouraged and a high degree of impartiality in decision-making could be desirable.

Building and Building Supervision

Flood retention basins have to be built according to the approved planning documents and in compliance with the generally accepted rules of technology, building regulations and other provisions (protection of health and safety of employees, etc.). In Styria, for supervision during the construction work, depending on its importance, the Water Authority may have the project inspected for compliance with the Water Act and, if necessary, also for fulfillment of ecological standards.

Commissioning, Operation and Maintenance

Performance and safety of flood retention installations are inseparably linked with their commissioning, operation and maintenance.

Carefully prepared commissioning, operation as approved and careful maintenance are fundamental requirements for the integration of such installations into a valley. It is particularly in the area of safety that some interesting sociological phenomena as well as aspects related to regional planning and development are to be observed:

- The lack of information of the population affected about function and operation repeatedly leads to misjudgment and wrong behavior.
- The spatial distance between areas that benefit from a retention basin and its actual location as well as absence or weak flood events frequently alienate valley residents from the protective installation. Warning sensitivity of people for flood events lessens their preparedness to take action themselves and instead responsibility is delegated to a growing extent to public authorities.
- The construction of flood retention installations increases settlement pressure in former flood run-off areas, especially as land-use plans permit activities in closer and closer vicinity to embankments. As a consequence, new settlement and industrial areas and traffic routes are emerging in zones of latent danger, which, in turn, makes the population working and living there highly dependent on the proper functioning and safety of protective works.
- Positive as well as negative experiences gained from commissioning, operation and maintenance are important not only for existing but also for new installations.

Secondary Use

Any secondary use of flood retention basins should have no appreciable effect on their main purpose. As a matter of principle, any storage or placement of floating material must be refrained from so as to minimize the blockage danger of the operating structures.

Agriculture

Areas that are inundated in case of a flood event with a return period of five years and onwards are disqualified as arable land. At best, their use as grassland may be acceptable.

Forestry

This form of management needs to take into particular account the resistance of the tree cover against floods as well as its fitness for the site. As this type of secondary use has a special impact on the safety of the installation, any storage of timber in the retention area must be forbidden.

Recreation and tourism

Any facilities must either be positioned outside the retention area or have to be designed to withstand floods, or appropriate safety measures have to be taken. The dangers associated with retention installations and their operation have to be pointed out.

Exploitation of energy, water replenishment and storage of drinking and service water

The necessary flood retention capacity has to be maintained also when the area is used for storage purposes. It has to be borne in mind that this type of use is always secondary to the operation as flood retention installation, whereby ecological aspects have to be considered as well.

Secondary habitats, succession, conservation of nature

If habitat and nature conservation is an additional task to be fulfilled by flood retention basins, natural succession must be the prime objective. When planning the natural environment, care must be taken to ensure that further development can ensue without human intervention. As, in most cases, only partial areas are suited for such use, priority areas have to be indicated accordingly. In case of multiple uses, a buffer zone to other forms of use has to be provided.

Responsibility for the dam

In Styria, according to the 1997 amendment to the Water Act, water licensees are required by law to appoint an accordingly qualified and reliable Dam Surveillant who is familiar with the installation and his or her substitute for dams and reservoirs - river power plants are exempted - whose heights above foundation level exceed 15 m or which are able to retain an additional water quantity of 500 000 m^3.

Study of flood relief installations

In a study, 42 Styrian flood retention basins were examined as regards their performance and safety. The installations under investigation had been planned by 15 different project teams and consist of 39 earthfill dams, two impounding walls and one combined-type dam.

Basins have been classified as small, medium and large:

Basin size	**Basin capacity (m^3)**	**Impounding head (m)**	**Special costs (EURO per m^3 of capacity)**
small	< 100 000	< 5	10.0 – 10.8
medium	100 000 – 500 000	5 - 15	5.4 – 6.1
large	> 500 000	> 15	3.0 – 3.9

A differentiation has been made also according to the potential damage:

S1	Hazard to human life, settlements, main traffic routes
S2	Like S1, however, demonstrable reduction of risk potential
S3	Land used by agriculture

Following a visit to the areas downstream the investigated retention basins, in Styria, most of them were assigned to category S1. Warning facilities and other safety installations such as bypasses were taken into consideration in the appraisal.

In the end, it was concluded from the study that a number of retention basins need to be adjusted to the state-of-the-art in the next years, depending on the urgency and the availability of funds. Based on uniform design criteria for flood relief installations, the existing installations were examined as to their performance and safety and the following major adjustments were proposed:

- re-calculation of the freeboard and possible solutions
- widening of the crest spillway
- revision of hydrological fundamentals
- optimization of bottom outlet by movable gates
- removal of earth cover in the dam crest area and in the chute
- no use of flat dams as farmland
- landslide stabilization in the watershed
- improvement and reconstruction of several inlet structures (bar distance of rakes, lifting the rake from inlet bottom)

Both the basin commission and the water authorities demand that installations be kept in orderly condition and that maintenance be carried out at regular intervals. In consultation with the local communities, the Department for Water Management in Styria has made arrangements for inspection and maintenance of 48 flood retention basins, which have been tested since 1995.

The enclosed scheme (see page 99) lists the technical and safety-related tasks that have to be performed by the Basin Surveillant (civil engineer). He is assisted by a Basin Overseer who is responsible for maintenance on site and who takes immediate action in case of emergency.

Like for the construction of flood retention basins, their regular maintenance is funded by the Federal Government as well as by the Land of Styria. The regulatory framework is provided by the Hydraulic Structures Promotion Act.

Principles of planning

1. Planning - process

a) Fundamental ascertainments

Hydrologic, topographic, geologic, ecological and economical data have to be set up and clearly arranged.

b) Preplanning

It contains considerations about the architectural constructive design of the planned retention-basin. Variants are being investigated and possible locations compared.

c) Form and content of the project

Technical report:

denotation of the building project, statement of place, purpose of the measure, building owner, importance of the measure, representation of the present condition, description of the project, legal questions, calculation of costs and computation of quantities.

Calculations:

hydraulics, bed load, technical and static calculations, clearly arranged and easy to verify.

Other enclosures:

catalogue of surface measures grant - decisions in the fields of water-law and native protection-law.

Maps:

overview maps and land-registers	1:25 000 or 1:50 000
detailed site plan:	1:1 000 or 1:500
longitudinal profile:	same scale as site plan and cross-sections
cross sections:	1:100 or 1:200
cross sections of the valley:	1:500
project - plans:	1:50 or 1:10
other plans:	topographic sketches, geologic profiles, soil-maps, maps of groundwater-layers etc. illustrative documentation.

d) Execution-planning

Detail-maps, static calculations, stability against collapse, planting-plans.

2 Hydrology

The foundations of the hydrologic determination of dimensions substantially influence the safety and efficiency of a retention-basin. The most important technological terms related to retention basins and to flood event are schematized in Figures 3.3.2.2 a and 3.3.2.2 b.

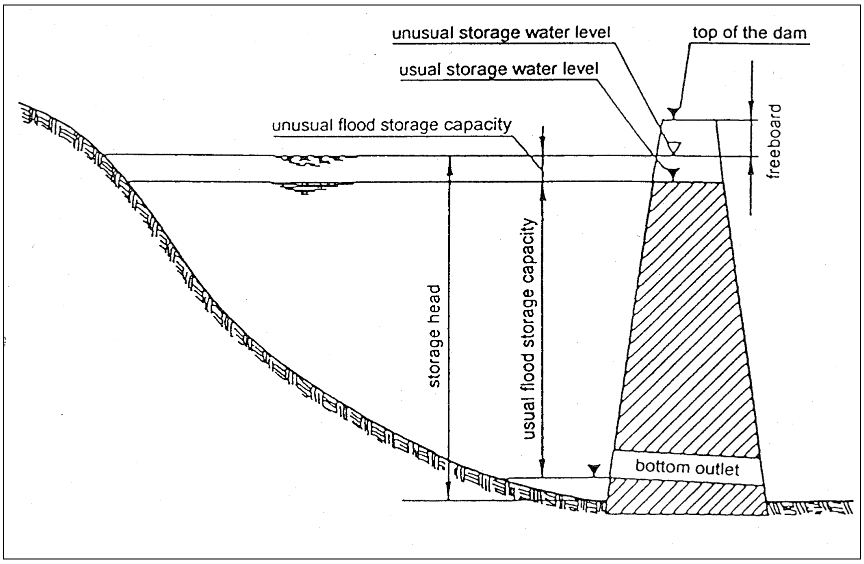

Figure 3.3.2.2 a - Scheme of a Retention Basin

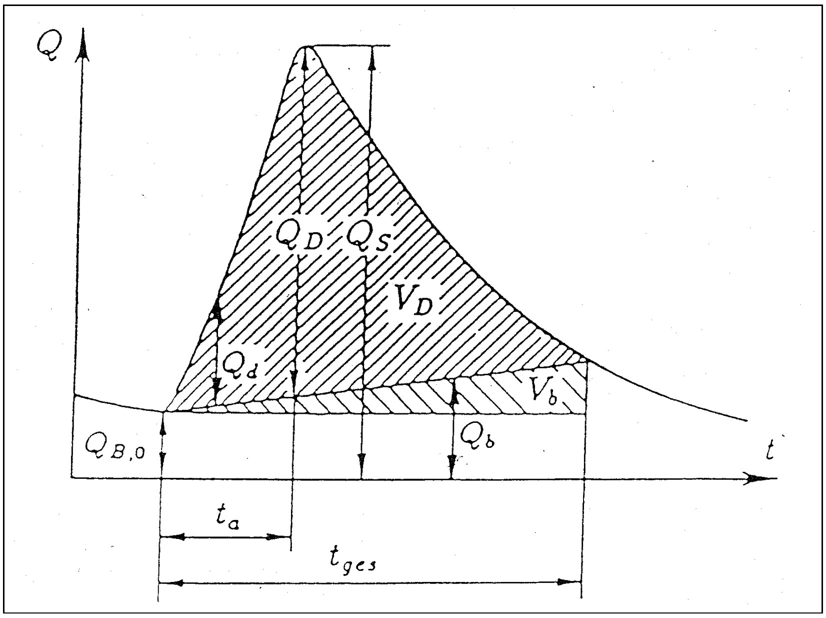

Figure 3.3.2.2 b - Scheme of a flood event and characteristics

where:

Q_s	[m³/s]	(total) flood peak discharge
Q_d	[m³/s]	direct flow
Q_D	[m³/s]	highest direct flow
Q_b	[m³/s]	base flow
$Q_{B,O}$	[m³/s]	initial base flow
V_D	[m³]	direct flow volume
V_b	[m³]	selected flow volume > $Q_{B,O}$
t_a	[*h*]	time of rise (water level)
t_{gcs}	[*h*]	total time

3 Hydraulic and constructive components

The essential operating-installations consist of bottom outlet, spillway, bypass as well as the necessary energy transformation plants.

4 Soil mechanics

In the surrounding area of the dam, the structure of the subsoil and the hydrogeologic conditions have to be explored in order to lay down the most appropriate dam-type and to carry out the corresponding investigations concerning the stability against collapse.

In the basin area, the stability of the slopes, particularly the ones situated above the storage water level have also to be inquired. The effects of the swift damming and swift daring out have to be taken into consideration.

5 Running and servicing

The essential requirements are:

a) Working plan, registration- and warning plan, working regulation containing the duties of the civil engineer, who is responsible for the retention basin and the keeper for the retention basin;
b) Appointment of the responsible civil engineer and the keeper of the retention-basin;
c) Final approval

6 Monitoring

a) Basin Surveillant / Civil Engineer

- drawing up of basin regulations and keeping of a basin log book
- annual inspection for safety and performance
- instruction and supervision of activity of basin overseer
- inspection of installation after floods
- reporting to the supervisory and special agencies
- taking of messages and reports
- giving out orders in case of imminent danger

b) Water Licensee / Basin Overseer

- keeping of an operation diary (inspections, measurements)
- maintenance of the installation
- four annual checks of the installation as to its condition
- removal of blockages and depositions
- presence on site in case of a flood
- information and warning plan
- notification in case of emergency: 1) basin surveillant
  2) fire brigade
  3) local authority.

The following figures (3.3.2.2 c, 3.3.2.2 d, 3.3.2.2 e, 3.3.2.2 f, 3.3.2.2 g, 3.3.2.2 h) show some examples of existing retention basins in Styria.

Figure 3.3.2.2 c – Retention basin also used for recreational purposes in Styria

Figure 3.3.2.2 d – The same retention basin after a flood event

Figure 3.3.2.2 e – Retention basin in Styria during a flood event

Figure 3.3.2.2 f – Retention basin in Styria after a flood event

Figure 3.3.2.2 g Embankment and spillway of retention basin in Styria

Figure 3.3.2.2 h – Bottom outlet of retention basin in Styria

3.3.2.3 - Lateral Retention Basins

Objectives

Lateral retention basins permit the temporary storage of flood waters in areas where land uses are compatible with the permanence, for a short time, of water (e.g. cultivation, meadows). These kind of structures work in the same way as the retention basins on the main river course (see Section 3.3.2.2) and aim to reduce the entity of the water discharge of flood in the downstream part of the hydrographic network.

Lateral retention basin requires the presence of areas of river pertinence where waters can spill during strong flood events.

These structures can be prepared in the flat areas close to the river course through the construction of artificial embankments that bound a portion of the alluvial plan where the flood water can be temporarily stored. Areas with low or very low morphological gradient are usually sought because they can hold a significant storage volume and present the lowest economic costs for the construction of artificial banks.

Application of this kind of solution requires large surfaces in flat alluvial areas that are not occupied by urbanized or industrial activities. Meadows or particular kinds of agriculture activities (cultivation of plants able to resist a temporary submersion), and recreation areas could represent compatible land uses. Furthermore, the creation of new areas of river pertinence can favour the improvement of ecological value of degraded areas with the preparation of wet habitat for special living species.

Structure typologies

Lateral retention basins represent a simple technical solution for the reduction of hydraulic risk in small and medium size basins subjected to flash floods. The preparation of these works requires the construction of embankments for the delimitation of the flooded areas and some technical devices for the inlet and outlet points of flood waters.

These interventions can be put in practice both along rivers with natural banks and along water courses bounded by longitudinal protective structures.

In-depth analysis of detailed maps (scale 1:5 000, 1:2 000) permits the identification of peculiar morphological situations that can simplify the construction of artificial embankments. Particular attention must be paid in the identification of ancient areas of river pertinence that could be restored at a low cost (e.g. lowlands, abandoned meanders, etc.). In some cases, these interventions can be coupled with the re-establishment of a natural evolution of the river through the arrangement, within the lateral retention basins, of the natural hydraulic section and/or a meandering trend of the course.

Flat areas that can be adapted for the use as lateral retention basins can sometimes be identified several hundred meters away from the river course. In these cases, the construction of inlet and outlet artificial channels in order to carry the flood waters represent a feasible technical solution.

The entrance and exit points between the river course and the lateral retention basin must be arranged with protective structures in order to avoid erosive problems.

The preparation of earthfill embankments to contain the flood waters must follow the same technical prescriptions that have to be put in practice for the preparation of longitudinal protective structures (see Section 3.3.3.2.1).

Figure 3.3.2.3 shows an example of a lateral retention basin.

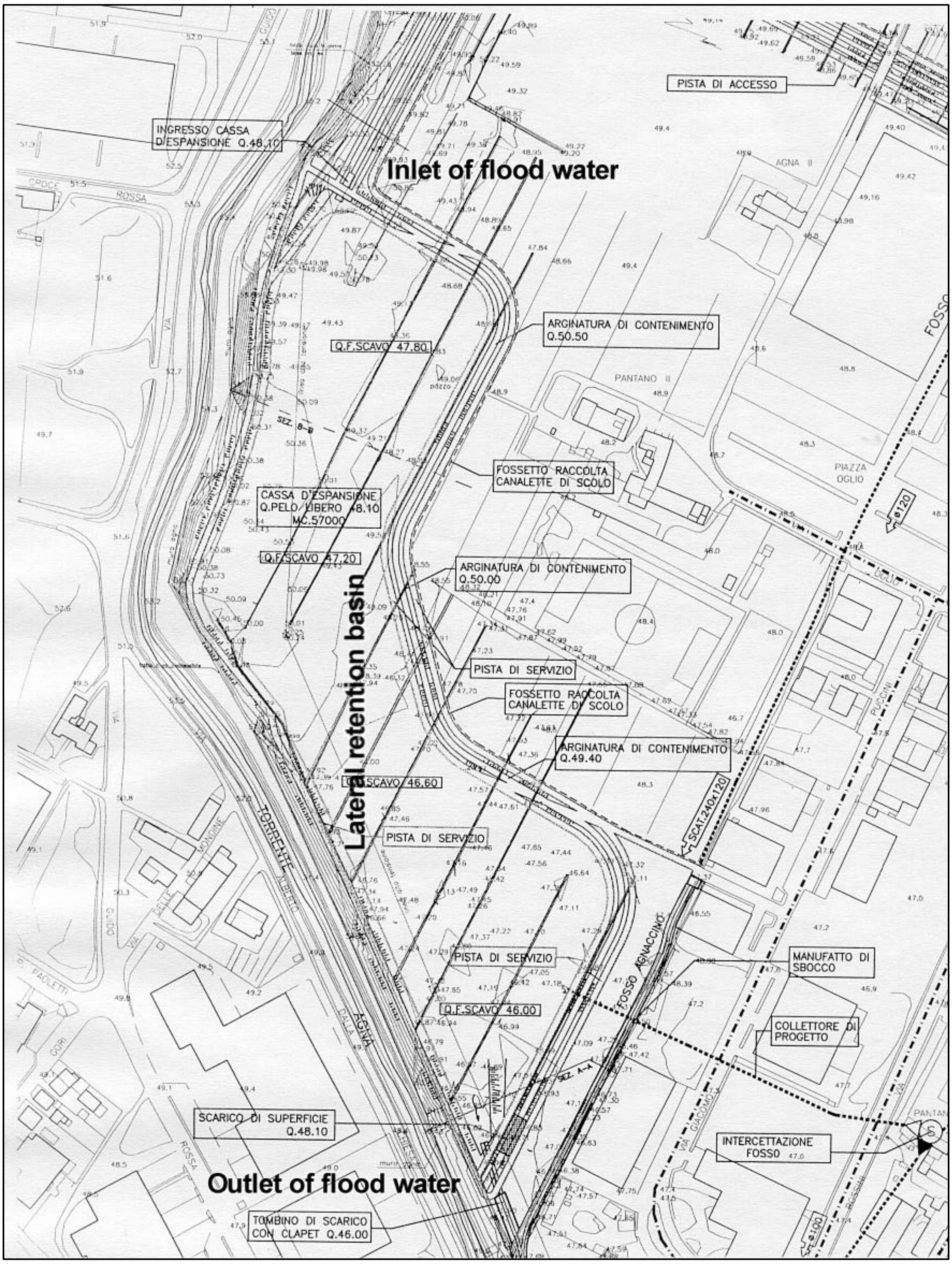

Figure 3.3.2.3 – Lateral retention basin near Prato **-** Italy (scale 1:4 000)

During the last years in Tuscany, this kind of interventions has been applied in many river courses subjected to recurrent flood events. However, because of the extensive urbanization of alluvial flat areas, areas free of buildings have become very scarse. For this reason, it is important that territorial planning of river basins identify bonds and prescriptions for preservation of areas that can potentially be used for the preparation of lateral retention basins. (See Section 3.2.2.1)

Constructive aspects and location

Construction of lateral retention basins must be planned in the central and lower portion of the hydrographic basin where the existence of flat areas permit to identify large surfaces for the storage of significant volumes of flood waters. Preparation of lateral retention basins must be preceded by hydraulic calculation of the basin, in order to define the volume of water that has to be stored in the retention areas. It must also consider the efficiency of the downstream hydraulic section of the river course and of the discharge of the expected floods in relation to a certain return time period.

In the construction of artificial embankments of lateral retention basin, certain technical aspects must be considered in order to prevent the collapse or the siphoning of the earthfill structure. In particular, the stability of the structure, through the analysis of the geotechnical characteristics of the banks and of foundation materials, must be verified.

Erosive problems must be analysed for the devices of both entrance and exit of flood waters while no protective structures have to be prepared for the artificial embankments because of the low velocity of stored waters inside the retention areas.

Hydrogeological aspects of the natural terrain and of the artificial body of earthfill structures must be analysed in order to avoid the formation of high inner neutral pressure inside the protective structure or under their foundations. Preparation of impermeable barriers inside and under the artificial embankment must be considered since the planning phase of these works.

Finally, supplying of materials must be planned and studied. It is important to identify the sites for collection of the constructive material. Often, the terrain in the surrounding area and the sediment in the river bed represent a good source for constructive materials.

Maintenance

Lateral retention basins must be maintained in order to avoid the breaking up or collapse of the embankments during the occurrence of high water levels. A periodical survey of the embankments can guarantee the identification of structural deficiencies of the artificial earthfill banks. Particular attention must be paid to critical conditions of embankments that can be produced by the activity of animals and plants. Rodents that make caves inside the earthfill structures may produce damages causing infiltration of water and the development of piping. Furthermore, large trees on the slope of the artificial embankment can favour the infiltration of water and, in case of collapse, the partial destruction of the earthfill structure. For this reason, a periodical cutting of the oldest and ill trees can reduce the risk of destruction of the artificial embankment.

The longitudinal structures for storage of flood waters must be planned or adapted with maintenance roads along the outer side or on the top of the structure, in order to guarantee the accessibility to men and machines for periodical or extraordinary maintenance of the retention area.

In relation to sedimentation of transported materials caused by the reduction of the water velocity inside the lateral retention basin, sediments must be periodically removed in order to maintain the volume for storage of the flood water.

Environmental impacts

These interventions do not produce a relevant environmental impact in the flat alluvial areas. On the contrary, their construction can favour the re-creation of natural conditions of river courses producing an increase of the bio-diversity within the riparian habitat in urbanized areas. For this reason, the adoption of bioengineering criteria for preparation of these interventions must be considered since the planning phase. In particular, the presence of wet zones within the retention area may represent habitats for avian, terrestrial, amphibian and aquatic species. Construction of artificial lakes, islands, the plantation of small wooded areas may also favour the colonization of many different plant species. Furthermore, the preparation of artificial embankments with an irregular longitudinal and transversal section permits the creation of natural conditions within the retention areas and a better environmental fitting in the flat area.

Costs

The costs concern only the constructive operations of the structures comprehending materials and labour work. They do not comprehend the expenses for the operations of preparation of the building yards and are value–added tax (VAT) free.

- Earthfill embankment: 30-35 Euros per m^3 of bank.

3.3.3 River Training Works

This Section offers an overview of different typologies of hydraulic structures that can be put in practice along torrent beds for the managing and control of the morphological evolution of streams, in order to identify appropriate criteria for prevention and mitigation of flash floods. The most important and widespread standard-typologies of structures can be planned with indication of general technical aspects are described, highlighting the limits or advantages of each hydraulic structure in relation to its environment-friendly capability which must be analysed in the planning phase. However, the structures presented do not represent an imposition for technicians working in this sector, but rather a chance to analyse hydraulic problems in order to conciliate hydraulic requirements with the ecological aspects of river habitats.

Many examples of incorrect and miss management of the hydrographic network have been pointed out in the last decades. Rediscovery of old rearrangement techniques applied in the last centuries and in the first part of XX century, which are today called bioengineering works, is a cultural heritage that cannot be ignored by the modern policy management of hydrographic networks. The introduction of new bioengineering techniques or the rediscovery of the old ones, sometimes coupled with the traditional type of interventions, are an extra choice among the applicable solutions for rearrangement of hydrographic networks.

Their employment causes an improvement of the ecological aspects of the river course, favouring, for example, the reduction of polluting substances in the water because of the filtering action of vegetal species and micro-organisms living in the stream habitats. Furthermore the existence of natural corridors favour the diffusion and preservation of many different living species within the riparian ecosystem.

The contributions brought into the project by each partner have highlighted that the application of techniques with a low environmental impact, also using vegetal species or rocky material available on the torrent beds, represents a resource that can easily be used in many circumstances and with low costs with respect to the more traditional works.

The management of stream courses, applying traditional interventions, has showed, in many cases, the inefficiency of the adopted solutions. These typologies of intervention have caused the alteration of the dynamic equilibrium of hydrodynamics aspects that cannot be correctly predicted. For example, the increase of embankments has clearly produced the grow up of maximum elevation of flood peaks causing higher risk conditions for the urbanized areas close to the stream courses. Strong modifications of the natural hydraulic conditions of long torrent stretches (straightening or lining of stream courses) have increased the discharge and produced the destruction of natural habitats and the modification of the natural dynamics in many torrent beds.

River training works are fundamental for torrent management in relation to their adaptability to the different typologies of torrent reaches, morphological conditions and hydraulic parameters. They can produce immediate benefits by removing or reducing the hydraulic problems, as a function of their correct fitting in, building techniques and constructive materials used.

Identification of the correct typologies of structures to be put in practice requires hydraulic investigations and studies as to guarantee that the planned works, even though they may solve localized problems, will not result in negative effects in adjacent torrent reaches or the creation of non-mitigable environmental impacts.

In some cases, it is important to pay attention to the “zero” option, which does not foresee the construction of any kind of interventions. For example, the necessity of furnish sediments to avoid erosion of banks can be planned with the elimination or not construction of check dams in unstable slopes (if the urbanistic and hydraulic safety is guaranteed), favouring the creation of controlled landslides or erosional phenomena.

The different typologies of hydraulic–forestry structures, described in the following pages, represent the most common and updated interventions to control and optimize the regime of water discharge by limiting its dynamic energy. They also have the function of reducing solid transport and the natural processes of bed and bank erosion along the water courses, whose uncontrolled evolution can lead to general instability of banks and adjoining slopes.

For practical purposes, a standard format of description which includes objectives, structure typologies, constructive aspects and location, maintenance, environmental impacts and finally, costs, of each typology of intervention has been chosen so that its advantages in relation to the hydraulic problem being faced can be better evaluated. A series of figures, drawings and schemes have also been inserted in the text, in order to give a synthetic and graphical overview of the different typologies of hydraulic-forestry structures put in practice in Italy.

The costs expressed in Euros concern only the constructive operations of the structures comprehending materials and labour work. They do not include expenses for the operations of preparation of the building yards and are value–added tax (VAT) free.

3.3.3.1 Transversal Hydraulic Works

3.3.3.1.1 Check Dam

Objectives

Use of this typology of hydraulic works permits to stabilize the elevation of the bed along river courses subjected to significant evolution of their morphological profile.

The construction of many check dams in succession along the water course (check dams in tiers) leads to the stabilization of the bed over long distances.

Control of the torrent bed elevation favours the prevention of landslides on natural slopes and artificial banks as well as the carrying out of rearrangement works on slopes involved by active instability phenomena.

The employment of these structures is fundamental in solving or mitigating erosional phenomena and in the control of solid transport, especially in areas subjected to strong erosive action of water flow (badlands).

These structures, that decrease the morphological gradient of the torrent bed, work towards the reduction of the water velocity during flood events by increasing the concentration time of the hydrographic basins and reducing the flood peak and solid transport capacity of the water flow.

This typology of hydraulic works is often coupled with the construction of bank protections, crossing structures or other typologies of hydraulic works, in order to guarantee their defence from undermining and breaking phenomena.

Structure typologies

The preparation of check dams can be made using different materials and constructive techniques. The application of bioengineering techniques, that agree with the environmental and ecological characteristics of the torrent bed, has been the most recent development. The choice of the most appropriate check dam structure typology is made as a function of the hydraulic parameters of the water course and also of their environmental and ecological factors. The planning phase of these structure must be preceded by an in-depth evaluation of their effects on the dynamics of the entire water course.

The constructive typologies that are usually carried out in torrent beds are:

- Cemented stones, concrete (Figures 3.3.3.1.1 a and b);

Figure 3.3.3.1.1 a

Figure 3.3.3.1.1 b

These structures can be located along the entire length of the hydrographic network because of their adaptability to different morphological and hydrodynamic conditions of the torrent bed. Their strong rigidity permits to plan check dams with considerable dimensions. A significant environmental impact is caused both during the preparation of the building yard and by the final structure that cannot be renaturized.

- Gabions (Figures 3.3.3.1.1 c and d);

Figure 3.3.3.1.1 c

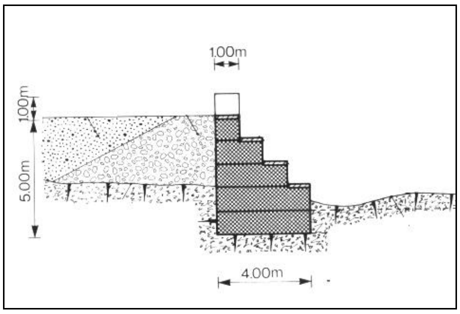

Figure 3.3.3.1.1 d

Construction of check dams made with gabions requires a sufficient volume of rocky materials that in some cases can be found along the torrent bed. The maximum dimension of these structures are bigger than check dams made with stones and wood. These works can reach a maximum height of 9 -10 meters. The adaptability of these structures allows their use along the entire hydrographic network. A significant environmental impact is caused during the preparation of building yard while the final structure permits a rapid renaturization by natural plants or cuttings.

- Wood, rocks and wood (figures 3.3.3.1.1 e and f);

Figure 3.3.3.1.1 e

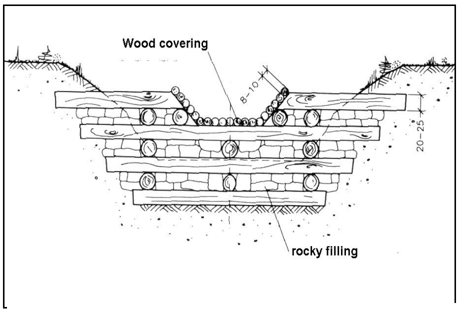

Figure 3.3.3.1.1 f

Preparation of these structures needs the construction of a well-organized structure made of rocks and wood (poles with diameter of 10-25 cm). In some cases, the constructive materials can be found and processed near the area where these structures are placed. Their maximum dimension is conditioned by their rigidity and by the hydraulic characteristics of water course. Their height does not exceed 2 meters while their width depends on the morphological condition of the torrent bed. For this reason they are usually built in the upper portion of the hydrographic network or along small tributaries with low or intermittent water. Construction of this typology of check dams reduces the environmental impact in relation to the renaturization capability of their structure. The wood species that are more suitable are: larch, chestnut, natural or treated resinous plants. In general, any kind of woods with strong resistance to water that can be found directly in the area of construction can be used.

- Dry stones (figures 3.3.3.1.1 g, 3.3.3.1.1 h);

Figure 3.3.3.1.1 g

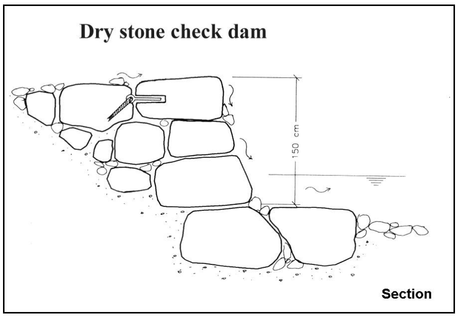

Figure 3.3.3.1.1 h

Carrying out of these works requires the construction of a well-organized structure made of big stones in order to resist to the dragging action of water flow. In some cases, the stones can be found near the area where these structures are built.

Rocky check dams are usually built in the upper portion of the hydrographic network or along small tributaries where the intermittent water flow with low discharge favours their durability. The maximum dimension of these works is conditioned by their rigidity and by the hydraulic characteristics of the water course. Usually, their height does not exceed 2 meters. Application of bioengineering criteria can foresee the use steel rope in order to anchor the structure to the substratum. Construction of rocky check dams reduces the environmental impact in relation to the renaturization capability of their structure.

Constructive aspects and location

Construction of these works requires careful planning of the foundation site in order to assure the stability and durability of the intervention. The collapse of check dams, caused by the undermining, turning and piping action of the water flow, can produce or increase the erosional phenomena, solid transport and instability of slopes and river banks.

For this reason, the planning phase of these interventions must foresee the carrying out of bank protection structures, foundation planks, etc.. Protection of check dams in their downstream part usually requires the fitting in of structures (auxiliary dams, torrent bed covering with stones or concrete, etc.) in order to dissipate the hydraulic power of the water fall.

The strong energetic environment where these hydraulic works are usually constructed requires that the technical execution must be carefully planned in advance to resist to the hydraulic strength of the water flow. For this reason, some typologies of check dams made with dry walls, wood and stones, etc., can only reach a maximum dimension that is a function of the technical characteristics of the constructive materials, morphological aspects of the bed and hydraulic aspects of the water flow.

The construction of wood, dry stone or gabion check dams permits to assure, in situations of instability conditions of their foundation site, a greater durability due to the flexibility of the structure and the possibility of settling of foundations. The renaturization of these structures assures a stronger resistance against the hydraulic stress of flowing water.

Check dams made of concrete and cemented stones can be constructed in larger scales and located along the entire torrent or river length because of their superior adaptability to the hydraulic and morphological characteristics of the water course.

Maintenance

The durability of these hydraulic works depends on their constructive techniques and it is closely linked to the maintenance and renovation operations as to guarantee stability conditions of the structures and thus preservation of the hydraulic stabilization of the water course.

In the last years, the maintenance and renovation of check dams have been sometimes carried out with the preservation of the ecological characteristics of the water course through the substitution or modification of traditional structures with other typologies with an increased ecological value (e.g. ramps or works made with stones and wood).

Environmental impacts

These hydraulic structures, transversal to the water course, cause a sensible environmental impact both during the constructive and the operation period.

Check dams made of wood, stones and wood and dry walls permit to minimize the impact of these structures in relation to their better insertion in a natural environment subjected to revegetation.

They may represent a physical barrier for the diffusion of the ichthyic species along the water courses. For this reason, along the torrent or river stretches with a perennial or semi-periennal water flows, or where the morphological hydraulic conditions are suitable, these structures should be constructed with a low height or adapted, in order to guarantee the going back up of the great part of the ichthyic species living in the stream.

Carrying out of ramps, lateral corridors, etc. is thus a necessary integration since the planning phase of new transversal works or restoration of the existing ones.

Construction of ramps with blocks placed or anchored to the ground permit the creation of zones with different energy that favour the overcoming of significant slopes by fish especially during the reproducing period (Figure 3.3.3.1.1 i).

In many cases, these transversal structures cause the destruction of the natural riparian habitats in the upstream portion of the water course because of the sedimentation of the transported materials that destroy the morphological variation of the natural torrent bed.

Figure 3.3.3.1.1 i

Costs

- Check dams with wood and rocks: 150-190 Euros per m^3;
- Check dams with dry wall: 50-70 Euros per m^3;
- Check dams with gabions: 110-125 Euros per m^3;
- Concrete check dam: 180-200 Euros per m^3.

3.3.3.1.2 Sill

Objectives

This typology of hydraulic works, with transversal orientation to water flow, assures the preservation of the river bed elevation. These structures are carried out along river stretches with a medium-low gradient subjected to bank and bed erosional phenomena that may cause instability conditions of the natural and artificial embankments and of the other existing hydraulic works. Their construction is often coupled with other hydraulic structures to avoid their undermining and erosion of the foundation (bridges, walls, etc.).

The purpose of this typology of hydraulic works is the same of check dams but, in relation to the medium-low gradient of the stream where they are usually carried out, sills have a more limited height.

Structure typologies

Sills, in relation to the low energy condition of the river course where they placed, can be built with many constructive typologies and different materials. The choice of constructive typology is also conditioned by the morphological and ecological aspect of streams.

The constructive typologies usually applied are:

- Concrete, cemented stones (Figures 3.3.3.1.2 a and b);

Figure 3.3.3.1.2 a

Figure 3.3.3.1.2 b

This typology of hydraulic works is widespread along torrent courses, in particular, in the lower portion of hydrographic network, characterized by a limited topographic gradient, in relation to their constructive facility. Rigidity of concrete or cemented stone sills favours the carrying out of width structures in all morphological conditions. Construction of these works does not cause a high environmental impact during the construction of the building yard, nor does the final structures due to their limited height.

- Gabions (Figures 3.3.3.1.2 c and d);

Figure 3.3.3.1.2 c

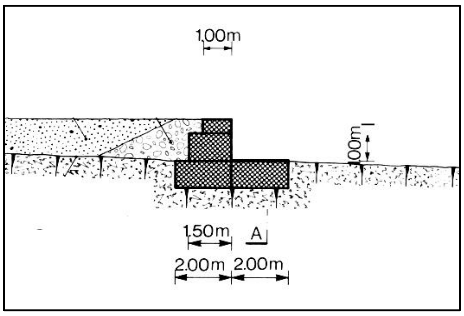

Figure 3.3.3.1.2 d

Sills made with gabions can take on in many different hydrodynamic conditions. Their limited height allow for a considerable width. Sometimes, building of gabions can be carried out with the rocky materials available along the torrent beds. Use of gabions, in relation to their capability to be renaturized, favours the ecological fitting of their structure in natural riverine habitats.

- Blocks, blocks anchored to ground, wood and rocks (Figures 3.3.3.1.2 e through h);

Figure 3.3.3.1.2 e

Figure 3.3.3.1.2 f

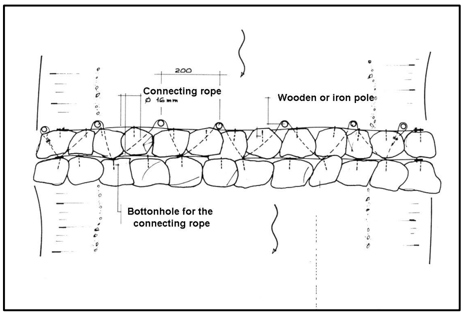

Figure 3.3.3.1.2 g

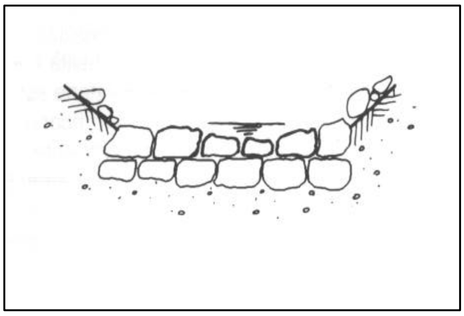

Figure 3.3.3.1.2 h

In relation to their constructive facility, this typology of sills are built mostly in the upper mountainous portion of the hydrographic network or in sites with morphological difficulties. Rocky sills cause a limited environmental impact because of their easiness of renaturization that favours the ecological fitting. The wood species most suitable are: larch, chestnut, natural or treated resinous plants. In general, any kind of woods with strong resistance to water that can be found in the area of construction can be used.

Sills made of concrete are up to now the ones most commonly used because they present a minimum constructive difficulty. The environmental sensitiveness of the last years has driven to the planning and construction of other typologies of structures made with natural materials in order to reduce environmental impact inside the torrent bed.

Sills built with rocks can be put in practice both using blocks of rock with a dimension and weight sufficient to resist to the tensile strength of the water flow during the maximum flood events and through the construction of anchor points with steel cables that fix blocks to the rocky or alluvial substratum. Furthermore, the use of gabions or rocks and wood favours the hydraulic fitting along torrent beds with strong morphological modifications in relation to the flexibility of their structures.

Constructive aspects and location

The stability of the foundation site (torrent bed and banks), in relation to the resistence of the structures to the turning, undermining and piping action caused by the water flow, must be verified.

Usually, these works are built together with bank protection structures (made in the upstream torrent stretch) to guarantee durability of their anchorage, favour directing of water flow and prevent the undermining of the embankment. Furthermore, the hydraulic energy of the torrent course where these works are built assumes that their structures are able to resist to collision, wear and tear action caused by the solid transport flow.

These hydraulic works are usually carried out along river stretches with a low morphological gradient where the preservation of torrent bed elevations does not require the construction of check dams.

Maintenance

The durability of these hydraulic works is directly linked to the maintenance that must be periodically put in practice in order to guarantee the global stability conditions of their structures. Therefore, their periodical control is a necessary operation in order to identify damages of structures, plan the necessary renovation action and guarantee their effectiveness.

Breaking and unanchorage of these works caused by water flow produce or increase bed and/or bank erosional phenomena that can signify damages to long torrent stretches.

In the last years, maintenance and renovation actions have been directed towards the respect of the ecological aspects of streams also with the substitution or modification of traditional structures with new typologies made with natural materials (rocks, wood) that are integrable with the natural torrent environment.

Environmental impacts

Carrying out of these hydraulic structures, even though they have a transversal direction with respect to the water flow, does not cause a significant environmental impact in relation to the low height of the structure above the bed elevation and, in cases where the stream has a permanent water flow, to the complete or partial submersion by the water level.

The use of concrete for construction of these works does not eliminate the environmental and landscape impacts of the structure located along torrent beds. The construction of different typologies of hydraulic sills using natural materials (wood, rocks, gabions) permit to guarantee a good environmental insertion.

Furthermore, the structures made of rocks and wood allow to create morphological variations of the torrent bed with the formation of new and different ecological habitats for the faunal species.

Costs

- concrete: 170-185 Euros per m^3;
- blocks of rock anchored to ground: 120-130 Euros per m^3;
- blocks of rock: 55-65 Euros per m^3;
- wood and rocks: 110- 120 Euros per m^3;
- gabions Euros 120-135 per m^3.

3.3.3.1.3 Beam Dam – Screen Dam

Objectives

This typology of hydraulic works is planned for retention of the rocky and vegetal materials transported along the stream course, during strong alluvial events, in order to avoid the formation of a dangerous mass transport and to prevent the obstruction of narrow hydraulic sections, covered stretches or check dams with fixed outlets that could cause disastrous flood events.

These structures can be carried out along stream stretches that have a significant transport of solid and vegetal materials (alluvial fans, mountain torrents, stretches with a steep slope, wooded areas) or in hydrographic basin that are subjected to frequent mass transports (debris flow, mud flow, etc.). Their function is to store, in a sedimentation pool with adequate volume, the great part of the transported materials and, thus, reduce the downstream discharge effects.

Structure typologies

The construction of beam dams – screen dams, because of the strong energy of the environment where they are constructed and in relation to the volume of stored materials, must be planned and carried out using materials that are able to resist to the solicitations produced by the transported terrigenous and vegetal materials during the strong flood events.

For these reasons, beam dam – screen dams must be constructed with a structure in concrete while the retention equipment for the floated sediments and vegetation can be built using different typologies in relation to the peculiar characteristics of the transported materials. The most applied typologies of beam dams – screen dams are the following:

- Screen dam with vertical steel bars for retention of mainly vegetal materials (Figures 3.3.3.1.3 a and b);

Figure 3.3.3.1.3 a

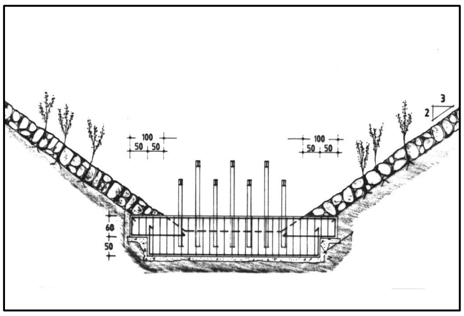

Figure 3.3.3.1.3 b

Screen dams can be put in practice in different reaches of the hydrographic network in relation to the need of reducing the transported materials (rocks, wood). These structures are often coupled with other typology of hydraulic works (retention basins, dams, bridges, etc.), in order to guarantee their protection and durability, reduce the sedimentation in artificial basins or prevent damages in water courses that cross urbanized areas. Screen dams are built using concrete and steel in order to create structures with a high resistance against the transported materials. Structures made with bioengineering techniques (using wood) can be carried out along small torrents or agricultural or forestal channels. Usually these works produce an impact on the natural aspect of the site because their structure cannot be renaturalized.

- Beam dams with central pylon bars (Figure 3.3.3.1.3 c), vertical opening (Figure 3.3.3.1.3 d) and horizontal steel bars (Figures 3.3.1.3 e and f);

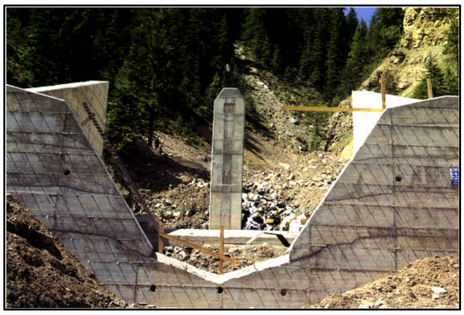

Figure 3.3.3.1.3 c

Figure 3.3.3.1.3 d

Figure 3.3.3.1.3 e

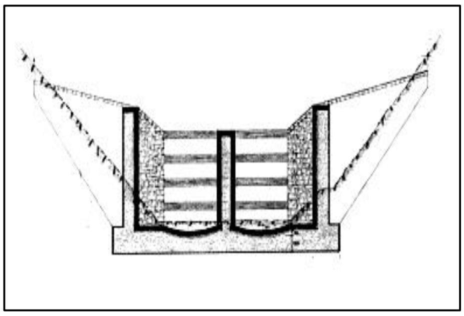

Figure 3.3.3.1.3 f

Planning of this typology of dams requires the definition of characteristics, entity and dimension of the transported materials in order to create a sufficient volume for the sedimentation pool and the correct size of openings. Usually, these structures are built to prevent the formation of mass transport that could involve urbanized areas. Beam dams are built with concrete and steel in order to guarantee a high resistance against the impact stress caused by transported materials. Construction of these works causes a significant environmental impact both during the preparation of the building yard and by the final structure that cannot be renaturalized.

The total capacity of the sedimentation pool is closely linked with the morphological characteristics of the upstream torrent stretches and the height of the planned structure. In some situations with low morphological gradient, this typology of structural works is coupled with the construction of width sedimentation pools (Figure 3.3.3.1.2 g) that are able to guarantee the storage of huge quantities of terrigenous and vegetal materials transported during the alluvial events. Construction of width sedimentation pools can be carried out with particular attention to the ecological rearrangement of the area and with the creation of many ecological habitats for different animal species.

Figure 3.3.3.1.3 g

Constructive aspects and location

Construction of this typology of hydraulic works must in particular verify the insertion of its structure in relation to the stability of the foundation site and must guarantee a sufficient safety coefficient against the turning and/or undermining caused by water flow.

For this reason, the planning phase must foresee the making of bank protection structures, foundation planks, etc., in order to avoid the dangerous collapse of the concrete structure.

Furthermore, the strong energetic conditions where these works are put in practice must foresee that their structure is able to resist to the impact of the transported vegetal and rocky materials and to the pressure of sediments on the upstream side of the retention structure. For this reason, their construction is put in practice using concrete and metallic structures.

Construction of these hydraulic works is usually located along reaches subjected to frequent and considerable alluvial events with high solid transport (debris flow, mud flow, etc.). Their location is usually planned in narrow torrent beds at the end of the valley before the alluvial fan or flat area.

The dimension of these structures must be planned, in relation to the morphological aspect of valley, to guarantee a significant volume of the sedimentation pool, in order to contain the total amount of solid materials brought down during alluvial events

Maintenance

The durability of these hydraulic structures depends on their constructive techniques and it is closely linked to maintenance and renovation actions that must be periodically put in practice, in order to preserve the stability of the concrete structure and of the foundation site, whose collapse, during an alluvial event, may produce the formation of dangerous mass transports.

For this reason, the inspection of these structures, after each significant alluvial event, is a fundamental action to identify damages and assure their correct function. Furthermore, the maintenance action must be put in practice after each significant alluvial event, in order to remove the transported material from the sedimentation pool and re-establish the storage volume for new alluvial events. Particular attention must be adopted in the cleaning up of the outlet to assure the flow of water.

The temporal distribution of maintenance and renovation actions cannot be planned periodically but must be put in practice after each alluvial event that has produced the refilling of the sedimentation pool or the occlusion of the outlet structure.

Environmental impacts

The carrying out of this typology of hydraulic works, that have a transversal disposition with respect to the water course, causes an inevitable impact on environment and landscape on the water course both during and after the constructive phase.

The necessity to build these hydraulic works with concrete and metallic structures does not permit a reduction of the impact in the foundation site.

The ecological respect of migratory fluxes of fish species is assured by the presence of width openings within the structure. Construction of ramps, lateral corridors, etc., is a fundamental integration during the planning phase of new works or the modification and renovation of the existing ones, in case of different elevations between the down and upstream parts of these structures.

Transversal structures, may cause destruction of natural riparian habitats in the upstream portion of the water course because of the sedimentation of transported materials that alter the natural equilibrium of the torrent bed.

Construction of wide sedimentation pools (Figure 3.3.3.1.2 g) can be carried out with particular attention to the ecological rearrangement of the area with the creation of a complex ecosystem with various habitats, in order to give shelter to different animal species.

Costs

- concrete with metallic bars: 190-220 Euros. per m^3.

3.3.3.1.4 Groyne

Objectives

Use of this typology of hydraulic structure modifies the direction of the water flow in order to protect the bank stretches subjected to lateral erosion phenomena or to protect other type of hydraulic works from undermining.

Construction of these works permits to decrease the velocity of the water flow along bank stretches favouring the sedimentation of the transported alluvial materials and the formation of a natural bank that protects the riparian zones.

In some cases, the carrying out of groynes is also planned to concentrate the water flow and increase its velocity in order to avoid or reduce the problems caused by the aggradation of the torrent and river channel by the transported sediments.

From the ecological point of view, these works can be applied to create different habitats for vegetal and faunal species living in the stream ecosystems. Carrying out of groynes is also applied to recreate natural meandering condition in the torrent beds.

Structure typologies

These works, in relation to the morphological and hydraulic aspects of the torrent beds, is built using different constructive techniques.

The most widespread typologies of groynes are made of:

- Concrete, cemented stones (Figures 3.3.3.1.4 a and b)

Figure 3.3.3.1.4 a

Figure 3.3.3.1.4 b

Construction of this type of hydraulic work is usually adopted along torrent beds subjected to strong bank erosional phenomena and are usually carried out in the lower portion of hydrographic basin where, in relation to the high water flow energy, rigid structures must be put in practice. These works must be built deep in the torrent bed in order to avoid undermining and destruction of their structures. The short transversal dimension of groynes have limited environmental impact on water courses but, on the other hand, they cannot be subjected to renaturation with bioenginnering works.

– Gabions (Figures 3.3.3.1.4 c and d);

Figure 3.3.3.1.4 c

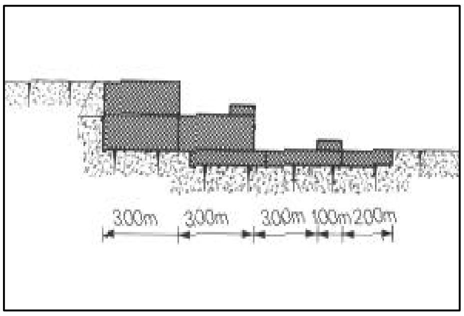

Figure 3.3.3.1.4 d

In relation to the flexibility of their structure, groynes made with gabions can be easily applied along torrent beds subjected to strong bank and bed erosional problems. They guarantee a longer durability in comparison with concrete or cemented stones groynes and can be put in practice with a lower technical and economical engagement, since they can be made with the rocky materials available in the torrent bed. Gabions cause a limited environmental impact because of their easiness of renaturation that favours their ecological fitting.

- Prefabricated or natural blocks (Figures 3.3.3.1.4 e and f);

Figure 3.3.3.1.4 e

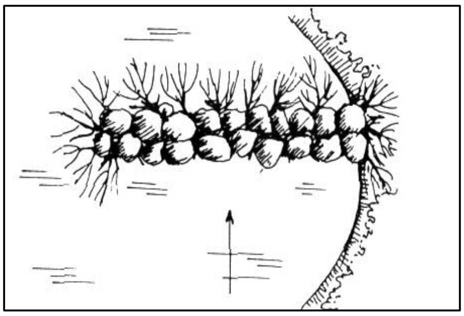

Figure 3.3.3.1.4 f

Groynes made with uncemented prefabricated or natural rocks are usually built along the upper portion of the hydrographic network where lower hydraulic power of water flow occurs. Natural blocks available inside the torrent bed can be used, with low costs, to build these works. Flexibility of their structure permits to guarantee the durability of their structures. which can be reinforced by fixing the blocks to the substratum with steel cables. This type of groynes also create limited environmental impact because of their easiness of renaturation that favours their ecological fitting.

In the last years, bioengineering techniques have consented the construction of hydraulic groynes utilizing natural materials (rocks, wood, plants) that can be subjected to revegetation and which have a low environmental impact. The most used typologies are the following are:

- Rocks and cuttings, wood and cuttings, (Figures 3.3.3.1.4 g and h);

Figure 3.3.3.1.4 g

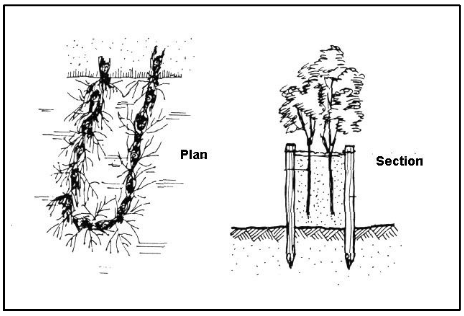

Figure 3.3.3.1.4 h

In relation to their reduced dimension and easiness of construction and durability, this typology of groynes can be applied in different morphological and hydraulic conditions in order to solve small erosional problems that involve the upper portion of water courses. Usually, they can be constructed with materials (rocks and wood) available in site with low costs. Their structures are reinforced with steel cables and poles in order to guarantee the resistance to water flow. They are easily renaturized and have limited environmental impact.

Use of cuttings within the structures made with dry materials (gabions, stones, prefabricated structure) works also towards the improvement of the physical resistance and durability of these structures.

Concerning wooden structures, the wood species that are most suitable are: larch, chestnut, natural or treated resinous trees and, in general, any kind of woods that can be directly taken in the area of construction as long as they have a certain resistance against water.

Constructive aspects and location

Planning and construction of these hydraulic works must verify aspects concerning the stability of their structures in relation to undermining, collapse and break away from the natural or artificial stream banks.

Their structure must be able to resist to the solicitations applied by the water flow. For this reason, the choice of the constructive typology must evaluate the energy conditions of the torrent bed and its solid transport aspects.

The orientation of these hydraulic structures may vary, in relation to morphological and hydraulic conditions of stream course, from a disposition perpendicular to the banks to orientations with a low angle in the same or opposite direction to the water flow. Number and distance of groynes, are a function of their length, hydraulic characteristics of the torrent and sediment discharge.

The location of these works is usually concentrated along the reaches with a medium-low morphological gradient. New typologies of structures, made with bioengineering techniques, have consented the application of these interventions to the hilly parts of the hydrographic network.

Maintenance

The strong energy conditions in which these structures operate require that a periodical control and maintenance action must be put in practice in order to avoid their breaking away from the bank and turning by of the water flow causing the formation of instability phenomena along the riparian zones.

Particular attention must also be applied to the verification of the stability of foundations of these works, usually located under the water level, in order to avoid the undermining and the collapse of the structure.

The construction of wood, stone or gabion groynes permits to assure, in relation to instability condition of their foundation place, the durability of these works thanks to the flexibility of the structure, which allows some movement in the settling of foundations.

Environmental impacts

The construction of hydraulic groynes causes a low environmental impact to the water courses because these structures are partially or completely submerged by the water level. When these works are above the water level for long periods, the use of bioengineering techniques (revegetation) allow to reduce the environmental impact.

As regards the ecological aspects, these hydraulic structures are able to form rather different morphological habitats, sometimes with large extension, where a great diversification of the floristic and faunistic species can develop. In particular, action of groynes may modify the corrent flow velocity favouring the formation of adjoning areas with different energetic conditions. These variable conditions favour the development of habitats in the riverine ecological system.

Carrying out of groyne in artifical courses can favour the recreation of a meandering water flow improving the ecological value of the torrent bed. Finally, the preservation of the water flow continuity along the stream course permits the diffusion and migration of the living species along it.

Costs

- groynes in blocks anchored to ground: 120-130 Euros per m^3;
- groynes of wood and cuttings: 110-120 Euros per m^3;
- groynes in concrete: 170-185 Euros per m^3;
- groynes of gabions: 100-110 Euros per m^3.

3.3.3.1.5 Channel-Lining Works

Objectives

Channel-Lining works are applied to avoid erosive phenomena of torrent bed and/or banks and to allow a high velocity of the water flow in order to guarantee the sediment load transport and avoid episodes of deposition and aggradation in the bed.

The work consists in the interposition between water flow and the natural river bed of a material resistant to erosive action and to the entrainment power of the water. Furthermore, the carrying out of natural channel lining interventions leads to the stabilization of the river bed elevation.

Choice of the appropriate materials typology will consent to obtain, in relation to the local stream morphologic characteristics, lower roughness coefficients, in order to favour, during flood events, the removal of sediments to prevent deposition where this aspect assumes a fundamental importance for the hydraulic safety (urbanized reaches, alluvial fans, etc).

The choice, location, extension and construction of channel lining works must be supported by accurate hydraulic studies, in order to foresee the consequences that variations in hydraulic flow may have in the upstream and downstream reaches with respect to the structure.

Structure typologies

The carrying out of these structures has seen in recent years a substantial diversification in the materials and techniques adopted for their building. The development of new bioengineering techniques, with the use of natural materials (wood, stones) has allowed to put in practice new channel lining typologies limiting by far the environmental impact that such typologies cause on the stream.

The most common construction typologies are:

– Concrete, cemented stones (Figures 3.3.3.1.5 a and b);

Figure 3.3.3.1.5 a

Figure 3.3.3.1.5 b

Carrying out of channel lining with concrete and cemented stones can be put in practice only in peculiar hydraulic and morphological conditions in relation to relevant technical exigency or defence protection measures of urbanized areas. Usually, these works are coupled with other important hydraulic structures (artificial basins, dams, etc.). Channel lining requires to set up strong building yard actions in order to reshape the water course and its hydraulic transversal sections. Building of channel lining with concrete and cemented stones produce a strong environmental impact on the torrent habitats affecting ecological and faunal aspects.

– Gabions (Figures 3.3.3.1.5 c and d);

Figure 3.3.3.1.5 c

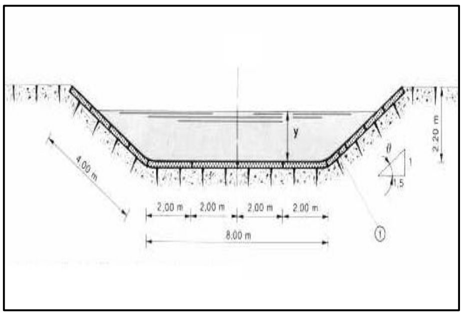

Figure 3.3.3.1.5 d

In some cases, carrying out of channel lining with gabions have involved long stretches of water courses subjected to erosional phenomena that produce frequent plano-altimetric modification of their course. These interventions require to put in practice strong building yard actions in order to reshape the water course and its hydraulic transversal sections. For this reason, channel lining with gabions produce, during the constructive phase, a strong environmental impact on the torrent habitats. In comparison with the previous typology of channel lining (concrete or cemented stones) gabions permit to renaturalize the water course.

– Wood and stones, wood (Figures 3.3.3.1.5 e and f);

Figure 3.3.3.1.5 e

Figure 3.3.3.1.5 f

Rocks or woods are applied, up to today, in peculiar situation where the ecological and environmental respect requires to use natural materials. This typology of lining consents limited building yard actions fitting the intervention to the natural characteristics of water course. Channel lining with rocks or wood permit to renaturalize the water course. Insertion of cuttings among the the structure allows the making of a stronger channel lining.

Regarding the use of wood for the execution of these hydraulic structures, the most eligible species are: larch, chesnut tree, locust tree, resinous plants opportunely treated and more often at a natural state, and in general locally available, with high water-contact and hydraulic flow abrasion durability.

Constructive aspects and location

The carrying out of this typology of structural works requires to verify the effectiveness of the adaptable planning solutions in relation to the resistance to water flow pulling action, the stability of the lining materials foundation and the abrasive and impact stress taken by the solid materials transported by the water. In detail, the lining structures must guarantee the necessary undermining resistance in order to not compromise the stability of the structure and the establishment of basement erosion which may result in instability processes and in the failure of the whole structure.

The carrying out of channel lining structures turns out to be an operation which has to be put into practice with caution where the morphologic and local conditions make it strictly necessary, since this typology of structure results of particularly large impact and of difficult introduction in the stream hydrodynamic context.

In detail, the carrying out of channel lining may interest stream reaches where the establishment of a high velocity water flow is needed to ensure sediment load transport and avoid in-channel aggradation processes, especially in basins prone to high rates of erosion.

This typology of works turns out to be applicable also for regularization and stabilization of reaches of channel bed prone to frequent divagations and altimetrical variations of the bed (torrential streams in semi-arid regions).

Applications of more limited extent can be put into practice coupled with hydraulic crossing structures or, in general, with hydraulic works next to natural or artificial water reservoirs.

Maintenance

The high energetic conditions in which these structures operate need the realization of an effective check and maintenance action, with the aim of avoiding the breaking away and undermining of the structure from channel bed and banks, cancelling the effectiveness of the structure and the consequent insetting of instability processes of the whole structure and of the interested stream reach.

Particular attention must also be paid to verify that the lining structure does not show discontinuity points in its surface (breaking, considerable differences in height among single elements etc.) since these represent weak points of the lining and where water action may more easily provoke damages.

The realization of structures made of wood, stones and gabions allows to assure a longer durability of the structure in relation to their better flexibility with respect to foundation shifts and settlings.

Environmental impacts

The realization of channel lining structures must be carried out only in peculiar conditions where there is need for defence and protection, in that their building produces a high environmental impact on the stream reach.

In particular, channel lining made of concrete or prefabricated cement plates determines the cancellation of environmental and ecological aspects of the stream and almost the total elimination of physical-biological exchanges between the stream and the surrounding environment. The use of constructive typologies which make use of natural material minimizes the environmental impact ensuring a partial revegetation of these structures, but it also assures the continuity of interactions between the fluvial habitat and those surrounding it.

In any case, the realization of channel lining structures gives cause to an appreciable impact on the stream, destroying or altering significantly the natural aspects of the structure-interested reach.

Costs

- concrete: 125-245 Euros per m^3;
- stone-filled metallic mattress: 115-130 Euros per m^3;
- wood and stones: 40-50 Euros per m^3.

3.3.3.2 Longitudinal Hydraulic Works

3.3.3.2.1 Artificial Banks for Flood Protection or Dikes

Objectives

Artificial banks for flood protection represent the oldest structural intervention for defence of alluvial events. Examples of embankments in the historical periods testify the large diffusion of these structures along the river bed, in particular, close to populated areas.

Longitudinal embankments or dikes permit to contain the flood water which have a discharge value lower than the efficiency of the new transversal sections. However, these typologies of intervention strongly modify the natural evolution of the river courses (meandering, formation of new bed) constraining the water within longitudinal protective structures.

Longitudinal structures can be applied also in some specific cases to lead the flow water towards particular situations (e.g. hydropower installations, railway crossings, highways, etc.). In these cases, longitudinal protection structures prevent the occurrence of alluvial or erosive problems for protection of human installations.

Usually, construction of an embankment along a natural river produces a significant impact on the ecological characteristics of the natural course but also on the hydraulic behaviour of the hydrographic network both concerning water and sediment discharges. On the other hand, if the building up of longitudinal flood protection guarantees the defence of plain area, the hydraulic risk conditions may be increased in the downstream portion of the basin (increase of maximum discharge values).

Breaking of these works during a flood represents a higher danger in particular for the people and buildings close to the collapse because of the higher energy of the water flow.

Structure typologies

Artificial banks for flood protection have been carried out in many different ways through the application of several kinds of constructive materials. Evolution of techniques has favoured wide employment of these works and the development of different types of embankment.

- Earthfill embankments (Figures 3.3.3.2.1 a and b)

Figure 3.3.3.2.1 a

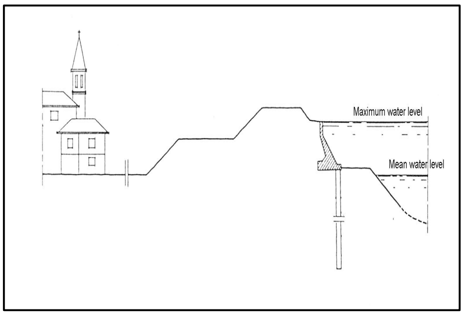

Figure 3.3.3.2.1 b

This kind of embankment represents the most common typology of longitudinal structures put in practice along the river courses because of their simple technical execution. The transversal section of these structures is usually trapezoidal. The trapezoidal angle varies the materials applied for their construction. Different angles are usually applied in the inner and outer side of the embankment. Frequently, it is higher in the inner side and lower in the outer.

Slope in high embankments is usually interrupted by a step to increase the stability of the earthfill works. Furthermore, these structures can be prepared with different materials (in particular, for the highest works), in the inner central and outer part of the structures, in order to assure a low permeability during floods and reduce the groundwater flow.

A protective structure can be arranged in the foot of the inner side of the embankment in order to avoid the erosion of the earthfill structure. These protections are usually prepared with dry stone, gabions, cemented stones, concrete, or prefabricated elements.

They can be covered by natural vegetation to improve their environmental insertion.

– Cemented bricks, stones and concrete embankments (Figures 3.3.3.2.1 c and d)

Figure 3.3.3.2.1 c

Figure 3.3.3.2.1 d

These works have been largely developed in the last decades taking advantage of the improved constructive techniques. There are dikes made of cemented brick, stones or concrete and are usually applied in the urbanized reaches of the river where the existence of building require to reduce the space for construction of hydraulic defence structures, but are also, in some cases, applied in non-urbanized river reaches because of the easiness of their technical execution.

Combination of this kind of embankment with an earthfill structure can be prepared through the application of a wall structure on the top of an earthfill embankment.

These artificial works produce a significant environmental impact, especially, in the non-urbanized areas.

Up to this day, a significant number of river and water courses are bounded by artificial embankments. In many cases, construction of longitudinal protective structures have been coupled with a modification of the altimetrical conditions of the natural course, producing substantial alteration of the natural equilibrium concerning both the water and sediment transport. Furthermore, the preparation of artificial hydraulic sections have caused the destruction of ecological characteristics of riparian habitats.

Constructive aspects and location

Construction of an embankment is usually planned in the central and lower portion of the hydrographic basin, particularly, in alluvial flat areas, in order to protect human settlements from inundation. Preparation of embankments must be preceded by hydraulic analysis of the hydrographic basins, in order to calculate the expected flood discharges as a function of return time periods and define the dimensions and characteristics of the new hydraulic sections .

Planning of these interventions have also to consider some factors concerning the stability of the structure both for the earthfill and cemented (bricks, stones) or concrete embankment. In particular, stability foundation of structure must be guaranteed in order to avoid the collapse or breaking of the structure. Particular attention must be paid in the identification of the geotechnical characteristics of the materials of foundation in order to avoid collapse, breaking or excessive subsidence of the longitudinal protective works.

Identification of erosive problems is important to prevent the collapse of a structure. For this reason, the foundation plan must be protected by the construction of transversal hydraulic works (sills, check dams) that guarantee the stabilization of the river bed. Furthermore, identification of the hydrogeological aspects of the natural terrain and of the artificial body of earthfill structures, is fundamental to prevent the formation of high inner neutral pressure inside the protective structure or under their foundations. In this case, the construction of an impermeable barrier inside and under the embankment represents a technical aspect that have to be considered in planning these works.

Finally, concerning the construction of earthfill works, it is important to identify the sites for material collection. Usually, the surrounding terrain and the transported sediments in the river bed can represent a great portion of the constructive materials. In relation to peculiar technical exigencies, special supplying of materials must be planned.

Maintenance

Maintenance action of artificial banks for flood protection is necessary to avoid their breaking or collapse during the occurrence of strong flood events, and for this reason, periodical surveys of the embankments permit to identify an eventual deficiency of the protective structures.

Particular attention must be paid to river courses subjected to lateral and bed degradation that may cause the undermining of the foundations and the partial or complete collapse of the structure.

Concerning earthfill embankments, it is important to foresee a periodical survey for the identification of critical condition caused by the presence of animals or plants. Wild animals that living in the riparian habitats can produce caves inside the earthfill structure that may favour the infiltration of water and the development of piping phenomena. Furthermore, the presence of large trees on the slope of the artificial embankment can favour the infiltration of water and, in case of collapse, the partial destruction of the structure. For this reason, grass or elastic shrubby vegetation are preferable.

Longitudinal protective structures should be planned or adapted with maintenance roads along the outer side or on the top of the structure, in order to guarantee the accessibility to men and machines for periodical or extraordinary maintenance. Furthermore, the river bed should also have an access.

Environmental impacts

Longitudinal structures usually produce significant environmental impact on riparian habitats since their construction causes the destruction of many natural aspects. Embankments represent a physical barrier between the river bed and the surrounding areas that limit the biotic interchanges of living species. Furthermore, preparation of artificial hydraulic sections reduces the morphological variability of the river causing the destruction of a significant number of habitats.

In order to limit the environmental impact, construction of embankments must foresee an arrangement of these structures through the insertion of ecological devices that can favour the creation of morphological variations of the river courses. Preparation of shelters for fishes made with stones and wood, collocation of small groynes to favour the meandering of low water, etc., permit the partial renaturization of the riparian habitat. For example, during operations of cutting of vegetation, small islands that can represent points of shelter and diffusion of living species can be maintained (see also Section 3.3.3.3.5.1).

The preparation of embankments can be spaced with an appropriate distance from the natural river banks that permits the creation of riparian zones that favour the development of living species, in order to reduce environmental impact. Furthermore, these structures can be arranged with an irregular shape both in longitudinal and transversal directions to favour the re-vegetation both of the embankments and of the riparian zones producing an ecological improvement of the river course (Figure 3.3.3.2.1 e).

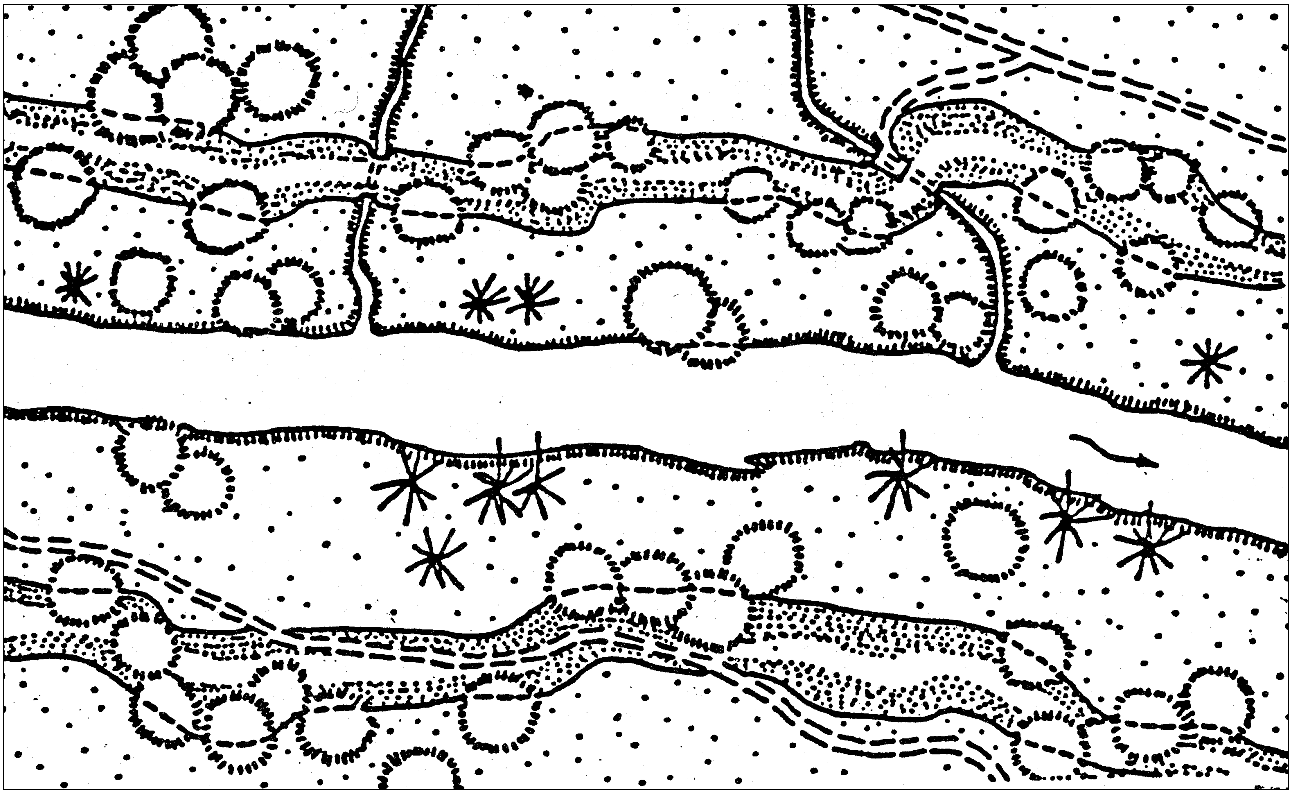

Figure 3.3.3.2.1 e - (adopted from Cavazza, 1990)

Costs

- Earthfill embankment: 30-35 Euros per m^3;
- Concrete embankment:160-180 Euros per m^3.

3.3.3.2.2 Bank Erosion Protection

Bank protection structures represent a widespread typology of hydraulic works along the river course. Their construction is usually planned along torrent stretches with bank erosive problems that can produce instability conditions both on natural, artificial banks and on steep slopes. Strong protective structures are usually put in practice for straightening works or planimetrical modification of the river course, or in combination with other hydraulic structures (bridges, dams, etc). In many cases, the construction of strong bank protection structures is required for the defence of urbanized areas or to stabilize landslides.

Construction of this kind of interventions causes a substantial modification of the natural aspect of river banks with the partial or complete destruction of the ecological conditions and the reduction of the biological diversification of the riparian habitats.

The traditional bank protection works, concrete walls, cemented stone and brick, play a significant role in the modification of the hydraulic aspect of the discharge values and in the interference in the water dynamics of erosive and depositional phenomena both upstream and downstream.

The construction of protective structures is usually coupled with carrying out transversal hydraulic works, in order to guarantee their protection against the undermining action of the flowing water.

In the last years, the application of bioengineering techniques has favoured the planning of protective structures with a lowered environmental impact. In particular, these have been applied along small-medium size basins where not extreme erosive action of the flowing water can be controlled with this kind of soft interventions. Bioengineering criteria are usually applied together with the planning of the transversal hydraulic section with a diversified morphological profile that favours the creation of different riparian habitats for faunal and floral living species. In particular, the use of wood and rocks favours the revegetation of these kind of interventions.

On the basis of the previous considerations, low environmental impact hydraulic works carried out in some Styrian rivers will be next described also through the use of schemes and figures that exemplify their application in a small-medium size basins.

CASE 1 - Safen river, in the area of the Spa town Blumau (bank restructuring works)

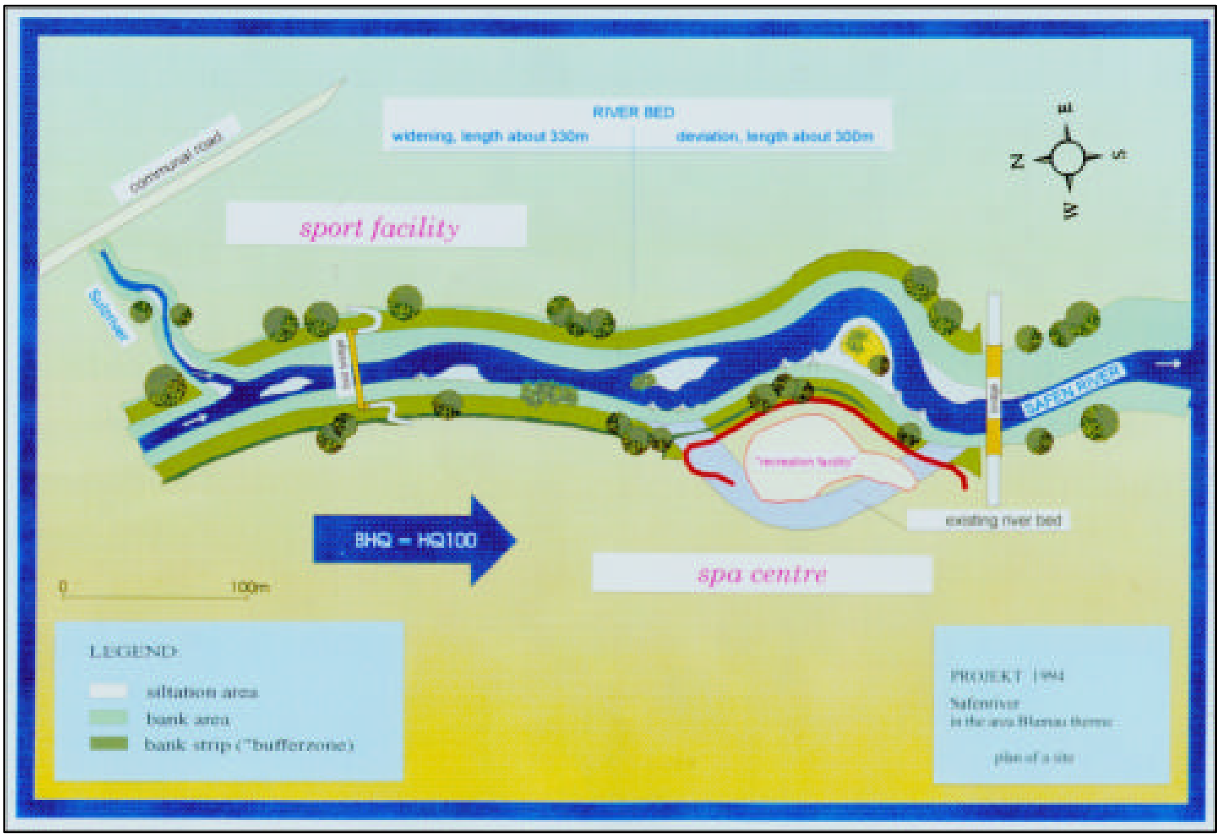

Figure 3.3.3.2.2 – Safen river: banks structured according to existing natural conditions

- <u>Data relating to the river</u>:

  Sea level = approx. 260 m
  Bed slope = approx. 2.0 ‰
  Bed width = 4.0 – 8.0 m
  Depth of profile = 2.0 – 3.5 m
  Bed shear stress = max. 70 N/m^2
  Type = lowland river
  Catchment basin = 38.2 km^2
  HQ_{100} = 130 m^3/s

- <u>Basic characteristics of bank protection measures:</u>

  Structured bank foot
  Use of live material (resprouting vegetation)
  Irregular bank line
  Room for succession
  Employment of locally suitable vegetation
  "Protection strips against water"

- <u>Basic structural elements:</u>

  1 – Base stone
  Function: hinders undermining and scouring, provides a structural element (fish shelters).
  Employment: securing of bank foot (permanently / temporarily), especially in case of course deviation.
  Maintenance: occasional adjustments until protective vegetation cover is formed.

  2 – Anterior stake
  Function: support element.
  Employment: securing of bank foot.
  Maintenance: none.

  3 – Sunken fascine roll
  Function: to provide mechanical protection of slope toe (150-200 N/m^2).
  Employment: toe stabilization in a number of bioengineering measures such as: fascine walls, fascine rows, etc. Sunken fascine rolls are especially used in cases where the bed shear stress is not too great and blockstone bank protection would not be suitable.
  Implementation: placed directly at the relevant sites in the toe. They are tied to wooden stakes with zinc-plated wire. The fascine rolls are bundles mainly consisting of dead and very resistant vegetable material and containing stones in their middle to weigh them down. Sunken fascine rolls are placed so that their lower end is perfectly attached to the river floor. Actual bank protection is an immediate result.
  Maintenance: none .
  Ecological evaluation: in water courses where blockstones do not fit into the nature-like hydrological context sunken fascine rolls are a good toe stabilization device, provided bed shear stress allows their use. The dead branches increase the total amount of dead wood in the water course. The presence of different materials (wood and stone) provides a variety of surfaces to organisms living in the water course (zoobenthos, plants).

  4 – Wattle work
  *Function: s*imilarly to a fascine wall, a wattle fence enables to protect banks running vertically in a rapid and effective way. Immediately after completion of the works, the wattle fence and the wood piles become effective and very soon a thick fence of willow brushes is formed.
  Employment: on water courses with low bed shear stress (50-100 N/m^2) and relatively straight course.
  Implementation: after driving wood pickets (10 - 15 cm) into the ground, strong and pliable willow branches (no fragile willows) are woven horizontally alternately before and behind the pickets so as to form a wattlework. The thicker branch end is always placed on the inside (i.e. facing the slope) so that enough humidity is always available and no protruding branch can hamper water flow. Branches should be placed very closely to one another, so as to prevent soil erosion by the waters. If the water course has periods of very poor flow, willow branches can also be woven transversally, so that their lower end can reach directly into the water. The height of a wattle fence should not exceed 50 cm.
  *Maintenance: i*n case of soil erosion, the material that has been washed away must be replaced in order to ensure adequate growth and root development and, as a consequence, proper bank stabilization.
  Ecological evaluation: optimal sprouting begins from above the mean water level; it is therefore possible for a variety of structures to develop freely below this level. The great number of habitats and the connections between water and land are also very interesting from an ecological viewpoint.

  5 – Log cribwall with branchlayers on one bank
  Function: the wooden crib provides a very strong supporting element and is able to resist very great bed shear stress.
  Employment: this type of bank stabilization measure can be employed also for torrents with irregular flow of water and bed load transport and for banks which are heavily exposed to the action of sweeping waters.
  Implementation: to build a log cribwall 18 - 25 strong wood logs are placed and nailed together to form a crib. These horizontal anchor logs, however, are not placed directly and uniformly over one another, but alternately. The spaces are filled with willow fascines or stones on the waterside

whereas behind it, on the inner side, they are filled with earth, as is done with pile walls. Willow fascines have to be slightly covered with earth, too, so that they can sprout above water and take over the stabilization function after the decaying of the wooden crib. Below the water level wooden cribs can also be filled up with smaller stones and fascines made of dead vegetable material. Never will the spaces between the anchor logs be filled with branchlayers, since these would be washed away by the flowing waters.
Maintenance: cutting back of vegetation is necessary according to type and growth.
Ecological evaluation: the spaces between the anchor logs produce great structural diversity.The use of fascines of dead vegetable material in the area below the mean water level increases the amount of dead wood and provides extensive surfaces for zoobenthos.

6 – Live brush mattresses
Function: the most effective method of bank stablization in the event of floods has proved to be the use of brush mattresses with willows. These develop very rapidly into a thick and functional bank vegetation. Mattresses protect river banks like a coat and provide immediate and effective mechanical stabilization. Owing to their rapid growth, willows are able to promptly reduce flow velocity and, as a consequence, bed shear stress. After only 1-2 years this type of stabilization measure is able to absorb a bed shear stress value of 300 N/m^2 which increases up to 460 N/m^2 in the case of a complete structure including a blockstone embankment.
Employment: owing to its high resistance to bed shear stress and in association with proper toe stabilization, this type of measure is ideally employed in the case of water courses with higher bed shear stress values as well as for banks heavily subjected to the action of sweeping waters or erosion. The slope, however, should not exceed 1:1 (ideally 1:3).
Implementation: willow branches are placed very closely to one another over the whole slope, at an angle with respect to the direction of flow. The cuttings are placed into the water (ideally directly into the river bed), so as to guarantee an adequate degree of humidity to the willow branches and prevent withering due to the action of possible underminings in the slope area. The slope should possibly have a regular shape so that willow branches placed on the ground can have optimal contact with the soil. The willow branches are tied with wire or coconut rope to wood pickets and then covered with a 3-4 cm thick earth layer. When live brush mattresses are employed toe stabilization is carried out up to the low water level by means of blockstones, a simple wooden crib or a simple cylindrical gabion. To enhance vegetation variety, rooted deciduous trees (such as alders, ash-trees, etc.) can be added to the willow cover. Live brush mattresses should ideally be planted in late autumn to achieve faster root development and make sure that, by the following spring, when the snow starts to melt, willows will be able to exert effective flood protection.
Maintenance: maintenance cutting will be necessary according to growth in order to preserve coppice elasticity, which is necessary in case of floods. The thick concentration of willows in the brush mattress increases competition pressure and, as a consequence, leads to the growth of mainly thin and higher shoots which, in its turn, ensures prolonged conservation of elasticity. When other deciduous trees are added, the area around them must be cleared from willows so as to eliminate competition with them.
Ecological evaluation: The extensive vegetation cover is able to reduce velocity of flow especially in the case of floods, thereby providing shelter for living organisms. In the summer these slopes offer shady, inaccessible and safe habitats.

7 – Cuttings/stakes
Function: firming effect on soil due to the growth of roots; it can be employed between stones as well; good protection in the long-term.
Employment: normally in combination with other measures.
Maintenance: containment of growth.

Sweeping water side – Type “A” measure

Water zone:

1 – Base stone

2 – Anterior stakes

3 – Sunken fascine roll

Wind and Water zone:

4 – Wattle work

7 – Cuttings/stakes

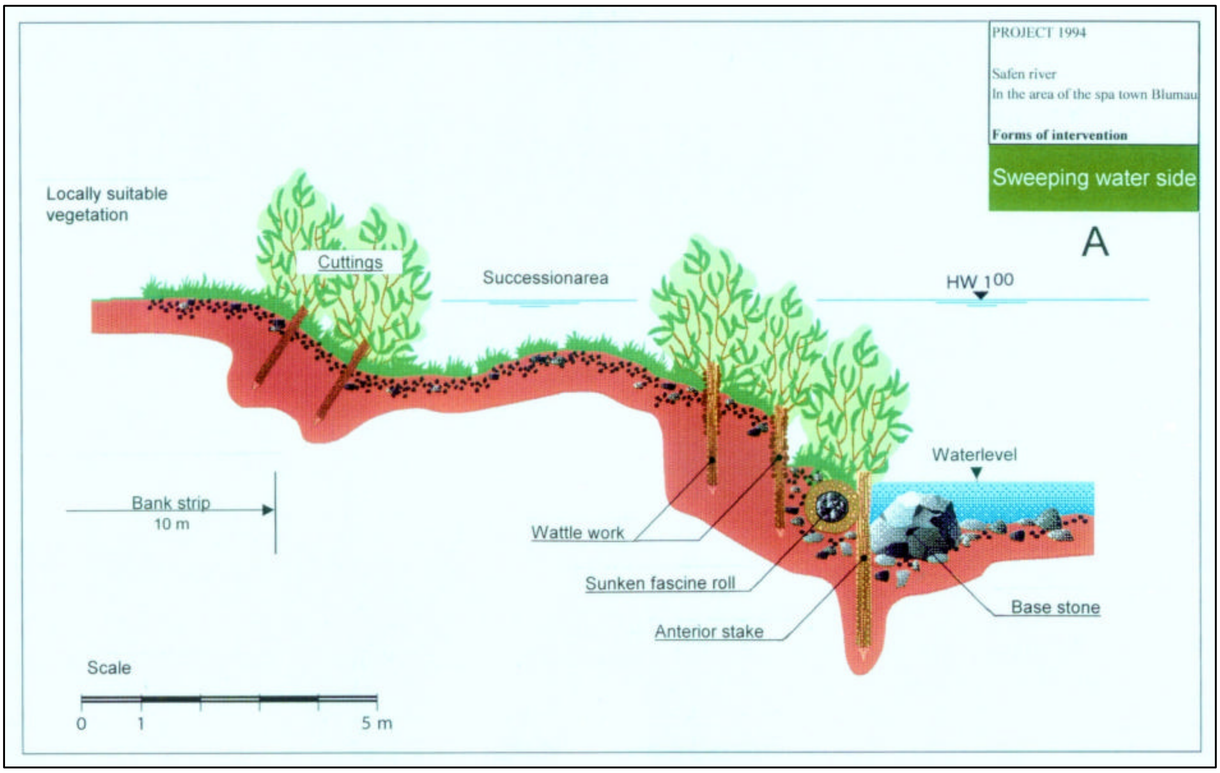

Figure 3.3.3.2.2 a - Sweeping water side (type “A” measure)

Sweeping Water side - Type “B” measure

Water zone

1 – Base stone

2 – Anterior stake

3 – Sunken fascine roll

Wind and water zone

5 – Log cribwall with branchlayers on one bank

6 – Live brush mattresses

7 – Cuttings / stakes

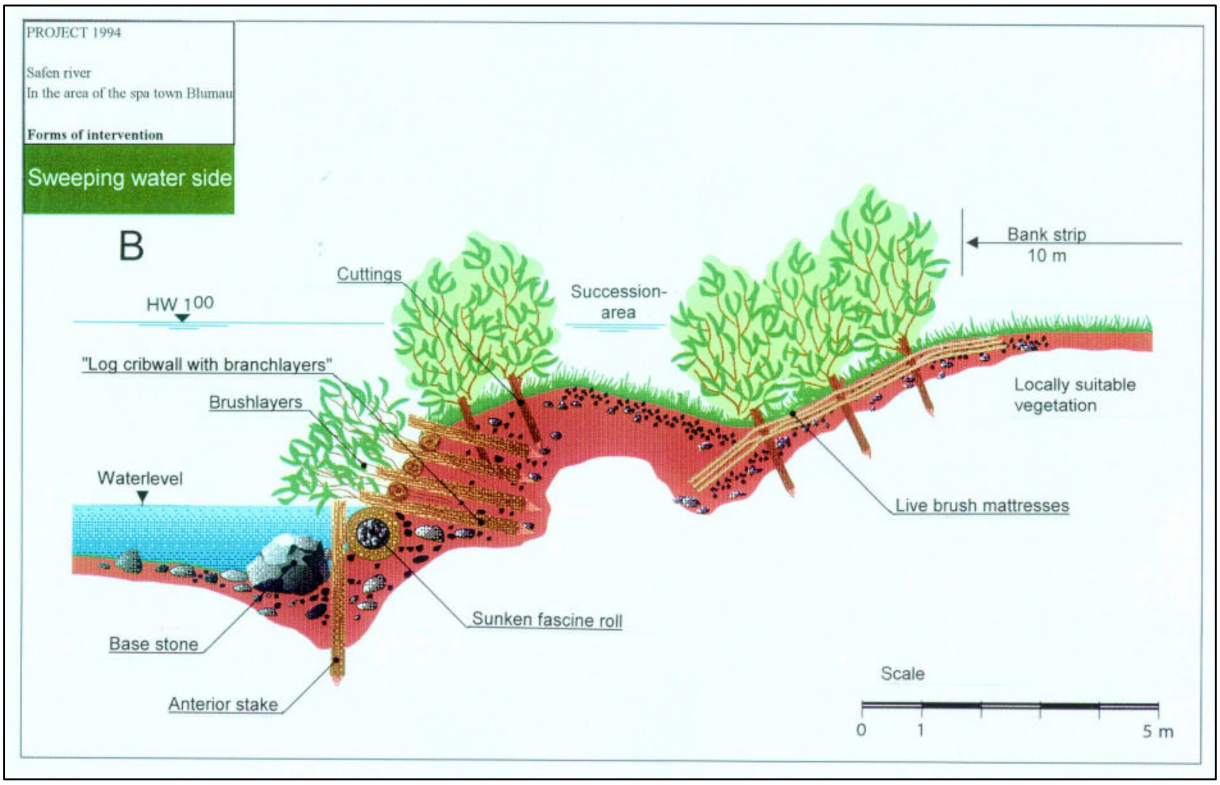

Figure 3.3.3.2.2 b - Sweeping water side (type “B” measure)

Gliding Water side - Type "C" measure

Water zone:

6 – Live brush mattresses

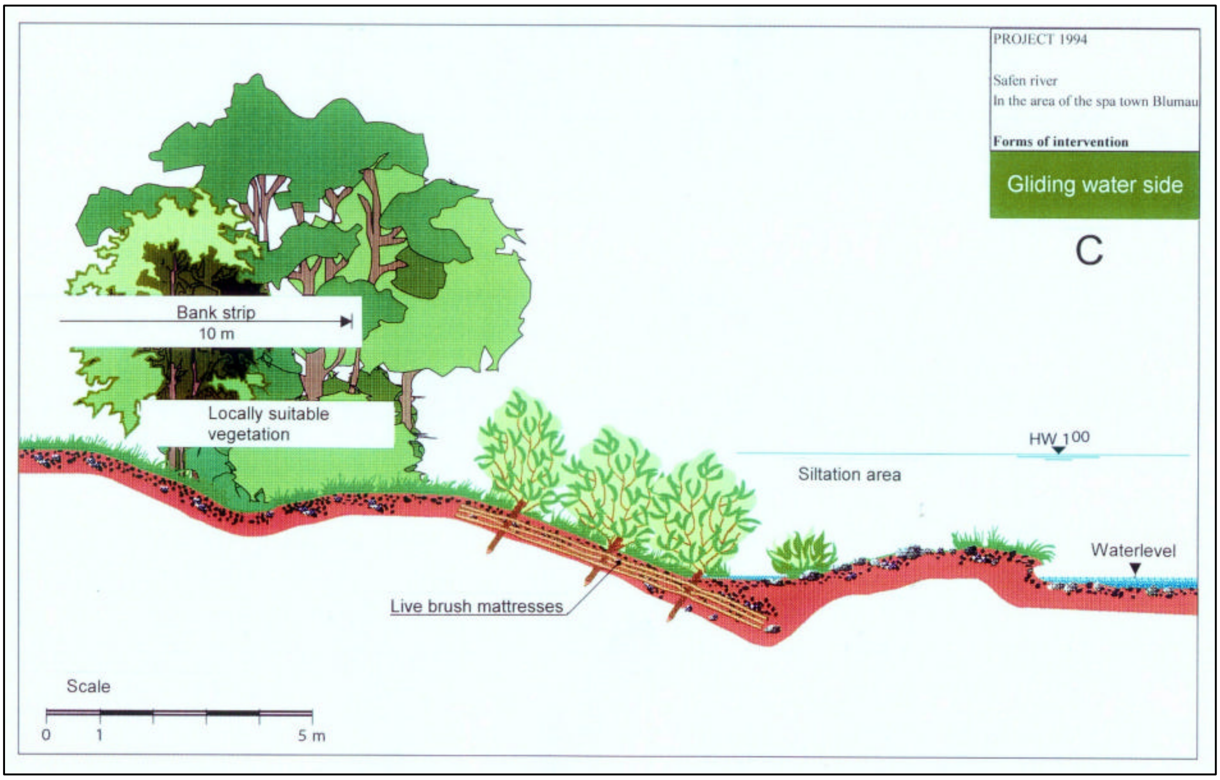

Figure 3.3.3.2.2 c - Gliding water side (type "C" measure)

Gliding water side – Type “D” measure

Water zone

4 – Wattle works

Wind and Water zone

4 – Wattle works

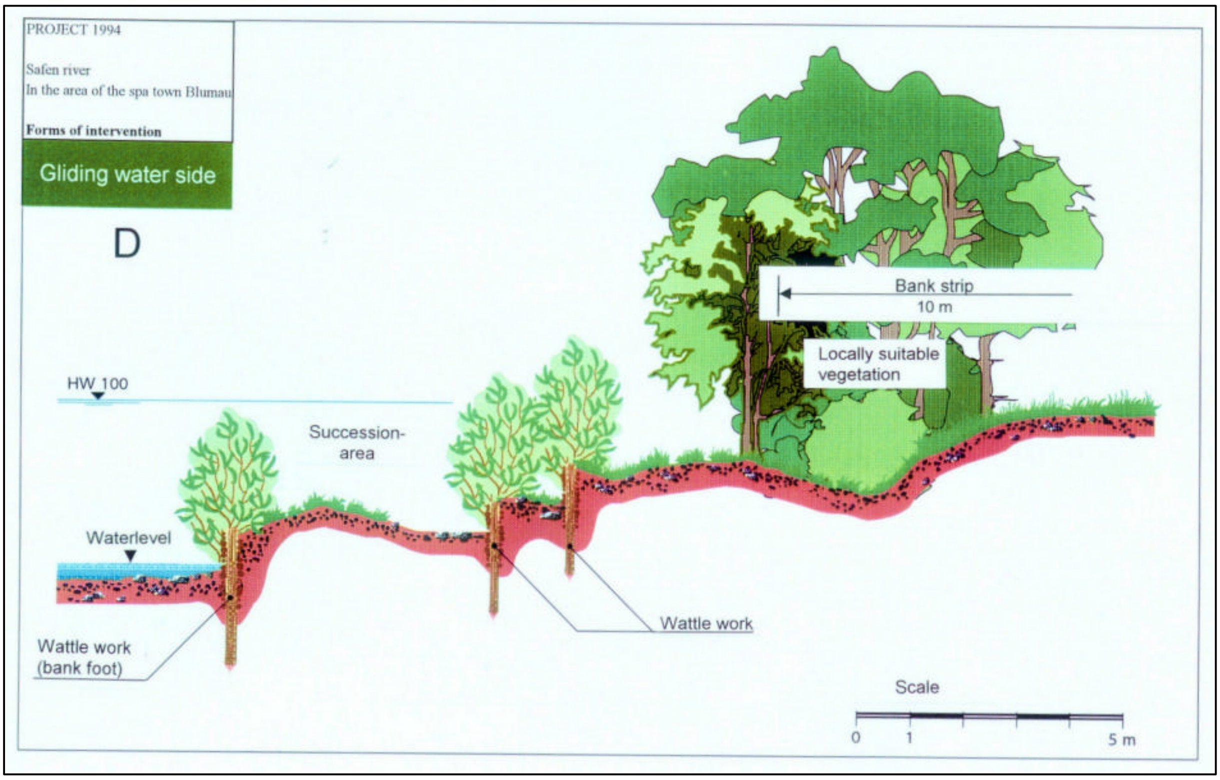

Figure 3.3.3.2.2 d - Gliding water side – Type “D” measure

CASE 2 – Lafnitz river, in the reach between Neudau and Burgau (securing of given conditions – bank with protection side-dam)

- Data relating to the river:

  Sea level = approx. 270 m
  Bed slope = approx. 1.8 ‰
  Bed width = 3.0 – 14.0 m
  Depth of profile = 2.2 – 4.3 m
  Type = lowland river ("river with dam banks")
  Catchment basin = 50.8 km^2
  HQ_1 = 45 m^3/s
  HQ_{100} = 155 m^3/s

- Basic characteristics of bank protection measures:

  Securing and protection of given conditions
  Structured bank foot
  Use of live material
  Irregular bank line
  Employment of locally suitable vegetation

- Additional basic structural elements in respect to Case 1:

  8 – Brushlayers ("living brushes and combs")
  Function: they promote siltation and are able to protect small bank segments affected by lateral erosion. By growing, the root mattress which is thus formed prevents soil erosion.
  Emp*loyment:* this type of measure is not resistant to high bed shear stress and is therefore often employed in the spaces between more laborious and resistant live siltation constructions.
  Implementation: Living brushes: a large number of loose willow branches is planted very thickly into the soil, at an angle to the direction of flow. Fascine bundles can also be used in place of the loose willow branches. Living combs: single cuttings of approx. 1 m in length are planted in rows at an angle to the direction of flow and at a depth of 70 cm into the ground. The distance between the cuttings must be about twice or three times the section of the cuttings themselves. The result is a sort of comb, offering lower resistance than living brushes. These types of construction are very easy and quick to carry out.
  *Maintenance: i*n case of excessively rapid siltation these types of construction will have to be renewed since willows take root only sporadically if completely covered.
  Ecological evaluation: in the free spaces between the living brushes or combs there is enough room for other seeds, carried over by the wind from surrounding areas, to sprout. This means that in time a bank vegetation cover will grow which is suitable for local conditions.

Sweeping water side with dam along the banks – Type “E” measure

Water zone:

1 – Base stone
5 – Log cribwall with branchlayers

Wind and water zone:

7 – Cuttings / stakes

Protection dam:

8 – Brushlayers (“living brushes”)

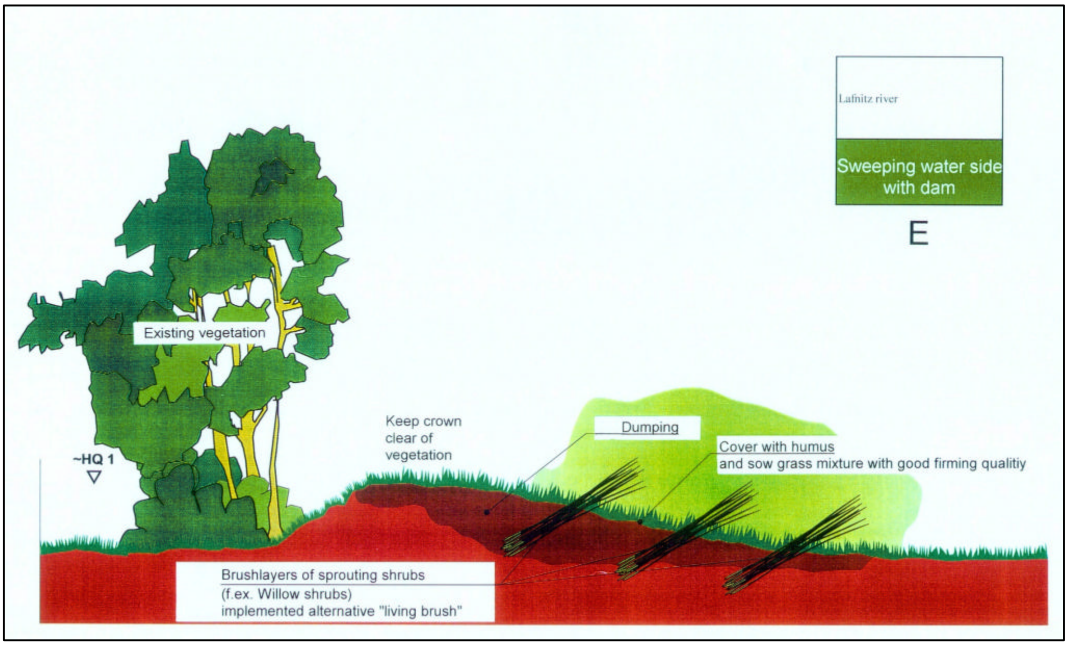

Figure 3.3.3.2.2 e - Sweeping water side with dam along the banks (type “E” measure)

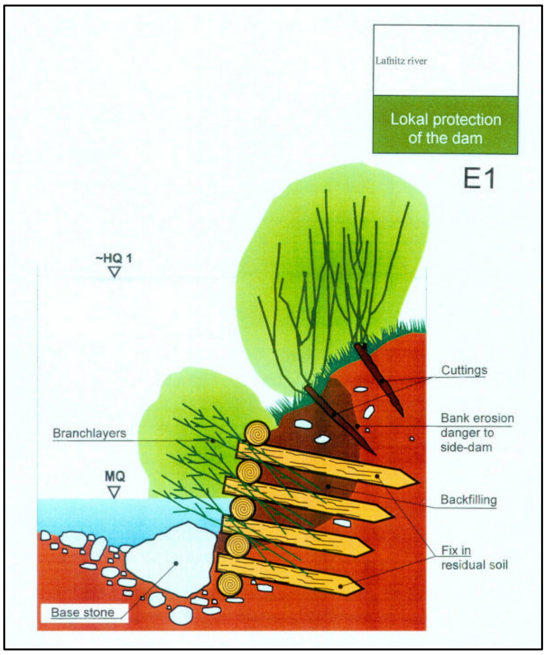

Figure 3.3.3.2.2 e1 – Local protection of the dam (type “E” measure)

CASE 3 – **Pöllau Saifen in Pöllau (Creation of transverse structures)**

- Additional basic structural elements in respect to Case 1 and 2:

9 – Crib groynes with cuttings (Living groynes)
Function: groynes are structures built near the banks and transversally with respect to the direction of flow. As a difference to guide banks, they limit the stream only at specific points and are generally used at larger rivers (10 m broad) to protect the banks and repair eroded segments. According to their height with respect to the flow level, base flow level, mean flow level and high flow level groynes can be distinguished. Considering the angle with respect to the direction of flow, perpendicular, upstream looking (inclined or attracting) and downstream facing (declined or fending) groynes can be distinguished. Inclined groynes, built at an angle of 75-80° against the direction of flow, are particularly effective bank protection measures in that they divert water towards the middle of the river. Along the segments between the groynes, known as groyne bays, suspended sediments, bed load material and debris are deposited. The distance between one groyne and the next one should never be longer than 1.5 - 2.5 times the length of the groynes themselves, otherwise the current could reach the banks and damage the slopes.
Employment: in case of extremely varying water level the construction of a mean flow level groyne could be in order, which would prove very valuable from an environmental point of view.
Furthermore, groynes can be employed for the protection and repair of bank erosions. The type of groyne to be chosen depends on local water level and bed shear stress.
Implementation: according to the extent of the stress to be borne and to the raw materials that are locally available, different types of groynes can be built out of different materials:

- log crib groynes with cuttings
- gabion groynes with cuttings
- branchpacking groynes
- tree spur groynes
- fascine groynes
- wood pile groynes with tree stumps
- log cribwall groynes
- gravel groynes with brush mattresses, etc.

Maintenance: coppice maintenance must be such as to keep the plants' elasticity in view of possible flood events.
Ecological evaluation: Groyne bays are of great ecological significance because they provide still water areas used by fish as spawning and growth places and, as a consequence of natural succession, they become the habitat of a variety of plant and animal species. If groynes are built alternately on both sides at a distance from one another of 5-7 times the measure of the bed width, meanders are formed in low water which contribute to enhance the presence of living organisms in the water course. The construction of a base flow level groyne improves living conditions in the water and upgrades water quality.

Transverse structure – Type “F” measure

Water zone:

9 – Groynes with cuttings

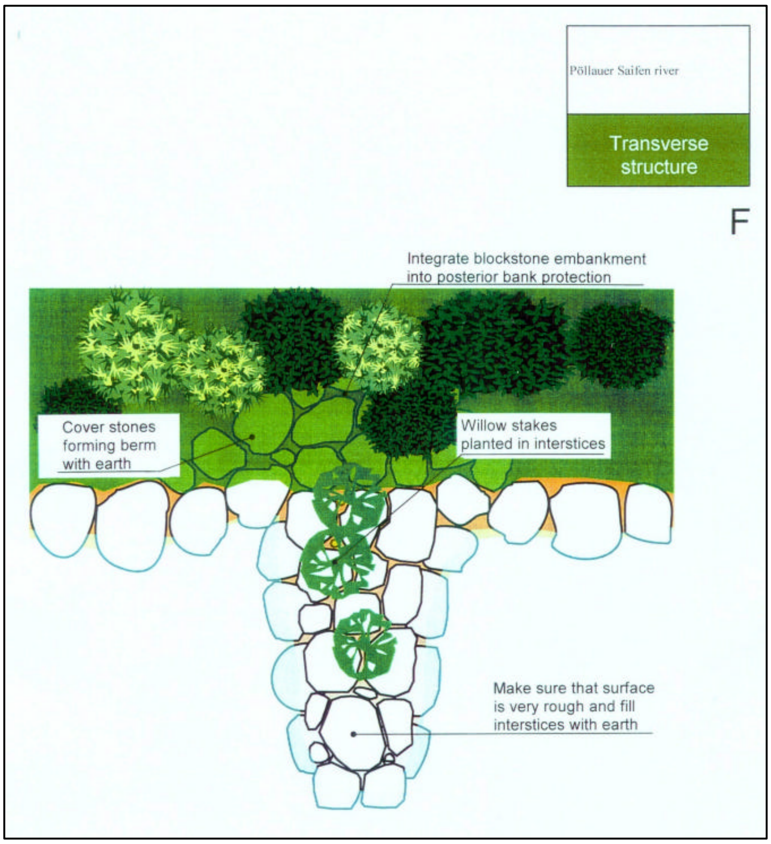

Figure 3.3.3.2.2 f – Top view of stone groyne with cutting (type “F” measure)

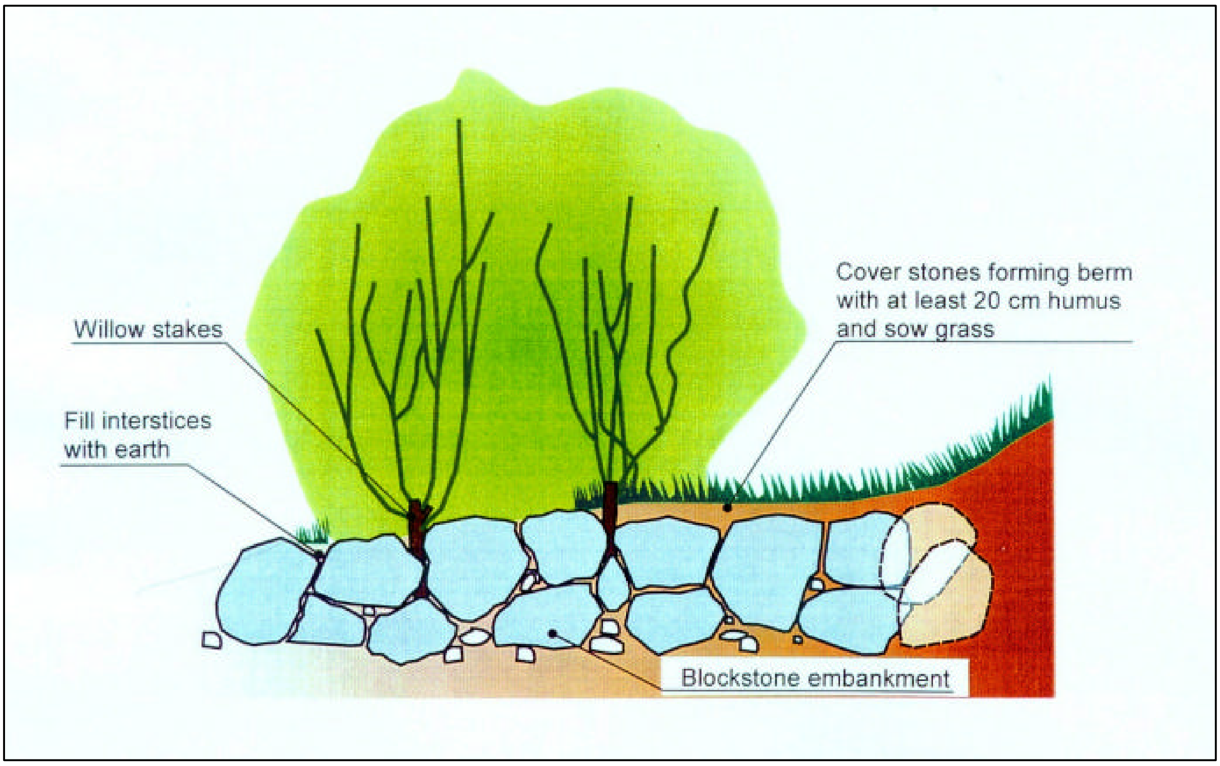

Figure 3.3.3.2.2 f 1- Cross section of stone groyne with cutting (type “F” measure)

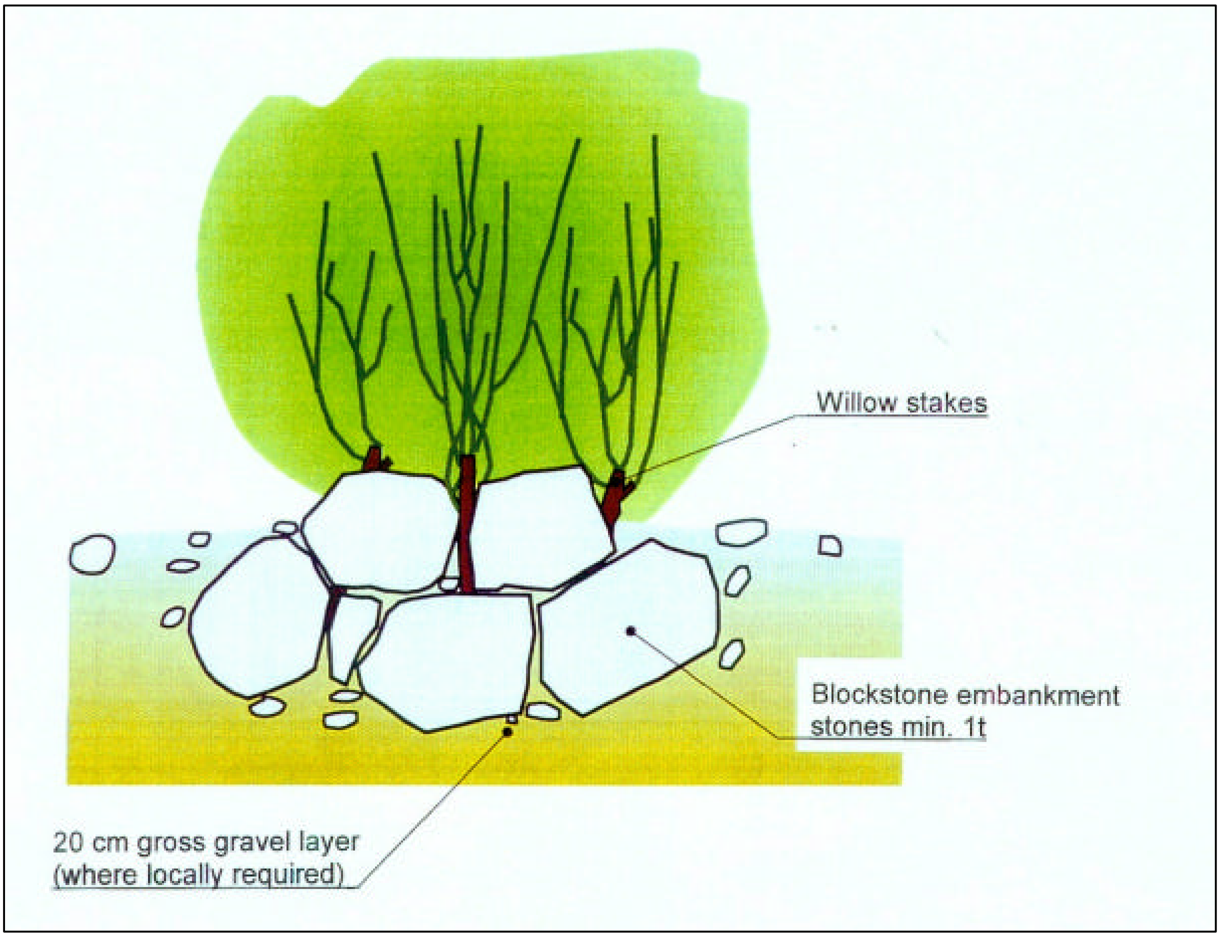

Figure 3.3.3.2.2 f 2 – Front view of stone groyne with cutting (type “F” measure)

CASE 4 – Project Doblbach: Planning of protective structures with a lowered environmental impact (bioengineering tecniques)

Figure available in separate file

Figure 3.3.3.2.2 g – Site plan showing the six torrent reaches interested by project Doblbach

In the following 14 figures that illustrate different solutions for bank erosion protection structures, the numbering on the top left indicates the corresponding torrent reach.

Figure available in separate file

Figure 3.3.3.2.2 h

Figure available in separate file

Figure 3.3.3.2.2 i

Figure available in separate file

Figure 3.3.3.2.2 j

Figure available in separate file

Figure 3.3.3.2.2 k

Figure available in separate file

Figure 3.3.3.2.2 l

Figure available in separate file

Figure 3.3.3.2.2 m

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Figure 3.3.3.2.2 n

Figure available in separate file

Figure 3.3.3.2.2 o

Figure available in separate file

Figure 3.3.3.2.2 p

Figure available in separate file

Figure 3.3.3.2.2 q

Figure available in separate file

Figure 3.3.3.2.2 r

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Figure 3.3.3.2.2 s

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Figure 3.3.3.2.2 t

Figure available in separate file

Figure 3.3.3.2.2 u

3.3.3.3 Maintenance of the Hydraulic Cross Section

Appropriate hydraulic cross sections for a given water discharge allow that the rearrangement hydraulic works, carried out along the water courses, can correctly perform the planned protection and regulation actions.

For this reason, maintenance works of the hydraulic cross section are, on the experience of past alluvial events, a priority for the correct management of the water courses.

Maintenance works such as cutting of vegetation and reshaping of the hydraulic cross section are the most common interventions undertaken especially on channels and on water courses that have artificial components.

It is important to underline that maintenance works are, in relation to the size of the areas involved, periodicity (one or more times during the year) and use of mechanical equipment, a very demanding work.

3.3.3.3.1 Cutting of vegetation

Objectives of the intervention

Cutting of vegetation, that naturally grows along natural and artificial torrent beds, is one of the most important actions of maintenance to be put in practice, in order to preserve the planned hydraulic cross sections, guarantee the nominal water discharge and avoid that the action of flood waters can pick up and carry downstream significant quantities of vegetal material that may cause, in critical hydraulic sections (bridges, narrow cross sections, etc.) a complete or partial occlusion of the torrent bed causing or increasing the outflow of flood waters.

Besides the hydraulic effectiveness of the water courses, cutting of vegetation must be carried out respecting some indications in order to avoid the formation of erosional phenomena of flowing waters or vary the water velocity. For this reason, removal of vegetation must be considered a tool for the hydraulic management of the water course.

Cleaning up of water courses through the cutting of the natural grassy, shrubby and arboreal vegetation is important also to permit the easy access to the torrent bed and banks in order to allow other maintenance works of the existing hydraulic structures. Special attention must be adopted in the defence of the existing hydraulic structures against undermining and breakdown since the growth of big trees close to the foundation may cause their collapse.

The cleaning up action of torrent reaches is a necessary hydraulic and landscape work for torrent beds that cross urbanized areas, in order to guarantee the planned hydraulic section and favour the easy access of natural or artificial banks for enjoyment of the population.

Performing aspects and location

Cutting of vegetation often requires, in relation to the length of the water courses that must be cleaned up, the use of machinery to perform, in a short time, long torrent reaches. Machinery can operate from the banks or directly from the torrent bed.

The peculiar knowledge of the water course permit to put in practice cutting of vegetation that respects both the hydraulic and ecological aspects of the hydrographic network. For this reason, cutting of vegetation must be applied with the use of manpower that is able to select the vegetation and the guarantee the respect of riparian habitat. Selective cutting of vegetation can be undertaken also to reduce the flood water velocity and bank erosion.

The removal of the vegetal cuttings, or its incineration, is also important in order to avoid, in case of floods, the occlusion of bridges and of critical hydraulic cross sections. In Italy, Portugal and other countries, this good practice is often undervalued.

Concerning the location of these structural interventions, they are concentrated along the medium-low stretches of the hydrographic network while, on the mountainside, cutting of vegetation is usually included in forestry works.

Frequency of cutting action

Planning of cutting actions is directly correlated to the seasonal growth of the natural vegetation. The peculiar climatic conditions of each area require one or two cutting periods in relation to the vegetative time of the region.

The carrying out of a regular cutting of vegetation will permit to reduce the cost of maintenance action and guarantee the speeding up of the river management, decreasing the hydraulic risk conditions linked to a torrent bed in state of neglect.

Environmental impacts

Usually, cutting of vegetation is a structural intervention that produce a high environmental impact along the water course causing destruction of ecological and environmental characteristics of the natural river habitats.

The ecological importance of the hydrographic network, that represents a natural corridor for diffusion of the faunal species in the basin, calls for the maintenance of the continuity of the different habitats along the river (see Section 3.3.4). The carrying out of indiscriminate cutting of vegetation may create a physical barrier for the amphibian, avian and terrestrial species.

For this reason, the adoption of suitable techniques for cutting of natural vegetation is a fundamental aspect for the correct management of natural hydrographic networks.
Among the criteria to carry out maintenance actions, it is important to reconcile both the hydraulic aspects for the flood waters discharge and the respect for the environmental and ecological aspects. For this reason, cutting of shrubby and arboreal vegetation must be put in practice through a thinning out action with the removal of weak elements, of trees that interfere with the water flow (ordinary flooded torrent bed) and of the elements grown on banks that are precariously balanced in order to promote the formation of riparian zones made of trees and shrubs with a high elasticity against the water flow during strong flood events.

The application of this criteria will guarantee the preservation of the ecological corridor reducing the alteration of local microclimatic aspects of the torrent bed (water temperature, sun radiation, wind, humidity, etc.).

These prescriptions fit well into the mountain and hilly portion of the hydrographic network where human changes of the natural environment are usually limited.

Concerning artificial torrent beds (artificial banks, channel realignment, etc.), cutting of vegetation must be carried out in order to maintain or create zones of renaturization located close to each other, both in the channel and on the banks, to guarantee shelter and diffusion of living species (Figure 3.3.3.3.1).

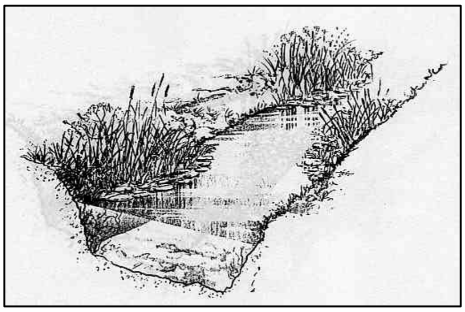


Figure 3.3.3.3.1

Costs

- Cutting of vegetation with machinery: 0.1 – 1.5 Euros per m^2.

3.3.3.3.2 Reshaping of the Hydraulic Cross Section

Objectives of the intervention

The reshaping of hydraulic cross sections is a maintenance operation that permits to regulate the transversal and longitudinal course of torrent bed subjected to irregularity of the channel because of the presence of sediments and/or bank instability phenomena and to carry out planned hydraulic cross sections in order to guarantee flood discharges of a fixed return time period.

In torrent stretches subjected to aggradation, the intervention of reshaping is a necessary operation to put in practice frequently in relation to the high sedimentation rate.

Operations of regularization of the torrent channel are also put in practice to reshape torrent stretches subjected to bed or bank erosion together with the carrying out of structural interventions to reduce erosion (check dams, sills, bank protection, etc.), in order to stabilize torrent beds.

The interventions of reshaping of torrent channels have been subjected, in the last years, to a remarkable evolution towards the respect for the ecological and environmental values. Both for natural and artificial channels, these maintenance interventions are directed towards the creation of hydraulic sections that are able to re-create the natural habitat of the torrent natural ecosystems.

Performing aspects and location

Interventions for regulation of hydraulic sections are usually carried out with machinery that is able to perform on wide surfaces in short time. The technical criteria adopted up to now has favoured the carrying out of hydraulic cross sections with a geometric shape that is able to satisfy the hydraulic parameters, in order to guarantee the flow of flood waters with particular attention along torrent stretches that have an artificial course or that cross urbanized areas.

In the last few years, the respect for the ecological aspects of the torrent ecosystem has favoured the application of naturalistic criteria with the carrying out of hydraulic cross sections with a "*natural*" transversal shape, in order to re-create different riverine habitats, that are able to guarantee a considerable biological diversification. In some cases, the reshaping action must be put in practice favouring the recreation of meandering course of torrent beds (Figure 3.3.3.3.2 a).

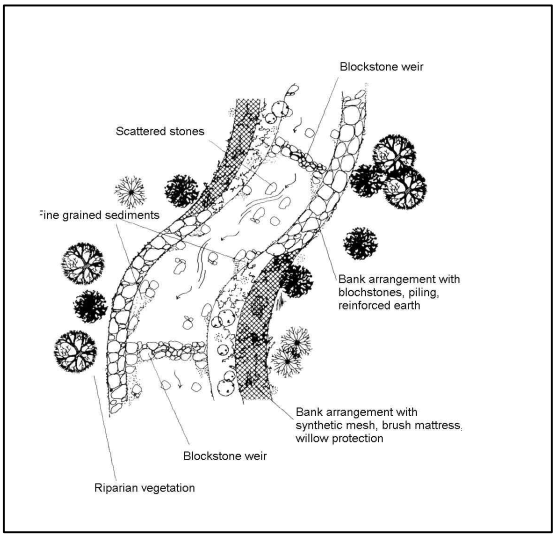


Figure 3.3.3.3.2 a

Concerning the location of this kind of structural interventions, they are usually carried out in the medium-low portion of the hydrographic network, and in hilly and flat areas where the channels are frequently embanked or cross urbanized areas.

In the upper portion of the catchment the intervention for the reshaping of the torrent channels can be put in practice along torrent stretches subjected to strong solid transport, that causes aggradation of the natural channel.

Frequency of reshaping action

The recurrence of interventions for the reshaping of channels is depends on the hydraulic dynamics of the water course and, in particular, on the natural sedimentation rate and the formation of erosional phenomena on the banks.

Usually, the reshaping action is carried out together with cutting of vegetation, in order to speed and to economize the global management of the maintenance of the hydrographic network.

Environmental impacts

Reshaping of torrent channels usually causes strong effects on the ecological and environmental characteristics of natural beds, producing the destruction, for long periods, of natural aspects of the water course. The geometrical shape of the channel formed during these interventions prevents re-creation of natural characteristics, in particular along artificial water courses where the natural corridor for the diffusion of faunal species has already been interrupted.

For this reason, in the last years, new ideas for the rearrangement and renaturalization of torrent stretches subjected to strong reshaping action have been put in practice through the adoption of ecological criteria, in order to favour the re-creation, in short time, of a natural environment similar to the original one.

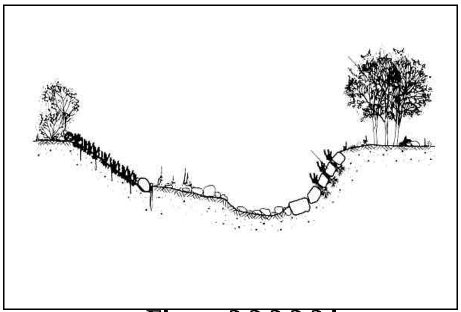


Figure 3.3.3.3.2 b

The new criteria foresee the carrying out of new transversal sections with an irregular profile, using blocks, bioengineering structures, groins, sills, etc. in order to create different morphological, sedimentological and hydraulic conditions to guarantee the formation of many habitats for different faunal species. The new rearrangement techniques fit in especially along natural channels with few human interferences (Figure 3.3.3.3.2 b) while the renaturalization action along torrent beds that have bed and bank protective structures is more difficult. Although some results can be reached using block, bioengineering structures, in order to create shelters for fishes and amphibians and favour a controlled growth of vegetation on the banks.

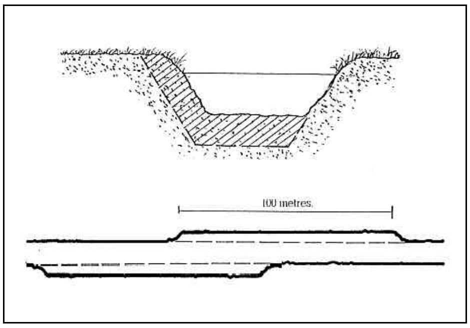


Figure 3.3.3.3.2 c

Strong difficulties in the renaturalization action are also evident in embanked artificial channels with geometrical transversal sections, where the reshaping action requires the removal of terrigenous and vegetal materials. In this case, these maintenance interventions can be concluded with the carrying out of morphological differences of cross sections and of the longitudinal course, through the creation of depressions, elevations and blocks in the torrent bed in order to form a meandering water flow, creating different habitats and favouring the development of areas for fish and amphibians (Figures 3.3.3.3.2 c and d).

On the basis of these new criteria, the cleaning up action of hydraulic channels can be carried out maintaining, along the torrent bed, small areas with natural sediments and vegetation, in order to favour the meandering water flow and the colonization and diffusion of ichthyic, amphibian and terrestrial species.

Figure 3.3.3.3.2 d

Costs

- Reshaping with removal of sediments and vegetation also with rearrangement of landslides on banks, transport of material, creation of easy access: Euros 1.5-2.5 per m^2.

3.3.3.4 Maintenance of Water Courses

The operations of maintenance and restoration along natural and artificial water courses are, together with other typology of structural interventions, a necessary tool in order to guarantee the effectiveness of the entire hydrographic system and preserve the discharge capacity during the strongest alluvial events.

For this reason, maintenance works are, on the experience of past alluvial events, a priority for the correct management of the water courses. The respect of this priority is often in opposition to the conservation of torrent ecological aspects (Figure 3.3.3.4).

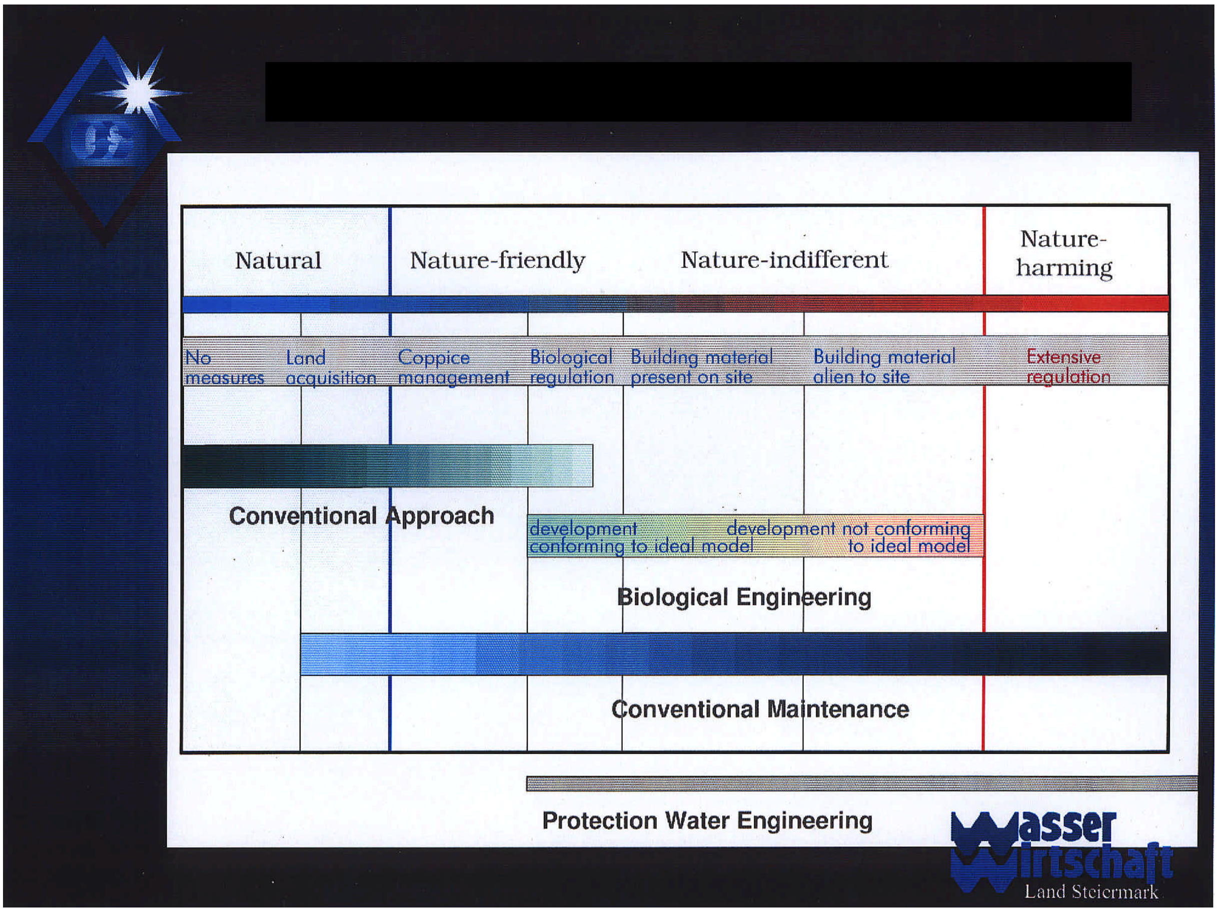


Figure 3.3.3.4 – Environmental impact of different approaches to management of water courses

On this basis, the recent evolution of the maintenance works and of global management of water courses has been driven towards the adoption of techniques and methodologies, such as "water-care" and "water preservation", that can preserve ecological and environmental values and assure the functioning of ordinary maintenance works.

The below listed measures are not to be simply regarded as instruments for reduction and solution of possible disturbances or failures. They are also used to remove and counter harmful influences on a stream or stream reach and on its banks, whose integrity is vital to the ecological function of any water course.

3.3.3.4.1 Measures

These measures aim towards the attainment of acceptable conditions in the stream and include a wide range of actions that can refer to water care and water preservation concepts (Figure 3.3.3.4.1):

- non-interference with given water conditions (zero variant);
- upkeep of stream reaches that are still in their natural state;
- protection of specific habitats;
- structural intervention for the improvement of the ecological function (activation of old branches; creation of biotopes where necessary to comply with the ideal conditions established by environmental models);
- flood damage prevention (local bank protection; constant stabilization interventions; re-channelling of course-deviation into the originary bed);
- measures to counter harmful influences on the whole system originating from the neighbourhood (protection against deposition of erosive materials; promotions of water-friendly exploitations);
- upkeep and activation of floodplains (location of inundation areas; reduction of already existing regulation constructions according to exploitation practices of the surrounding land);
- preservation and improvement of the stream as a whole (low-water channels, levy on restitution discharge; by-pass canals and fish ladders);
- measures to control the bed load regime (through retention basins and check dams).

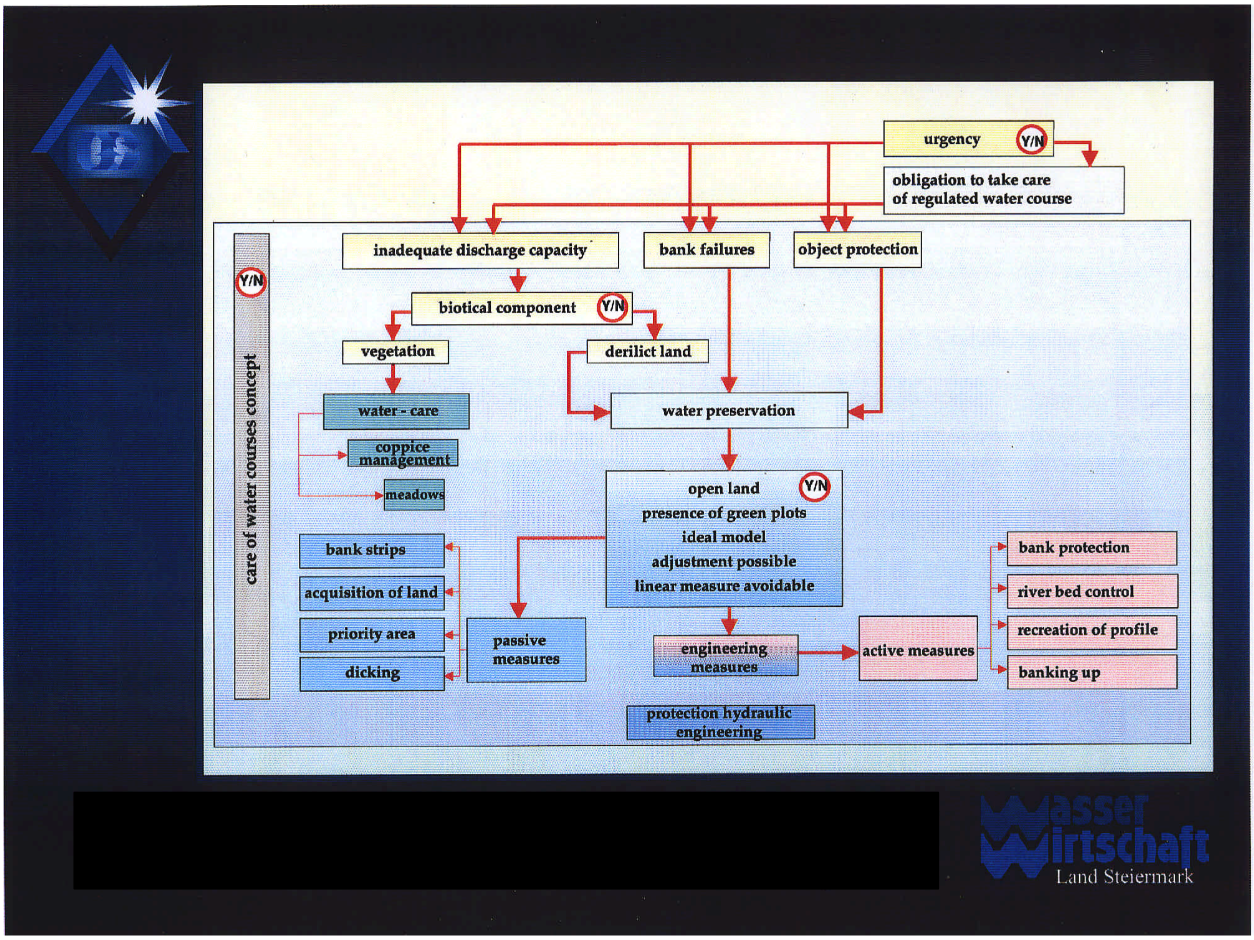


Figure 3.3.3.4.1 – Concepts of water care and water preservation in relation to torrent management in Styria

3.3.3.4.2 Flowing Water Care (Tending)

Water-care measures favour the organization and development of a water course, its banks and inundation areas according to a biological and scenic point of view. They include:

1. tending of bank vegetation
2. afforestation and integration of plant species
3. rejuvenation of standing trees
4. protection of specific habitats
5. removal of waste, debris and quicksand

The scope of water care coincides primarily with biological measures, even though it is almost impossible to separate it from preservation measures. Therefore, water care actions can practically be considered a form of preservation devoting particular attention to the specific biological requirements of a water course.

3.3.3.4.3 Flowing Water Preservation (Maintenance)

The expression "water preservation" refers to measures aimed at maintaining certain conditions at a water course. They include:

1. maintenance of a specific discharge cross section;
2. local stabilization of a determined bank line;
3. servicing of structures and means for course regulation and flood control.

The concept also includes activities and measures that change or preserve given conditions.

Water preservation measures can be viewed as a reaction to unwanted alterations, but they also allow to reach and preserve certain conditions (ideal state of single reaches of the water course).

3.3.4 River Corridor Enhancement, Rehabilitation and Restoration

3.3.4.1 Introduction

One particular type of problem which is common to many industrialized countries, due to heavy human interference on natural environments, is the one connected to transportation networks (roads, highways, railroads) which act as non surmountable barriers for many species of animals disjoining territory in separated ecological strips. The deterioration of the environment in a certain region derives not only from a quantitative reduction of natural areas, but from their fragmentation in "islands" of limited extension, not connected between each other and immersed in a more or less artificial territorial matrix hostile to the movements of most species of animals.

The principal intervention to be able to guarantee the survival of these ecosystems consists in the breaking of their isolation by the enhancement ecological corridors that interrupt the continuity of the barriers consenting the passage of animal species from one ecosystem to another.

Rivers, and more precisely, their riparian systems made of tree and shrub vegetation represent the main (and sometimes the only) ecological corridors and therefore assume a determinant importance for the dispersion of many species and for the functionality of the systems they cross.

The term "River Corridor" is recent; it is associated with the change of attitude in dealing with environmental questions that gave rise to an increasing contestation of some big hydraulic infrastructures. These structures had the objective of improving hydraulic flow conditions causing alterations in the physical aspect of water courses which can be reflected in the destruction of habitats vegetation, alteration of physic-chemical water characteristics and modifications at the level of the whole fluvial ecosystem.

An excessive alteration of the fluvial system gives rises to substantial alterations in its integrity as an ecological system. An artificial change of this system requires the consideration of a new and distinct approach in the relationship between the society and the river.

In some countries, the proposals for the rehabilitation and restoration of degraded rivers are being implemented, with the reposition of the original situation.

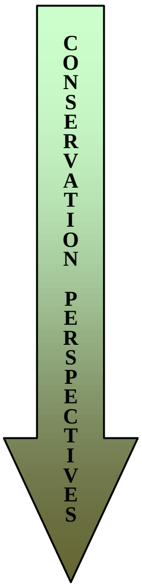
The requirement of the elaboration of Impact Assessment Studies, relative to the execution of hydraulic structures, appears in some countries like USA as a first symptom of the different attitude between society and environment previously mentioned. These studies have been required from the decade of 70, and demanded since 1985 in European Community, according to the regulation created specifically for each member state.

3.3.4.2 Fluvial Corridor

Traditionally, the structural actions of fluvial regularization have the objective of improving the hydraulic conditions of draining, originating changes throughout the fluvial ecosystem.

The increasing conscientialization of natural and cultural values associated to rivers and their influence zones, conduced to the reflection on the environmental impacts caused by these kind of actions. Nowadays, the methodologies for an integrated management of river basins aim at an integration of conservation strategies and valorization of fluvial systems, appraising resources and values, as alternatives to planning and management. According to BONN (1992, quoted by Saraiva, 1999), the following alternatives to fluvial systems management can be considered:

NATURAL
SEMI-NATURAL



- Preservation or conservation
- Restriction of land or resources use
- Mitigation – regulating activities such as regularization, effluent captation or reception, considering the protection of natural values
- Recovery and restoring – establishing a reconversion process: recovery of water quality, of the hydrological regime, of habitat structures and riparian zones
- Abandon

DEGRADED

The ecological values are relevant factors to fluvial systems management. A question may be raised: how can we equate the mutual relationships between the fluvial system and the soil area where its influence is felt?

The concept of fluvial corridor enables the understanding of fluvial ecosystems as a whole. It allows the adoption of actions considering the physical, chemical, biological and human relationships that interfere in those ecosystems.

According to Angold (1993, quoted by Saraiva, 1999) and Budd (1987, quoted by Saraiva, 1999), a fluvial corridor is not only the superficial draining system and its margins, but also the whole adjacent ecosystem where the riparian influence is felt, including the animal life.

The delimitation of fluvial corridors may turn out to be a complex issue, considering the variability of water-soil relationship. This is how the concept of ecotone appears, integrating the transition areas between adjacent ecological systems.

In relation to fluvial ecosystems, the ecotone corresponds to the transition areas between the lotical systems and the adjacent soil systems. In these areas, the influence of periodical flooding fluvial processes, sedimentation and erosion, whose structure and heterogeneity depends on the magnitude and the variability of these processes (hydrological regime and geomorphological dynamic) can be felt. This transition area is also known as riparian area and it presents a variable width: for example, along low order rivers it includes a narrow area but in alluvial rivers it is much wider (Figure 3.3.4.2 a).

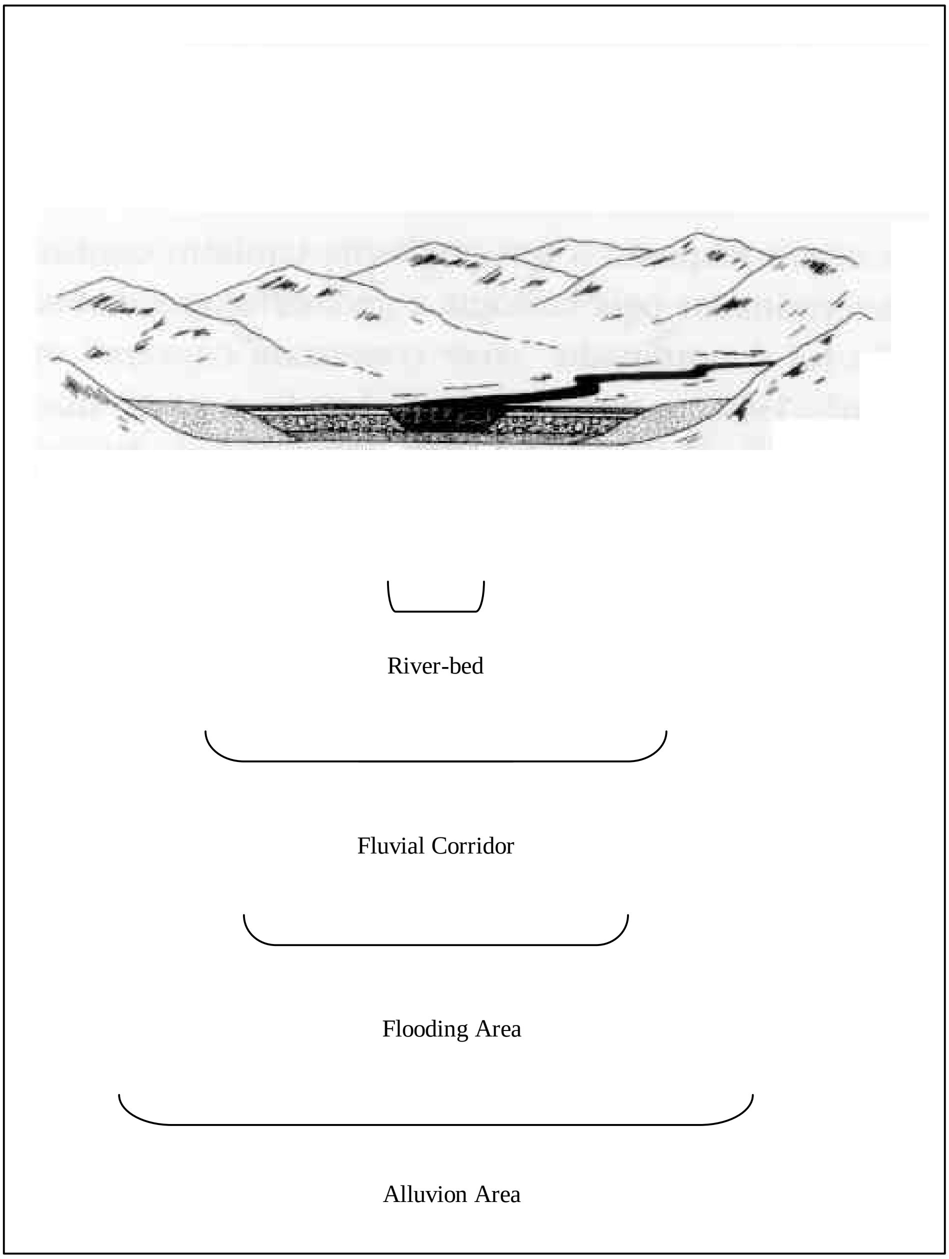


Figure 3.3.4.2 a - Transversal zones on a fluvial valley
(adapted from Newson, 1992, presented by Saraiva, 1999)

The fluvial corridors present multi-dimensional characteristics that stir up difficulties of analysis and management. Generally, we can consider the following fluvial corridors characteristics (Carmona, 1990; Forman and Godron, 1986, quoted by Saraiva, 1999) (Figure 3.3.4.2 b):

- Linear or curvilinear structure, related to the morphological characteristics of the drainage system;
- High connection to adjacent systems, acting at the same time as a union and a division element;
- Favouring of refugee and protection conditions, establishing habitats for a large number of species;

- Existence of gradients: gradual changes on composition and abundance of species which originates conducting functions of movement and circulation of biological species;
- Border, filtering and/or barrier effects;
- Existence of functional relations with underground waters, favouring its ascendant flow, as well as the superficial waters circulation, controlling the draining and the infiltrating functions, the nutrient and the sediment retention and the protection against erosion;
- Large tolerance and flexibility to the cyclic modifications on the river flow regime;
- Control, through shadowing, of aquatic plants development;
- Landscape richness and diversity and landscape scenical valorization.

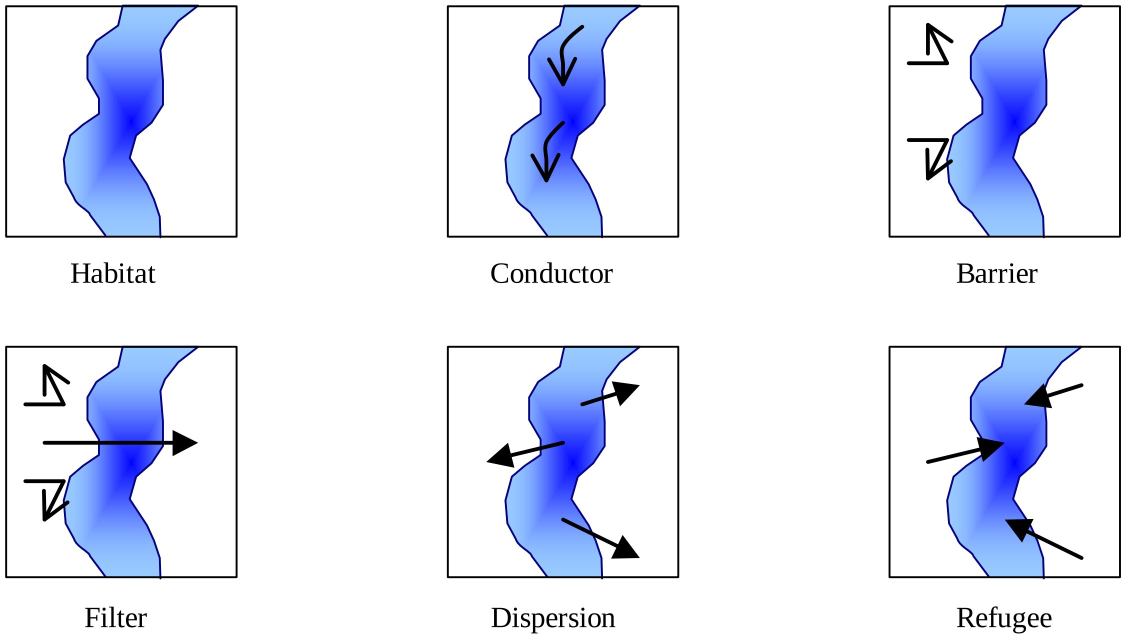


Figure 3.3.4.2 b – Characteristic functions of corridors
(adapted from Smith and Hellmund, 1993, presented by Saraiva, 1999)

The riparian vegetation is an essential component of fluvial corridors that presents certain characteristics, a structure and a dynamic; their ecological functions must be considered in the intervention processes on the fluvial systems (Figure 3.3.4.2 c).

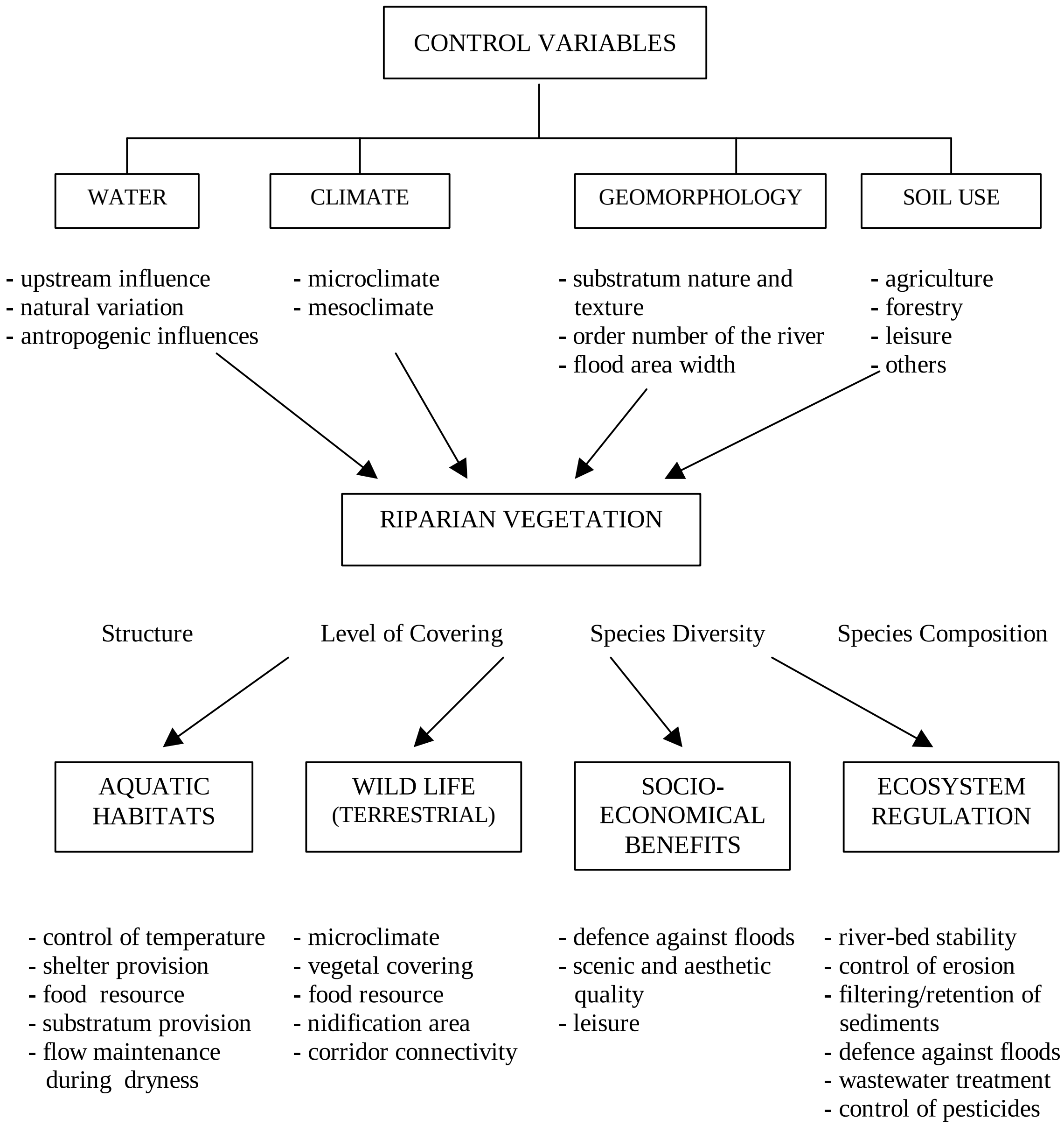


Figure 3.3.4.2 c – Schematism of riparian vegetation functions
(adapted from Large and Petts, 1993, presented by Saraiva, 1999)

Riparian vegetation:

- confers dynamic stability to the ground in relation to the type of existing vegetation (for example, a resistance to traction of 20-30 N/m^2 for roots of some grasses was calculated, of 100–140 N/m^2 for shrubs and of 150–300 N/m^2 for an extended covering of willows);
- creates natural habitats for wildlife, providing places where to feed, take refuge and reproduce;

- provides shade to the water course that controls excessive development of other plants (especially grass species) and hinders excessive water warming;
- performs important functions of purification of water through the action of roots which can absorb excess amounts of organic matter, heavy metals and other chemical substances.

Maintenance, rehabilitation and restoration of well structured creek corridors consisting in wide lateral strips along water courses containing varied topographical elements such as mounts, depressions and marshes and populated by autochthonous grass, shrub and tree species must therefore be the central objective of every intervention on rivers and creeks not only for the enhancement of functionality of river ecosystems but of entire river basin territories.

Management of riparian vegetation on river pertinence areas must be closely followed since many situations contribute to the worsening of hydraulic risk conditions, especially where large trees obstruct water flow creating a bottle neck effect on river sections that are narrowed by structures such bridges, etc. In these cases, interventions should consider the following sylvicultural criteria:

- Keeping of a structure of vegetation of different ages that allows the presence of both a shrub and a tree layer;
- Periodic cuttings and selective thinning of the adult tree vegetation that presents problems of stability, especially if they closely confine to the river bed, and elimination of invading species such as Robinia pseudoacacia, Ailanthus altissima, etc., in favour of autochthonous species (Salix sp., Alnus sp., Corylus avellana, Populus sp., etc, salici, ontani, noccioli, pioppi, etc.) and eventually valued species (Acer sp., Fraxinus sp., Prunus sp., Quercus sp., etc.);
- Keeping shrub vegetation as much as possible, since it can bend easily during floods and, being of smaller dimensions, it does not obstruct bridge sections. Sometimes shrub vegetation can be coppiced when their growth becomes excessive, especially along small water courses.

In this perspective, the interventions on fluvial corridors must consider a collection of principles and technical methods, respecting the several dimensions and functions of these systems, in order to conjugate the utilization of the resources with the conservation, valorization, recovery and restoring objectives.

Particular attention must also be paid to minor road systems along creek and river banks and canals so as to absolve their maintenance. The social function, particularly the recreational one, that riparian areas have must be remembered and footpaths should always be included in projects to this regard.

3.3.4.3 Valorization

The concern with valorization of degraded rivers appeared in the XIX century associated with urban proposals or interventions. These proposals intended to meet existing problems related with the effects of increasing industrial activities, e.g. the urban concentration, the contamination and lack of sanitary conditions in urban areas and the creation of green spaces for the leisure of population.

The rivers were seen as natural spaces, which could be associated to parks, green areas and other open important urban spaces. One example of this is the development of parks alongside of rivers.

This line of orientation still goes on in the present with the rehabilitation of urban areas adjacent to rivers. However, the awareness of the ecological importance of river conservation gives rise to the concern for the valorization out of urban areas. This kind of matter may be regarded in the context of the nature conservation with the integration in natural parks and reserves.

3.3.4.4 Recovery and Restoring of Fluvial Corridors

The concept of "*continuum naturale*" appears as the consideration of a global perspective of landscape management. In Portugal, according to the Environment Basis Law (Portuguese Law 11/87 of 7 April), this concept is defined as "the continuous system of natural occurrences that compose the support to wild life and to the maintenance of the genetic potential and that contributes to the equilibrium and the stability of the territory".

According to Cabral (1980, 1989; quoted by Saraiva, 1999), there are four basic principles that must be considered in the orientation of an intervention, in view of a landscape equilibrium:

- The functional continuity among the ecological elements that are more active in the landscape, allowing the flux of energy and the circulation of materials and live beings;
- The elasticity or the adapting capacity to different situations;
- The meandering, through the possibility of increasing limit surfaces among the different landscape elements, corresponding to the maximization of the riverfront effect;
- The increase of ecological activity in the ecosystem structural elements and in the capacity if its auto-regeneration.

The implementation of recovery and restoring strategies can be set into a combination of ten principles (adapted from Wasserwirtschaft in Bayern, 1989, quoted by Saraiva, 1999):

1. Ecological and functional **unity** (river bed, margins and flooding areas);
2. **Diversity** - the measures to implement must maintain and, if possible, increase the structural diversity of the river and its margins;
3. **Dynamic** - depends on erosion and sedimentation processes, its frequency and duration, establishing the characteristics of the biotope associated to the fluvial system;
4. **Individuality** - establishing solutions according to the specific situations and problems;
5. **Continuity** - respect to the particularities of the system (continuity of the fluvial system and of the linear biotopes associated);
6. **Orientated Maintenance** of the development structure and the maturity of the biotopes;
7. **Integrated Development** - consider the natural processes dynamic and evolution;
8. **Naturalistic Conception** of constructions and utilization of traditional techniques;
9. **Technical Competencies** – collaboration of an interdisciplinary team; development of a specific project for each situation;
10. **Availability of Intervention Area** - acquisition of land; definition of buffer zones.

Figure 3.3.4.4, prepared by the Bavarian Water management, illustrates how some of these principles are applied in restoration of water courses.

River Banks: In their natural state, the banks of water courses are covered by coppice with forms that vary according to morphological, climatic and edaphic conditions. Types of coppice range from the thin strips of herbaceous in the mountains to the huge riparian forests extending over the entire bottom of the valley or plain. Water courses and their banks are therefore important and integral components of the natural beauties of landscapes. If possible, they have to be preserved in their pristine state and their natural development has to be promoted.

Protective hydraulic engineering has to focus on the protections of settlements and other crucial sites and structures in accordance with the above objectives. In open country specific areas have to be made available to build the necessary areas between the river course, its surroundings and the landscape of the valley.

Free Development*:* Natural and nature-like water courses are left free to develop and modify their course and the habitats that depend on them in the area of their riparian forests. As a difference to trained segments, therefore, convergent structures are almost completely absent.

Divergent structures, which are linked to one another an their surrounding areas, not only fulfil the requirements of „natural conditions“ but are also varied and consistent elements of an ecologically functional water course.

Natural Conditions*:* The degree in which natural conditions are preserved in a water course and along its bank strips constitutes a basic criterion to judge the capacity to maintain interaction between the water course and its surrounding land, i.e. the biotopes characterizing the area. Ecological functionally, expressing the potential of self-regulations, resiliency and resistance, serves very well the purpose of observing the dynamics of change and is a useful for the evaluation of control measures carried out in the framework of water course maintenance.

Figure 3.3.4.4 – Restoration of water course

Table 3.3.4.4 - Technical measures to consider in a fluvial corridor re-qualification strategy (adapted from Saraiva, 1999)

Types of Measures	River-Bed	Margin	Flooding area
Non- Structural Measures	Public Water Domain legal regime	Public Water Domain legal regime	Adjacent Zone Regimen
	Ecological Reserve legal regime	Ecological Reserve legal regime	Ecological Reserve legal regime
	River Basin Plan	River Basin Plan	River Basin Plan
	Environmental Impact Assessment	Environmental Impact Assessment	Environmental Impact Assessment
	Soil acquisition	Soil acquisition	Soil acquisition
Structural Measures	Cleaning and removal of obstructions	Cleaning and removal of obstructions, managing damaged trees	Cleaning and removal of obstructions
	Recovery and restoring of natural conditions	Recovery and restoring of natural conditions	Recovery and restoring of natural conditions
	Ecological and aesthetics valorization	Ecological and aesthetics valorization	Ecological and aesthetics valorization
	River-bed modification	Re-vegetation plantings and seeding	Re-vegetation plantings and seeding
	Meandering	Stabilization, protection and/or natural, semi-natural and artificial revetment	Increasing of hydrological communication with the river-bed and the margins
	Narrowing/ Widening	Plaiteds, reed rhizomes	Level lowering
	Ecological flow regime	Gabions, geo-textiles, foundation-stones, etc., used with or without vegetal materials	Humid zones and increase of habitat diversity
	Substratum modification	Flow deflectors	Flood retention basins
	Silt-traps	Slope modelling	Compartmentalization systems
	Alternative river-beds	Buffer strips	

3.3.5 Agricultural and Forestry Measures

3.3.5.3 Introduction

The "hydrological cycle" comprehends the whole water exchange between land and atmosphere, and vice versa, powered by solar radiation (evaporative process) and by the influence of the force of gravity (precipitation). Water absorbs solar energy, evaporates from all surfaces which are in contact with the atmosphere, then it is conveyed into the air as steam, which – when temperature and pressure reach certain levels – condenses and falls as precipitation, liquid and/or solid, feeding lakes, rivers, seas and/or other water bodies.

From an engineering point of view, given its importance, hydrologists have paid greater attention to that part of the hydrological cycle which affects more directly water circulation within watersheds, especially to the factors which change precipitation into runoff in the closure section of watersheds. In fact precipitation, when reaching the ground, triggers a number of events, the most important of which are the following (Figure 3.3.5.1):

a) water accumulation in *surface depressions*, *interception* from vegetation of some precipitation;
b) water *infiltration* into the ground and *runoff;* when the intensity of the rainfall is greater than the capacity of infiltration, or when the more superficial layer of the ground attains full saturation, then *surface runoff* occurs;
c) *percolation* and *filtration* in unsaturated and saturated pores of the ground;
d) *evaporation* from liquid surfaces and *transpiration* from plants;
e) *loss* due to water exchange between neighbouring basins.

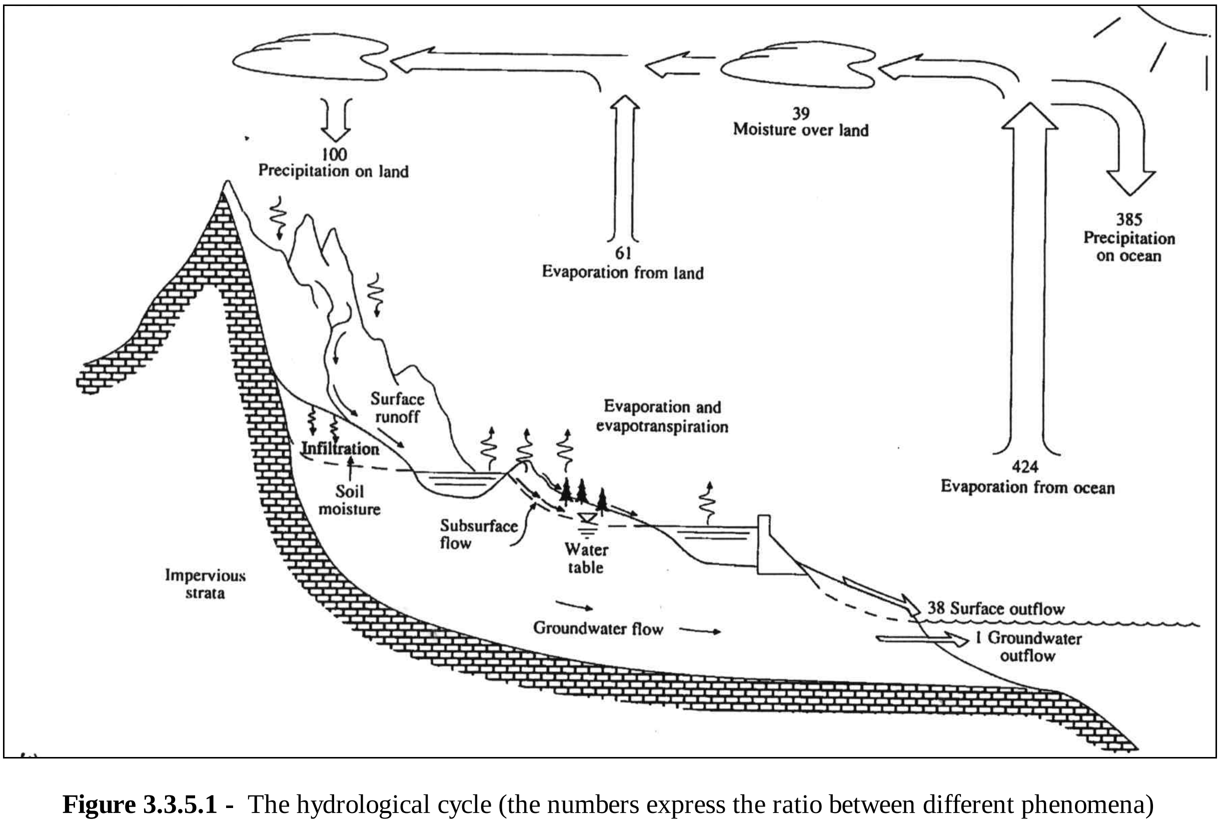


Figure 3.3.5.1 - The hydrological cycle (the numbers express the ratio between different phenomena)

The formation of surface runoff – normal or flood runoff – is certainly the most apparent hydrological process from a technical point of view. In particular, normal *runoff*, resulting from meteoric events which are not particularly intense and lasting, is distinguish from *flood runoff*, which can make river beds hydrologically insufficient, and cause flooding.

In any event, water runoff on the soil surface is a complex process since water speed and quantity can vary according to the nature of the surface. In fact, as thin layers of water it can affect wide areas, or it can divide into micro-channels and rills, and form incisions in the soil.

Erosion, solid transport, formation of sediments are strictly related to runoff and intense rainfall, and affected by soil utilization/coverage and anthropic activities. In particular, erosion occurs when rainfall and the consequent runoff affect erodible soil. Erosion is chiefly due to the combination of direct triggering factors – soil detachment due to rainfall, solid transport by surface runoff – and the factors of resistance peculiar to the soil. Other factors, such as soil utilization, vegetable covering, anti-erosive practices and demographic presence affect erosion processes, and their action can be either a reduction or an increase of soil loss.

Prevention and protection activities, related to soil conservation, can be evaluated from different points of view, especially in terms of slope stability, flow rate control, quantitative and qualitative conservation of water resources.

These activities can be evaluated taking into consideration single areas, or watersheds on a larger spatial scale. In fact, it is possible to approximately evaluate the effect of soil utilization on surface erosion within areas of some hectares, while on a scale of the watersheds it is not only possible to evaluate the role played by soil utilization on runoff regulation but also the effects on surface and mass erosion.

In the following Sections the main factors that affect both surface erosion and runoff have been considered, emphasizing the most significant interactions among them.

3.3.5.4 Runoff Components

The main factors affecting runoff are: soil, topography (gradient and length of slopes), way of cultivation, anti-erosive action (which concerns the possible actions carried out by men in order to reduce the runoff process). These four factors can, in turn, be grouped as follows:

- natural components (soil and topography);
- anthropic components (cultivation and anti-erosive action).

3.3.5.2.1 Natural Components

Soil: the intrinsic features of the soil which can affect surface runoff are

- texture;
- structure of soil particles (porosity);
- organic matter rate;
- pH.

These properties directly affect soil permeability, enhancing infiltration. Rainfall being equal, the greater the amount of water infiltration will be, the smaller the runoff.

Table 3.3.5.2.1 a shows how water retention varies with different types of forest soils.

Table 3.3..5.2.1 a - Influence of soil type on water retention and percolation

TYPE OF SOIL	**Water, m^3/ha**			
	Retention	**Slow percolation**	**Quick percolation**	**Total (saturated soil)**
	NORMAL SOILS			
Brown forest soil	3 518	934	2 588	7 040
Podsolic soil	2 803	906	2 089	5 798
	ERODED SOILS WITH CONSOLIDATED “B”			
Brown forest soil	2 015	580	1 740	4 335
Podsolic soil	2 072	584	1 684	4 520
Brown podsolic soil	980	280	840	2 100

There results a smaller capacity of retention of podsolic soils in comparison with brown soils, and an even lesser retention capacity of eroded and consolidated soils. This difference is due to the fact that brown forest soils have a better structure and a higher organic matter rate.

Within the method "Curve Numbers (CN)", which has been developed over the Fifties by the US-Soil Conservation Service and applied to surface runoff possible occurrence, infiltration is divided into three groups: infiltration before runoff, infiltration during runoff, and water retention.

When considering the above-mentioned features, soil structure is regarded to be the most significant factor; organic matter rate and soil texture are important as well. All these factors contribute to soil drainage capacity.

In the CN model, the factor represented by soil is evaluated by considering texture, surface and deep permeability, and by placing the unit being examined in one of four hydrological group, where runoff increases from the first to the fourth. Evaluation of pedological parameters such us structure, permeability, organic matter rate, sand and silt content, permit to place each type of soil in one of these groups.

Surface runoff increases from left to right when considering each parameter.

Structure: Granular very thin — Granular thin — Granular medium or coarse — Polyhedric, lamellar or massive

Permeability: Quick (<12.7 cm h^{-1}) — Moderate to quick (> 6.4 < 12.7) — Moderate (>2.0 < 6.4) — Slow to moderate (> 0.5 < 2.0) — Slow (> 0.1 < 0..5) — Very slow (< 0.1 cm h^{-1}).

Organic matter rate: High — Medium — Low

Sand content: High — Medium — Low

Silt content: Low — Medium — High

Topography: it is often the most significant factor in surface runoff. When there are no obstacles to runoff on a surface, as the gradient increases, the potential energy of the water particles flowing on the soil – and thus their speed – increases too. This is why, as a consequence, it affects the time of the runoff itself, as well as surface erosion.

The factor concerning the gradient is regarded as essential in order to assess surface erosion, i.e. water runoff. Table 3.3.5.2.1 b shows the maximum length that cultivated fields should have, in relation to the gradient, to maintain the same erosion rate.

Table3.3.5.2.1 b - Maximum length of cultivated fields, in relation to the gradient (Wischmeier and Smith, 1987)

Gradient (%)	Maximum length* (m)
1-2	120
3-5	90
6-8	60
9-12	36
13-16	24
17-20	18
21-25	15

(*) These values can be increased by 25% if more than 50% of the cultivation residues are left on the ground after sowing.

3.3.5.2.2 Anthropic Components

Type of covering can be divided as shown in Table 3.3.5.2.2 a:

Table 3.3.5.2.2 a - Classification of soil coverage

Cultivated lands	Herbaceous crops (coarse grains, grain seeds and grain fodder, etc.) Woodland crops (vineyards, olive groves, fruit orchards, etc.)
Natural systems	Natural turf-forming plants Woods

Cultivated lands are determined directly by man, while in the case of natural systems, there is an indirect interference by man who interacts with nature to make use of its resources, such as grasslands for pasture, forests for harvesting wood, etc., and for this reason natural systems are included among the anthropic components.

Cultivated lands

Vegetable covering, according to the type of crops, affects both the amount of water which infiltrates into the ground, and the erosion of the ground itself. Protective effects of the vegetable covering vary according to the vegetable species which form the covering. In fact, the protective function of forest species is greater than that of fruit trees, and similarly, pasture herbaceous species provide a better protection against erosive processes than do arable herbaceous species (Table 3.3.5.2.2 b).

Table 3.3.5.2.2 b - Relative effectiveness of vegetable coverage in protecting the soil from erosion (in order of decreasing effectiveness - from Kohnke and Bertrand, 1959)

Groups of land use	Crops
Permanent vegetation	Lands protected by woods Prairie Permanent pasture Grass-covered orchard Permanent grassland
Grasslands constituted by leguminous plants and graminaceous plants	Alfalfa and brome-grass Clover and Phleum pratense Meadow fescue and clover
Monophytous grasslands with legume for forage	White clover Alfalfa Red clover Yellow sweet-clover Crimson clover
Cereals	Rye Wheat Barley Oats
Legume seedling crops	Soybean Peanut Pea
Row crops	Cotton Potato Tobacco Soybean Corn
Soil with no crops at the moment	Summer fallow Period in which the soil, which is bare after the ploughing, is not yet covered with the crops already planted or which are going to be planted

Decreasing effectiveness

Taking into consideration the last group, as far as the erosive process is concerned, crops rotation and cultivated landss are highly important.

In cultivated lands, surface runoff and erosion are greatly affected by cultural practices which farmers carry out. The most important are:

- tilling;
- surface laying-out
- type of crops;
- Covering duration;
- management of residues coming from previous cultivation and preservation of soil fertility.

Tilling - It affects the structure of the ground, thus porosity and permeability, the conservation or the breaking of the "ploughing sole", the chemical and biological fertility of the ground. Trials carried out by Chisci et al., 1985, compared theories concerning ploughing carried out along the maximum gradients and length-side, associated or not associated with open ditches. Table 3.3.5.2.2 c shows the results of these trials; some of the most significant aspects are the following:

- the runoff coefficient is higher in ploughing performed along the maximum gradients, with no open ditches;
- the rate of soil loss, which varies from 1.71 t/ha/year in length-side ploughed parcel with open ditches to 38.27 t/ha per year in fields ploughed along the maximum gradients, without open ditches.

Table 3.3.5.2.2 c - Comparison between water values concerning parcels ploughed along the maximum gradients and length-side, with and without open ditches

Parameters	Length-side with open ditches (B)	Along the maximum gradients without open ditches (A)
Rainfall (mm)	793	
Rill (mm)	126	201
Water load (t/ha per year)	1.71	38.27

Water regulation of cultivated landss is made by agronomic measures, which can control surface and underground runoff of surplus water and preserve water storage in the soil.

This regulation is carried out through technical measures which take into consideration the type of soil utilization, the soil depth, the management of draining by ditches, and finally the type and the period of vegetable covering which crops can ensure.

The depth of ploughing is a parameter which must be taken into consideration, as it affects both water retention of farmlands, and surface runoff. Tables 3.3.5.2.2 d and e show trials carried out by Landi (1984) on parcels cultivated at different depth.

Table 3.3.5.2.2 d - Runoff (mm) on dry soils in parcels cultivated at different depth (Figline Valdarno **-** Firenze)

Depth of the ploughing	Precipitation on dry soil 4.11.80 (Inflow 79 mm)		
	Surface runoff	**Underground runoff**	**Total runoff**
30 cm	16.13	7.61	23.74
50 cm	8.88	5.50	14.38
Average	12.51	6.55	19.06

Table 3.3.5.2.2 e - Runoff (mm) on wet soil in parcels cultivated at different depth (Figline Valdarno **-** Firenze)

Depth of the ploughing	Precipitation on wet soil 18-19.12.81 (Inflow 36.9 mm)		
	Surface runoff	**Underground runoff**	**Total runoff**
30 cm	10.40	6.85	16.99
50 cm	7.25	17.48	24.73
Average	8.69	12.17	20.86

As can be observed, the effects of the depth of ploughing are very significant, as it lowers by 50% the surface component of runoff in deeply ploughed dry soils. Deep ploughing, compared to topsoil ploughing, allows greater water retention and an actual reduction of total runoff. This effect is less evident if the soil is wet.

Surface laying-out - Much attention is paid to surface laying-out methods, which constitute one of the most effective systems for surface runoff regulation, and for prevention of erosive events triggered by the lack of hydraulic arrangements (Figure 3.3.5.2.2 a).

Figure 3.3.5.2.2 a - Laying-out of lands in a piedmont area where the complete absence of length-side ditching within the fields can be observed.

"Open ditches" or "drainage ditches", which store water coming from field surface and subsurface runoff, are effective to slow down surface runoff. The elements to be considered in order to establish an adequate draining system are the following:

- volume of the water in open ditches;
- spacing of open ditches;
- section of open ditches;
- gradient of open ditches.

Concerning the volume of the water contained in open ditches**,** the values to be considered are 200 to 300 m^3/ha in case of impermeable soil, and 100 to 150 m^3/ha in case of more permeable soils.

With regards to spacing of open ditches, the following formula is widely used; it especially takes into consideration the topographic factor in order to keep runoff speed within acceptable limits:

$$L = H x 100/P$$

where **L** means horizontal spacing, **P** gradient and **H** vertical difference in level.

The most common spacing is 25 - 30 m in medium-textured soil, 30 – 35 m in ameliorated soil, 20 m in difficult soil (clay soil). The length of open ditches per hectare of surface obviously increases as L decreases.

The section should be trapezoidal, 60 - 70 cm deep, and the lower base not less than 30 cm. These values often depend on the type of trencher which is used.

Concerning the gradient, the values which are considered as adequate for water draining - without causing problems due to increased runoff - are from 0.8 to 1%; if the width of open ditches is greater, the gradient can decrease to 0.5%. In case of steep grounds, the slope can be interrupted through artificial differences in level, by placing some small barrages along the open ditches; this applies especially to the main drainage ditches. Figure 3.3.5.2.2 b shows an example of surface laying-out with open ditches.

Figure 3.3.5.2.2 b – Scheme of cultivated land with simple surface laying-out with open ditches

Type of crops - Rotation forage crops, in particular, multiannual crops such as monophytous and polyphytous grasslands, when compared to arable crops, prove to be very important both for soil conservation and for correct water regulation because of their positive effects on physical, chemical and biological conditions of the ground. Extensive trials showed the effectiveness of these crops, when included in different rotations, in reducing rill and erosion. The trial carried out by Boschi et al., 1984 (Table 3.3.5.2.2 f)., on the effect of alfalfa meadow-grass on water regulation and of physical protection of soil showed clearly that this type of crops can regulate the extent of surface runoff.

Table 3.3.5.2.2 f - Comparison between alfalfa, row crops and wheat.

Year	**1976-77**		**1978-79**		**1979-80**	
Type of crop	**Alfalfa 2nd year**	**Rowcrops**	**Alfalfa 1st year**	**Rowcrops**	**Alfalfa 1st year**	**Wheat**
Overall rainfall (mm)	885		748		892	
Rill (mm)	170	331	140	164	261	345
Runoff coefficient (%)	0.19	0.37	0.19	0.22	0.29	0.39
Water load (t/ha)	2.90	16.40	6.50	8.30	2.30	4.05

The rotation of these crops with alfalfa meadow-grass proved to be a successful method to keep soil erosion within acceptable limits.

Covering duration - This is a difficult parameter to be managed, as it is strictly connected with soil utilization, therefore with technical management and yield expected by the farmer.

Of the different agronomic practices, crops rotation can be considered of great use since it can bring benefits similar to those achieved by a good surface laying-out. On the contrary, single-crop farming is regarded as the most at risk, since soil is left bare for several months year.

A good practice consists in the contour strip-cropping system, where there are strips of different crops alongside the slope of the land. The effectiveness of protection depends on the crops which are put in the strips, of course, and it will be greater with a larger amount of lay farming.

Table 3.3.5.2.2 g shows "P" values (parameter which represents the ratio between the soil loss in fields where conservative practices are carried out, and in fields cultivated along the maximum gradient), comparing two different four-year rotation systems and a strip-cropping one (from Wischmeier and Smith, 1978).

Table 3.3.5.2.2 g - P values in crop rotation and strip-cropping

Gradient (%)	**P values**		
	Four-year rotation: 1st year - broad seeded crops (i.e. corn); 2nd year - narrow seeded crops (i.e. wheat); 3rd and 4th year - hay crop	Four year rotation: 1st and 2nd year - broad seeded crops (i.e. corn); 3rd year - narrow seeded crops (i.e. wheat); 4th year - hay crop	Strip-cropping and alternation of broad seeded crops and narrow seeded crops
1-2	0.30	0.45	0.60
3-5	0.25	0.38	0.50
6-8	0.25	0.38	0.50
9-12	0.30	0.45	0.60
13-16	0.35	0.52	0.70
17-20	0.40	0.60	0.80
21-25	0.45	0.68	0.90

As the table shows, the protection proves to be better in rotations, and in particular in the first trial, where hay-crops are utilized for a longer time; however, the results obtained by strip-cropping are interesting as well.

As far as tree cultivation is concerned, cultural practices which enhance a greater soil covering ensure a better regulating power. In particular, in fruit plantations and vineyards, total or partial coverage with grass (with rotary-hoeing on rows) can bring about very significant benefits.

However, it is necessary to emphasize that, when considering different types of crops and the duration of the covering, true benefits can be obtained on scales larger than the single farm, and the same applies tree top-soil. To this regard, a territorial planning which also regulates cultural practices can attain an improved runoff control.

Management of residues from previous crops and maintenance of soil fertility - This aspect is important, as it is directly related to the soil features. In fact, following increased organic matter release in the soil, an indirect improvement of the structure, and thus of the physical features of the soil, will certainly result.

Natural systems

Natural turf-forming plants

The essential activity carried out by turf-forming plants in soil protection against erosion is due to the fact that they give stability and resistance to the soil against erosive, leaching and mechanical activity of water. In fact, it has been demonstrated that - slope and other conditions being equal - water speed through turf-forming plants is reduced by 1/3 compared to that which can be observed on a monophytous grassland. Table 3.3.5.2.2 h shows the results of trials carried out by Basso and Linsalata (1983) comparing the regulating effect and the anti-erosive activity of pastures and arable crops.

Table 3.3.5.2.2 h - Hydrological data collected from July 1973 to January 1976 during trials carried out in hills facing South.

Hydrological data	**Hard corn**	**Seedling horse-bean**	**Sweetvetch meadow**	**Polyphytous alfalfa meadow-grass**	**Natural pasture**
Inflow (m^3/ha)	15 403				
Runoff (m^3/ha)	724	467	714	887	467
Runoff coefficient	4.7	3.1	4.6	5.7	3.1
Runoff duration (hours)	542	475	499	531	418
Eroded soil (kg/ha)	5 435	7 015	3 855	2 740	1 265

Table 3.3.5.2.2 i shows the most important effects of natural turf-forming plants on runoff and erosion.

Table 3.3.5.2.2 i - Activity of turf-forming plants on runoff and erosion

Aerial part:	- Reduction of the effects due to driving rain. - Catchment by adhesion of some of the excess water, which will subsequently be released to the atmosphere. - Reduced rill speed (the pasture can stand rill speeds up to 2.4 m/s - Ballatore, 1967). - "Mulching" effect, i.e. water catchment from dead vegetation.
Hypogeous part:	- Soil bridling and stabilization, especially from fascicled roots of graminaceous plants (Chisci, 1960). - Direct improvement of the structure: this aspect is very important, because of the effects on the speed of instantaneous and regimen infiltration, which, if increased, reduces and sometimes even cancels surface runoff. - Indirect improvement of the strucutre, due to the significant contribution of humificated organic substances, especially from graminaceous plants.
Other activities:	- Increased evapotranspiration. - Deferred melting of the snow.

Compact pastures can control high-intensity rains, even up to 150 mm/hour, as it has been observed using simulators (D'Egidio et al., 1981).

Table 3.3.5.2.2 j shows the most significant factors affecting turf-forming plants efficiency.

Table 3.3.5.2.2.2 j - Factors which affect anti-erosive action and runoff in turf-forming plants

Natural factors	Natural factors	Temperature Rainfall Wind
	Topographic	Slope length and profile of the slope Roughness Exposure
	Pedologic	Chemical, physical and biological characteristics
	Vegetational	Composition, ratio between biological species
Anthropic factors	Agronomical	Selection of species Planting and regeneration of pastures Manuring, irrigation and weeding Slashing Removal of stones Fire Assessment of livestock number
	Non-agricultural	Industrial activities Building activities Spare time activities

Turf-forming plants show a greater protective action compared to crop systems; nevertheless, an unbalanced exploitation of these lands can change soil fertility, and as consequence, the vegetation density and retention capacity.

It is worthwhile to examine more thoroughly some of the most significant factors listed in Table 3.3.5.2.2 j.

Several methods assessing optimum livestock number have been established: some are based on the overall forage value of pastures, some on the value of pastures coming from food contribution given by different species and still some others are more precise and are based on the growth curve of grass. Anyhow, it is not only necessary to make a mere balance between quantitative and qualitative production on one side and animal requirements on the other side, but to take into account also the carrying capacity of pastures in order to conserve the existing grass cover. In fact, the maintenance of the most natural balance between input and output preserves ecological features of pastures, and consequently all its protective factors.

The effect of livestock numbers which are not correctly assessed lead to two events known as "over-carrying" and "under-carrying": the first one causes soil compactness and acidification of pasture, and triggers a change in flora composition, which in a first phase favours annual species and then favours defence species (poisonous, thorned plants, etc.). Such a transformation inevitably leads to a change in the grass cover and in overall characteristics of the system. Usually, reduction of fertility, thinning out of pasture, decreased capacity of resilience of the system, which is not able to react against climatic adversities, are observed. In case of over-carrying, equine and ovine species are regarded as the most dangerous livestock, as they tend to graze very close to the ground, while cattle can prove to be very harmful in case of steep slopes, because the turfs are damaged following the slidings of cattle.

Under-carrying, which is much more diffused, causes effects which are not very different from those due to over-carrying; like the latter, it causes significant changes in the grass cover, due to selection activity of livestock, which increases the number of less valuable species and noxious weeds. Moreover, livestock selects preferred routes and places where it tends to concentrate, which in the long run causes pasture breaking, and consequently loss of covering continuity and of soil fertility. One of the most known event due to under-carrying is the formation of paths, which often triggers important cases of erosion and of movement of mass.

The grazing system affects the conservation of soil fertility and the conditions of balance of turf-forming plants. We can essentially take into consideration two grazing methods: deferred rotation grazing, and continuous grazing. Continuous grazing is regarded as more soil-depleting, since in the long run it changes the stand, with the creation of different "ecofacies", due to the occurrence of over-carrying and under-carrying situations occurring in small areas. In other words, continuous grazing - even if it is rightly assessed - causes both selectivity and packing in small parcels.

Another aspect to be considered in grazing arrangement concerns the creation of elements of attraction on the pasture, i.e. which can attract livestock in different places of the pasture: in fact, it is possible to ensure a greater homogeneity of the pasture exploitation by the correct location of watering points, of salt distribution, of milking points, of shelters.

Finally, a similar effect to the one of formation of paths by livestock, is that of the passage of agricultural machines or off-road vehicles by excursionists that produce clear cuts especially when the soil is wet (Figure 3.3.5.2.2 c).

Figure 3.3.5.2.2 c - Pasture showing clear cuts due to the passage of agricultural machines when the soil was wet.

The use of fire to renew turf-forming plants – a widespread method in some regions – causes the increase of annual species and the reduction of organic matter in the soil. This makes the risk of erosion increase considerably, especially in slopes, where soil losses can increase up to 34 times (De Bano and Conrad, 1976).

Woods

Woods carry out a throughout protective, regulating and anti-erosive action, on condition that they are fully effective as an integrated ecological system, that they are wide and that they cover the watershed in a balanced way.

The protective effect is due to the following factors:

- reduction of rain intensity by interception from foliage and litter;
- greater speed of infiltration, due to litter and humus;
- water retention from mesopores and macropores of the soil, gradual release of water;
- water conveyance downhill as hypodermic oblique runoff, which causes a delayed concentration of water masses and a significant reduction of flood peaks.

Interception capacity varies from 30 to 50%, depending especially on crown morphology, spacing, foliage density and phenological conditions (Figure 3.3.5.2.2 d). Interception capacity can be assessed as about 150% of the foliage dried weight. Interception is greater in evergreen species in comparison with other species; the relative average values are the following:

- deciduous broad-leaved 17%
- firs 40%
- pines and evergreen broad-leaved 30-31%

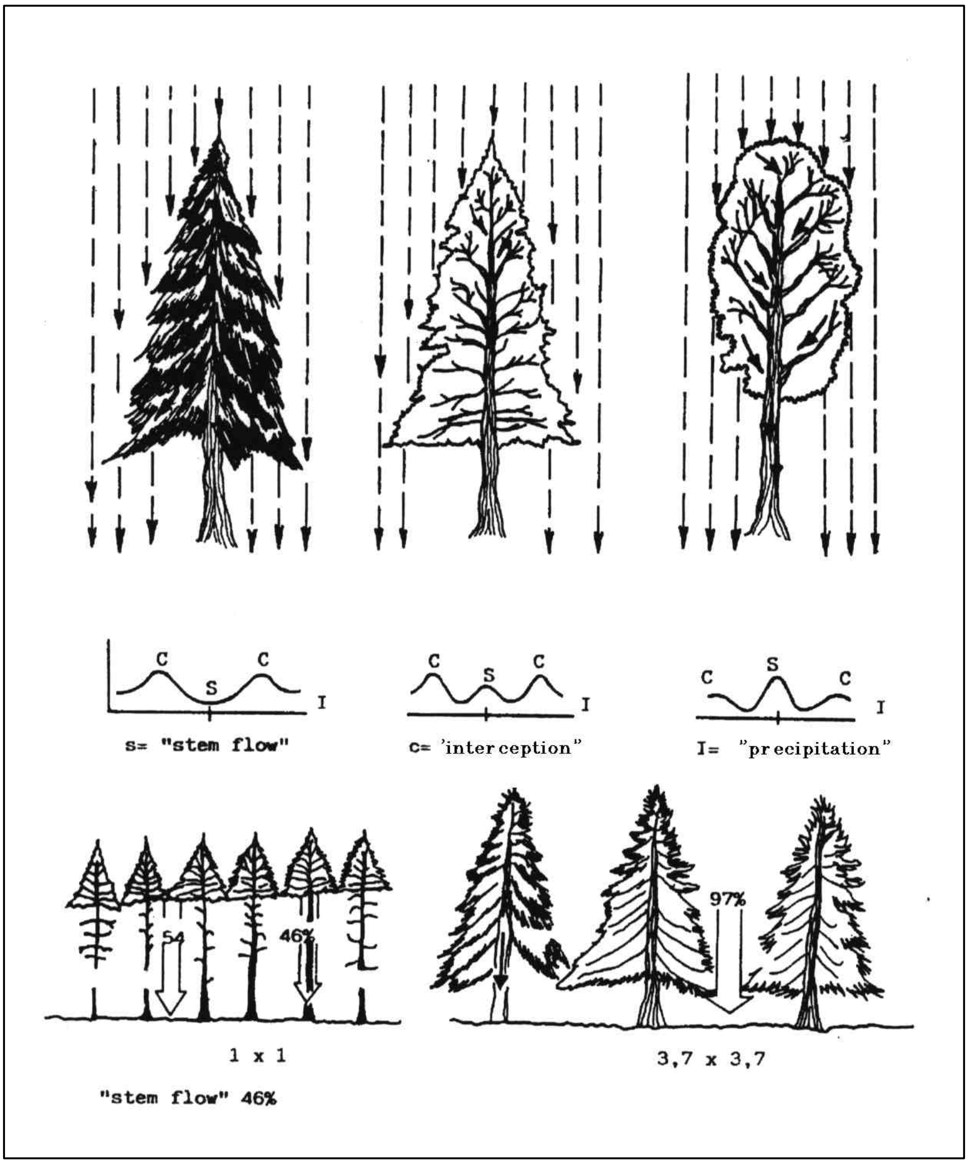


Figure 3.3.5.2.2 d - Effects of the crown morphology and of the plant spacing on the rainfall interception and on the stem flow (from Kimmings, 1987).

Also the litter and the moss layer intercept rainfall (up to 18% of precipitation); the effect of the litter layer depends on its thickness and decay. An increase of surface roughness must be considered too, resulting in a significant reduction of surface runoff. Table 3.3.5.2.2 k shows how top-soil efficiency varies according to the type of covering affecting values of surface runoff.

Table 3.3.5.2.2 k - Runoff variations depending on top-soil ecological efficiency

Covering	**Runoff (%)**
Efficient woods	0 - 10
Inefficient woods	20 - 50
Natural pasture	30 - 95
Non-laid up or abandoned lands	50 - 100

According to Susmel (1990), vegetable covering ensures an anti-erosive and regulating action, which make surface runoff values change and runoff erosive capacity reduce as covering density decreases. Values, in the case of a 60 mm/hour rainfall, are shown in Table 3.3.5.2.2 l.

Table 3.3.5.2.2 l - Wood density effect on runoff and surface erosion

Covering	Heavy (60-75%)	Medium (37%)	Scarce (10%)
Surface runoff (% of precipitation)	2	14	73
Erosion (t/ha)	0.1	1	10

Infiltration is:

- greater in old plants in comparison with young plants;
- greater in forests with no pastures;
- greater in non-thinned or poorly thinned forests.

Moreover, infiltration is different when considering:

- the type of management and of treatment which apply, according to the timing and importance of forest-cultural care and techniques which are used, and to the crops structure and density over the different stages of the cultural cycle;
- the incidence of negative elements (fires, forest road conditions, grazing, etc.) both in terms of extent and intensity, as they have important negative effects on hydrological features of soils (compactness, removal of the litter, formation of underground water-repellent horizons in case of fires).

In terms of volume, a well-structured, 100 cm deep forest soil, can retain half a cubic meter of water every square meter of surface, which is worth to 500 mm of rain.

Forest lands are one of the most effective deterrents against erosion and hydrogeological lack of arrangement. In spite of that, this type of covering can affect - sometimes in a dangerous way - surface runoff. Excessive exploitation of forest land by the man can cause extended erosion and movement of mass.

Forest cutting is the main anthropic activity affecting the protective role played by woods; in Italy coppice system is more diffused than high forest system and cyclically more frequent cut.

Utilization of woods suddenly interrupt the forest protective activity, and the surface where cutting takes place is usually left full of wounds, due to the passage of agricultural machines used for logging. The effects of the cutting last about 3 to 5 years; within this period, regeneration progressively restores covering.

It is necessary to consider that forest lands are often located on very steep slopes, therefore their protective capacity becomes less effective, following the increase of the gradient.

Some variables to be considered in order to improve the protective capacity of woods in which utilization takes place are the following:

- cutting period
- shape and extent of the cutting area
- logging period
- logging system
- slash
- seed bearers (coppice standards).

An example of how utilization is accomplished and how legislation has dealt with these variables is brought here, providing the occasion to examine them more in depth, referring to the Italian Forest Law 3267 of 1923.

The <u>period of cutting</u> is considered by the Italian National Law in a series of rules called "Directions of Principles and Forest Police", which fix the period in which cutting is allowed in every Province. These rules provide for cuttings during dormancy, in order to avoid the destruction of a large part of biomass that is present in the leaves during the vegetative period .

The <u>shape and extent of the cutting area</u> is one of the most important parameters, and it is not always taken care of; in fact, the above-mentioned rules do not provide for the extent of cuttings, and refer to provincial rules, if any (Figure 3.3.5.2.2 e). Many Italian regional administrations, when enacting their forest plans, have considered this matter, often establishing less than 10 ha for coppice cutting areas, and 5 ha for high forest. Moreover, the principle of contiguity with other cutting areas is often applied, so that a utilization of forest, greater than the parameters established, may not occur.

Figure 3.3.5.2.2 e - Panoramic picture of utilized coppice (you can see the branches stacked along the maximum gradient).

References to morphology do not exist in the Italian forest law: i.e., cutting areas placed on steep slopes and cutting areas placed on plain grounds areas are considered alike. Moreover, specific bonds on the shape of cutting areas do not exist either, so that narrow cuttings crossing all the slopes and cuttings which are more balanced are considered alike. These parameters (morphology and shape of cutting) can affect surface runoff and water erosion very significantly, although studies concerning their influence do not exist. However, their importance is undoubted, since they are fundamental variables of the universal equation used to calculate slope erosion (USLE) proposed by Wischmeier (1961), factors L and S.

Although the period of cutting is specified by the above-mentioned rules, they do not specify the period of logging (operation of taking the wood that has been cut out of the forest). Cutting operations begin starting from late Autumn and continue until the end of Winter; logging takes then place in Spring, using a series of heavy agricultural machines. It is during this period that the ground is damaged, both along the logging routes inside the stand, and along the skidding roads used to carry the wood to the landing. The major damages are soil compaction and road system impairment; these effects, however, are smaller if logging is performed in dry soil, whilst they can be ravaging if it is carried out in wet soil. It is important to emphasize that often runoff through erosion ditches starts from rides or skipping roads which have been left in bad conditions or not arranged.

The logging system (method in which the wood is logged) is linked to the logging period; The most frequently used method is the transport by means of skidders, both by dragging and loading on four-wheel drive log-carriages. In the cutting areas, agricultural machines work in areas which are morphologically more easily reachable; these machines run along the pre-existing roads, but also freely inside the forest (Figure 3.3.5.2.2 f). From the loading points they go towards a ride or a pre-existing or expressly created skidding road.

More seldom, the logging can be performed using less impacting means, such as cable ways and helicopters.

Figure 3.3.5.2.2 f - Detail of cutting in a coppice area, showing high density of skidding roads.

In the past, and still in some mountain regions, logging is carried out by means of beasts of burden, which still remains the least impacting method (Figure 3.3.5.2.2 g).

Planning previously the system of logging and assessing the best technical choice is the right way to carry out forest utilizations, but technical rules are often replaced by aspects of economic profitability, which do not always coincide with a good forest management (Figure 3.3.5.2.2 h).

The slash - formed by barks and branches - is usually left on the ground and stacked in trash bunds, that is, in heaps crossing the slope according to fish-bone design. This method is certainly to be preferred to the removal and the destruction of slash through burning off, which is instead the method that the above-mentioned rules often require.

Figure 3.3.5.2.2 g - Logging through beasts of burden.

Figure 3.3.5.2.2 h - Example of excessive forest cutting in coppice: cutting crosses all the versant up to the watercourse situated below.

The subject of <u>*seed bearers*</u> this is provided for in the Italian Forest Law 3267 of 1923, and is also mentioned in regional forest legislation, according to the different specific cases. The quantity of standards is a parameter to be taken into account in order to evaluate the protective effectiveness of forests which have been utilized: the higher this amount, the greater the protective effect. However, it is necessary to evaluate the physical stability of the standards: in fact, often many drawn up standards are seen, many times belonging to the co-dominant class, or even to the dominant one. In this case, the standards look drawn up, the crown is weak and sparse, roots are not much developed, so that precipitation can easily injure them, especially if they are located on steep slopes. The selection of standards according to their crown, trunk and roots is important to ensure the real protective function of the standards themselves. Some regional laws provide for the selection of standards on the basis of precise requirements: once the standards have been selected, they cannot be utilized anymore.

Abandon of Lands

The European agricultural landscape is very different both with regard to its morphology, rather variable, and to the growing practice which is used. In fact, there are large cultivated areas which are widely mechanized, and where the factors of agronomic fertility are controlled and regulated. On the other hand there are areas characterized by fields of small dimensions which are managed according to the agricultural systems still used at the beginning of the century and that are often situated in marginal lands or in environmentally protected regions (especially in the Mediterranean countries).

Many of the areas which have become economically marginal because of the mechanization of agriculture have been abandoned since decades. First they were turned into pastures and subsequently covered by shrubs and trees (Figure 3.3.5.2.2 i). This process of natural transformation implies indeed a benefit: as the coverage which is formed is made of permanent shrubs or turfs ensuring a greater protection both against erosion and surface runoff. It must be taken into account, however, that besides the covering transformation, a reduced control of pre-existing water operations has taken place and this has often triggered serious erosive events. These situations tend to continue especially in those abandoned areas where extensive forms of utilization – such as grazing, for instance – were carried out.

Figure 3.3.5.2.2 i - Abandoned area evolving to wood

In general, abandon is therefore to be regarded as an improvement in runoff regulation, as it represents a significant increase in permanent vegetable covering: however, it must be combined with a careful management, especially if processes of revegetation are slowed because of wrong exploitations, such as grazing or the removal of the previous agricultural lays out.

As already mentioned concerning agricultural lands, also the abandon of forest lands is common in Italy. In many areas, the anthropic pressure is reduced significantly, especially in mountain areas, where forest lands are more diffused, and large regions, which were once utilized according to specific systems, are now completely left to natural evolution. This event can be regarded as positive, since covering tends to increase naturally, and protection is greater; in spite of that, some dangerous situations may occur in some areas, because of forest abandon and critical precipitations, that cause exceptional erosion and movement of mass. Recently in Tuscany, after the flood of 19 June 1996 which occurred in the watershed of Versilia (Province of Lucca) - an exceptional event which killed 16 people - raging movements of mass and erosions took place. These events concentrated especially in abandoned fruit chestnut groves (Amorfini et al., 1997); in fact, abandoned fruit chestnut groves are very unstable, since the complete abandon of surface regulation (which in the past was made by man) and the general degeneration of trees (especially of roots) have to be added to the excessive load of trees (Figures 3.3.5.2.2 j and k).

In this case, the conversion of forest lands to simple structures (for instance, coppice) is recommended.

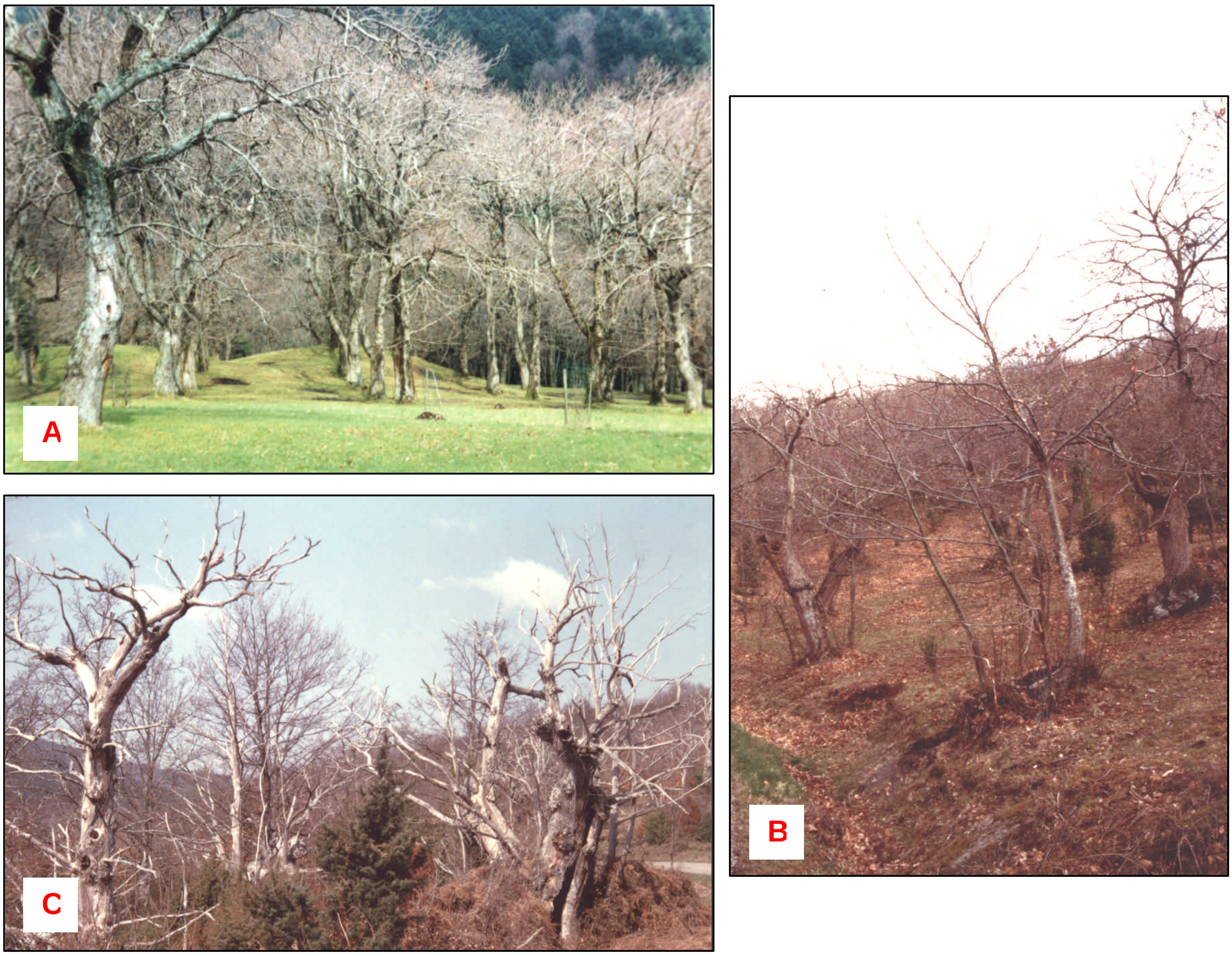


Figure 3.3.5.2.2 j - Fruit chestnut groves: cultivated (A), being abandoned (B), after abandon (C).

Figure 3.3.5.2.2 k - Deteriorating fruit chestnut collapsed on the road due to precipitation.

3.3.5.3 Measures

The variables and conditions which interact with water surface runoff have been taken into consideration in the previous Section, with regard to the major types of soil. Hereinafter the necessary actions which are regarded as to affect protective efficiency in the different types of soil are described (Table 3.3.5.3).

Table 3.3.5.3 a - Interactions concerning different types of soil covering.

Type of covering	Anthropic activities	Variables and conditions
Cultivated landss	Type of cultivation Surface laying-out Methods of cultivation Abandon of land	Depth and direction Length of the parcels Duration of the covering Guidance of evolutive processes
Natural turf-forming plants	Methods of pasturing	Livestock number Methods of exploitation
Woods	Utilizations Road system Fires Abandon of land	Extent of cutting areas Period of cutting Seedling bearer density System of logging Road maintenance Methods of restoration Guidance of evolutive processes

The activities that emerge from this report stem from the demand to find useful agricultural and forest measures in preventing floods.

Major attention is given to maintain and improve the resilience of agricultural and forest systems through the preservation of existing natural structures and the maintenance of more conservative cultural practices.

The strong anthropic pressure carried out by local populations to satisfy their socio-economic needs has already brought in the past to a considerable and sometimes irreversible deterioration of the most frail soils, unduly exploited. Many sloping areas, deprived of the natural forest ecosystems, have been degraded to secondary thicket, degraded pastures or even to bare parent rocks or compact sandstones like in some areas of the Italian Apennines.

Sustainable agricultural systems have developed in the best areas of Italian ‘typical hills’ and ‘structural hills’, and have remained till now through the adoption of cultivated landss based on mixed crops, long rotations on pluriennal grassland, animal breeding (commercial and working animals), recycling of residual organic matter of pastures and/or of manure, systems of agricultural management duly integrated with a rational regulation of surplus water coming from surface runoff and deep flow (arrangements such as terraces, open ditches, drain ditches, sewers, gutters, etc.).

The technological and structural evolution of Italian hills has greatly changed both productive organization and agricultural management systems. In particular, a real agro-technical revolution has taken place due, first of all, to the increase of industrial products in agriculture such as artificial fertilizers, pesticides and weed-killers, on one hand, engines and working machines helping and/or substituting men and animal work in the agricultural activities on the other.

The necessary adjustments of agricultural systems have also determined a considerable impact on the concerned cultivated areas, causing often an increased fragility of lands: agronomic fertility of farm lands tends to degrade, erosion increases, water penetration and soil storage capacity decreases, and consequently, runoff increases. Runoff is hardly regulated because of the reduction of anthropic arrangements determined by the necessity of fully mechanizing the agricultural systems.

It is then important to define and implement appropriate measures, also of agronomic type, which, even if preserving as much as possible the productive and managerial benefits, will be able to improve the general structure of hills bound to agricultural use.

The following Sections will describe some principles and guidelines for agricultural and forest areas management, and some minor works as well, which can affect flood prevention positively when applied.

3.3.5.3.1 Principles and Guidelines for Agriculture and Forestry

3.3.5.3.1.1 Cultivated Lands (Herbaceous and Arboreal Plantations)

General principles
- Conserve quick hedges and existing agricultural lay out: dry walls, water storage channels, terraces, etc.;
- Avoid the shaping of slopes aimed at changing the size of agricultural holdings;
- Carry out periodical servicing of all water channels, especially of water mains which impound water from the ditches of agricultural holdings;
- Favour permanent vegetation on water mains and ensure a sufficient section for downflow.

Soil fertility
- Enhance all agronomic practices aimed at increasing organic matter in the soil (manuring, rotation with improving crops, rational management of residues from previous crops).

Ditches
Cross ditches are necessary elements in land laying-out; their number depends on soil features (Table 3.3.5.3 b) and slope:

Table 3.3.5.3.1.1 – Ditch spacing in relation to soil texture

Soil texture	Ditch spacing (m)	Meters of ditches per hectare
Clay	20	500
Medium mixture	30	333
Sand	40	250

When slopes are less than 7%, very simple ditches can be made, as, in general, problems due to erosion and water regulation do not occur. When slopes are greater than 25%, it is necessary to assess the spacing between ditches according to each case, using the formula earlier described: L=Hx100/P (see Section 3.3.5.2.2).
Cross strips of shrubs can be regarded as breaks in land length.

Tillage
It is suggested to carry out crosswise tillage where the slope allows to do so, and in case tillage along the maximum gradient proves to be necessary, cross ditches must be carried out as well, on the basis of the values above-mentioned. The use of rippers combined with superficial tillage increases the storage capacity of surface waters in the ground yet maintaining organic substance in the superficial level.

Cultivation systems
- Favour pluriannual rotation of crops planted both using the plough and without it, contouring crops and contour strip-cropping;
- Select crops which ensure longer covering, especially in rainy periods;
- Stimulate the cultivation of species with a greater covering action (broad-leave species, fast-growing species;
- Favour grass growth on the entire surface, or at least on inter-rows, in case of arboreal plantations.

3.3.5.3.1.2 Natural Systems

Turf-forming Plants

General principles

- Keep quick hedges and existing cultural lay out: dry walls, water impounding channels, terraces, tracks;
- Avoid pasture renewal through fires;
- Avoid conversion into arable lands where slope is greater than 25%.

Soil fertility

- Favour all cultural practices which aim at increasing organic matter in the soil (manuring).

Livestock number

- Regulation of grazing through the correct assessment of optimum livestock number (see Section 3.3.5.2.2).
- Balanced spreading of places of attraction, such as watering, feeding and standing spots, in order to ensure a more homogenous distribution of livestock within the grazing area.

Grazing

- The rotation grazing method should be used as much as possible.

Woods

General principles

- Stimulate and favour forest management plans. As in the field of forestry transformations are significant only over long periods, it is necessary to plan changes: for instance, to assess the surface of forest utilization in every watershed, so that forest covering can ensure a positive action against runoff on a watershed level;
- Favour more evolved and ecologically stable type of woods: for instance, by stimulating the formation of woods with a more complex structure (woods of different age), or with a different composition (by increasing the rate of mixture of the species), or by increasing the biomass (transformation of coppices into high forests);
- Favour the planning of access to woods, taking into account the different management of woods.

Coppices

- Shape and extent of cutting**:** it is necessary to favour cuttings with minimum development along the maximum gradient. It is possible, for instance, to establish an extent limit – the extent must not be greater than 10 hectares in woods placed on slopes where the gradient is up to 50%, and it must not be greater than 5 hectares where the gradient is more than 50%; the ratio between the length (along the maximum gradient) and the broadness (along the contour lines), should not be more than 0.75, applied to slopes where the gradient is less than 50%; when it is greater, the ratio must not exceed 0.5.
- Period of logging**:** it is necessary that logging operations be carried out in non-rainy periods, in order to avoid the damage of skidding roads and soil compactage, due to agricultural machines use.
- System of logging: as the most common system of logging is that in which farm tractors are used, it is necessary to design adequate skidding roads. Both routine upkeep of pre-existing roads (re-arrangement of the ground and of the slope after the logging) and special upkeep (cross ditches, drains, etc.), shoul be carried out.
- Concerning new works, the roads which are regarded as generally useful to wide forest basins must be favoured – that is, the works which are useful to many users and by which many agricultural holdings can improve access to their properties.
- Seedling bearers: when choosing seedling bearers, the objective must be the increase of variability. Thus heliophile broad-leaved species should be favoured: Maple-trees, Ash-trees, Lindens, Cherry-trees, Sorbus spp., etc. If there are not many seedling trees, coppice shoots can be used as well.
- Conversion from coppice to seedling forest**:** in case of fertile aged coppices, the conversion to stable seedling forests, formed by a mixture of species, should be favoured. In case of extremely pure woods, shoots of broad-leaved trees should be ensured, even if they are in the underwood.

Seedling forests

- Favour mixed woods: as indicated concerning coppices, thinning should favour the increase of secondary species.
- Favour uneven aged woods: that is, measures aimed at increasing structural complexity, both with regard to groups and large areas of territory.
- Forest utilizations: utilizations in small areas are to be favoured (less than 5 hectares). In case of clear cutting, utilizations in areas smaller than 5 000 m^2 should be favoured.
- Abandoned woods: the improvement and care of Abandoned woods should be favoured. Conversion to coppices or seedling forest should be the choice.
- Plantations: Favour the increase of autochthonous species, through selection thinning, in order to get pre-regeneration groups or to favour their implantation.

3.3.5.3.2 Minor Works of Water Control in Watersheds

Minor, inexpensive, environmentally friendly works, which can be implemented by landowners and farmers, are next illustrated. These are building arrangements that are able to ensure an efficient protection aiming at improving soil regulating capacity both through the consolidation of the existing draining systems, and the use of more stable land utilization that can resist meteoric events.

The choice of the wood material used for their structure has to take into account criteria of durability and mechanical resistance. Larch is the specie which is most widely used in mountain area, whilst chestnut and Douglas fir are employed in warmer climates.

3.3.5.3.2.1 Check Dams

Cross works positioned in beds, play two main roles: mechanical role, i.e., they catch the most coarse part of the floated or suspended material; hydraulic role, i.e., they rectify the gradient of the course.

Timber Check Dams (Figure 3.3.5.3.2.1 a)

MATERIALS: boles, 15 - 20 cm in diameter, 4 m long. Nails, iron stirrups.

CARRYING OUT: mechanical or manual digging of the ditch, building of the frame, shaping of dapped boles and fixing by nails and stirrups.

USE: catchment areas and minor waterways, main drains of cross ditches, and all those places where mechanization is difficult, and the material is available on the spot.

MAINTENANCE: little; removal of the obstructing coarse material, if any; replacement of deteriorated boles.

NEGATIVE EFFECTS ON ENVIRONMENT: small, both because of the material used and for its size.

ECOLOGICAL ASPECTS: the very modest height of this handwork allows trout to ascend, but it raises an obstacle for the remaining ichtyic fauna.

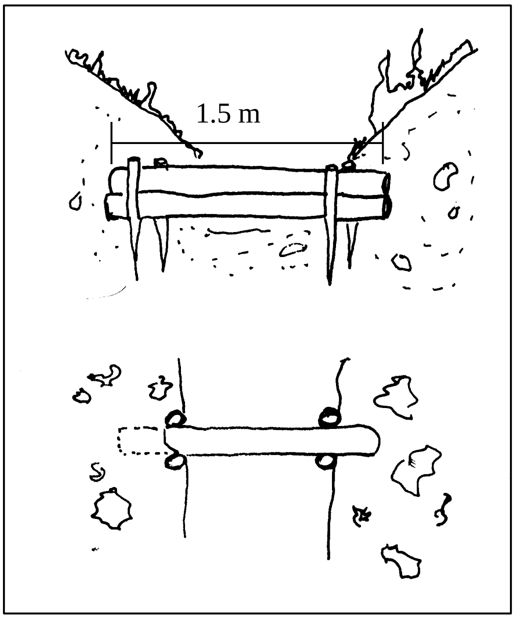


Figure 3.3.5.3.2.1 a – Scheme of a timber check dam

COSTS: the approximate costs concern a structure 1.5 m long, and include the carrying out of a timber check dam by using chestnut stakes,.8 to 10 cm in diameter, 70 cm long, 50 cm in girth, plunged in the ground. The costs include also digging by hand and fastening of the single pieces.

Overall cost for each work: 50 Euros.

Timber and Loose Stones Check Dams (Figure 3.3.5.3.2.1 b)

MATERIALS: chestnut or conifers boles, 15 - 25 cm in diameter, 3 m long; homogeneously sized loose stones, 20-30 cm in diameter for the quarry face, and variable size for the back-filling; miscellaneous nails.

CARRYING OUT: mechanical digging (by means of "spider" - type diggers), shaping of dapped boles and building of the frame, laying and fastening of the first layer of boles, back-filling with stone material and building of subsequent layers. Possible surrounding of the top by means of small-sized posts.

USE: mountain stretch of waterways or main drains placed in strong slopes, for conveying solid coarse material.

MAINTENANCE: little; removal of vegetable and stony material.

NEGATIVE EFFECTS ON ENVIRONMENT: in spite of their size, these works are carried out by using environmentally friendly materials, thus they easily match the environment.

ECOLOGICAL ASPECTS: timber and loose stone check dams raise an insurmountable obstacle for ichtyiofauna; in order to obviate that, a side slope allowing fishes to ascend might be built.

COST: 150 Euros/m^3 including the carrying out of a check and strengthening dam, made out of loose stones and chestnut boles, 15 to 25 cm in diameter, 1.5 to 3 m long, barked and superimposed one upon another both crosswise and lengthwise. They include also riveting by means of improved adhesion nails, 8 to 10 mm in diameter, metal stirrups, digging and back-filling, stones found on the spot and used for the stones in sight.

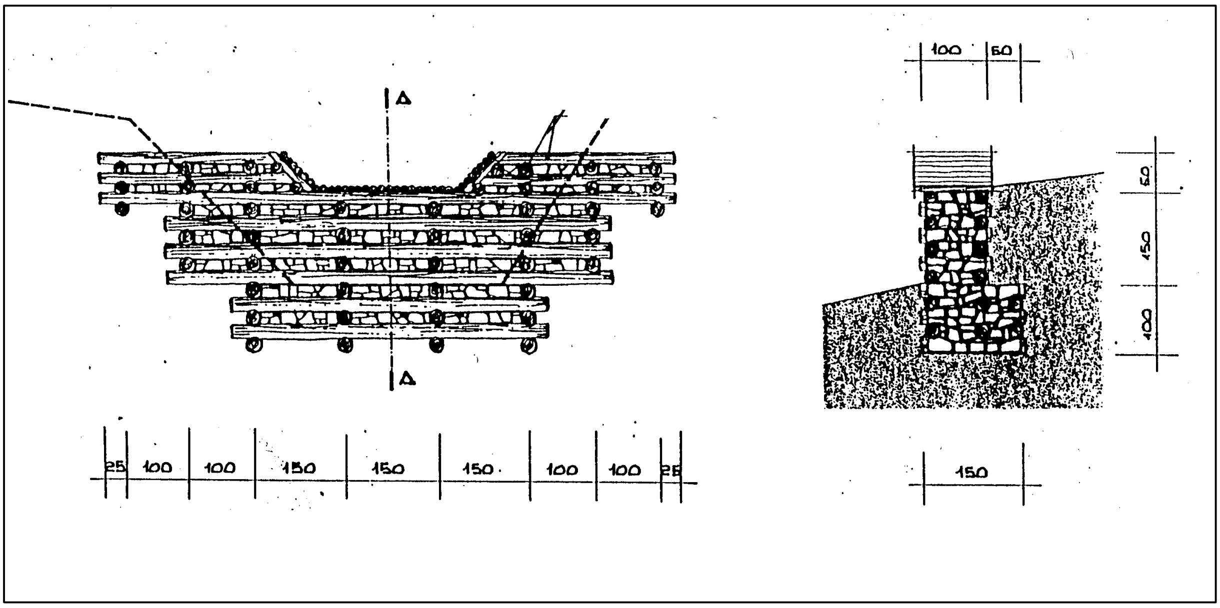


Figure 3.3.5.3.2.1 b – Scheme of a timber and loose stones check dam

Dry Check Dams (Figure 3.3.5.3.2.1 c)

MATERIALS: homogeneously-sized stones, 35 - 40 cm in diameter, to be found on the spot because of economical and landscape reasons.

CARRYING OUT: manual or mechanical digging; laying of the stones, staggered in such a way that the largest diagonal of the dam is parallel to the axis of the torrent.

USE: slightly sloping small catchment areas and drains, conveying small-sized solid material.

MAINTENANCE: little; removal of the obstructions, replacement of the missing stones.

NEGATIVE EFFECTS ON ENVIRONMENT: very few, because of the small size of the weir and the good mimicry of the local stones in the work.

ECOLOGICAL ASPECTS: possible obstacle for the ascension of fishes.

COST: 140 Euros/m^3 including the carrying out of a dry check dam, aiming at bed checking and strengthening, the digging and the back-filling, the building of the visible side by means of stones got on the spot.

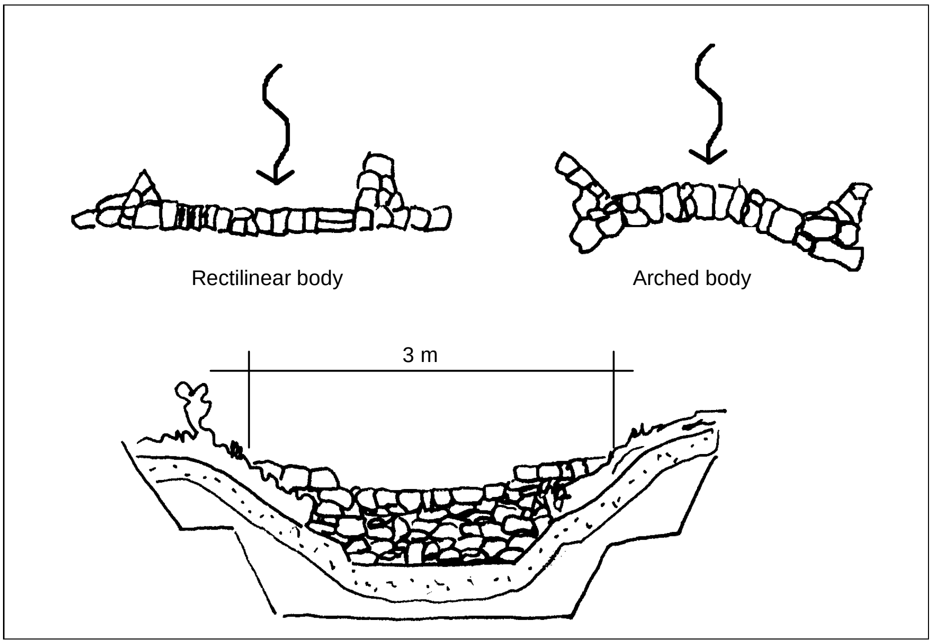


Figure 3.3.5.3.2.1 c – Scheme of a dry check dam

3.3.5.3.2.2 Drainage Ditches

Coating and canalization works, for protection of bank and bed erosion. These structures are used especially in cases of watercourses running in easily erodible and sloping substratum.

Timbered Ditches

MATERIALS: boles, 15 - 20 cm in diameter, > 2 m long, metal stirrups and nails.

CARRYING OUT: digging of the ditch, manually or mechanically; laying of the timber on the bottom and along the walls; every 2 m the timber will be fastened, by means of fasteners and nails, to chestnut boles which will be plunged in the ground at least 40 cm.

USE: coating of small-sized ditches, also sloping, built as a protection of main ditches and drains in a lower layer which can be easily eroded.

MAINTENANCE: little; removal, replacement and strengthening of disconnected timber.

NEGATIVE EFFECTS ON ENVIRONMENT: very few; the materials used and the size of the dams are considered to be environmentally friendly.

ECOLOGICAL ASPECTS: greater draining speed of surface waters.

COST: 30 Euros/m including the carrying out of a ditch made of chestnut boles, 15 to 18 cm in diameter, hand-made; the laying of the timber, placed along the oblique side of the ditch, fastened to the boles plunged in the ground by nails and stirrups.

Ditches Made out of Timber and Stones (Figure 3.3.5.3.2.2)

MATERIALS: boles, 15 - 20 cm in diameter, > 2 m long, chestnut boles, 15 cm in diameter and 1.50 m long, stones, metal stirrups and nails.

CARRYING OUT: digging of the ditch, trapezium-shaped, building of the bottom of the ditch by laying stones, building of the oblique walls by chestnut timber crosswise and placed lengthwise: every two meters the boles will be riveted to chestnut boles plunged in the ground following the inclined side of the ditch.

USE: main drains of surface and road ditches; conveying of water coming from landslides.

MAINTENANCE: removal of obstruction; check of disconnected or unriveted boles.

NEGATIVE EFFECTS ON ENVIRONMENT: none, this work is environmentally friendly. In the case of slight slopes and long periods of dryness, the oblique wall of the ditch can be carried out by mere revegetation.

ECOLOGICAL ASPECTS: this kind of work does not cause changes in the environment, although it makes the draining speed of water increase.

COST: 55 Euros/m including the carrying out of a ditch made out of timber and stones, trapezium-shaped (height, 60 cm, smaller base 60 cm, greater base 100 cm), frame made of chestnut boles, 12 to 16 cm in diameter; the bottom and the walls are coated with stones available on the spot and hand-laid. The boles are placed every 2 meters and plunged at least 40 cm into the ground, then they are riveted to the bottom by nails and stirrups.

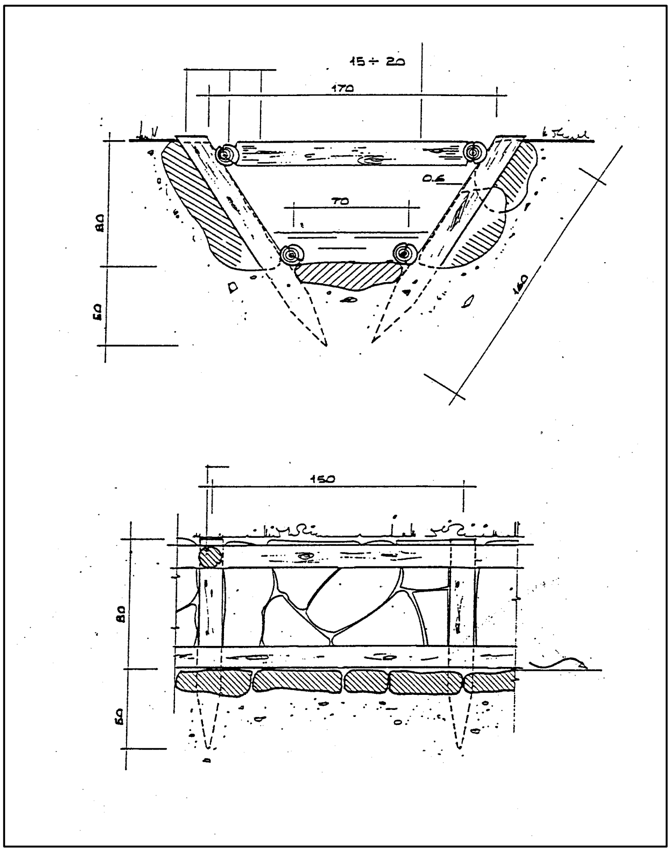


Figure 3.3.5.3.2.2 – Scheme of a ditches made out of timber and stones

3.3.5.3.2.3 Surface Drainage

Works aiming at improving surface water draining in slopes, where erosion due to runoff or to intrinsic water disarrangement makes it necessary to reduce the time of permanence of water, in order to lighten the slope. Usually, surface drainage is carried out by means of vegetable material (fascines), alive or dead, that form units 30 - 40 cm in diameter, which are placed in semicircular ditches dug along the maximum gradient. Another method which is included among drainages is the 'draining or filtering wedge', which is used to stabilize the basis of slopes and to enhance water draining.

Drainage by Fascines (Figure 3.3.5.3.2.3)

MATERIALS: cuttings or branchwood of willow-trees longer than 60 cm, 3-10 cm in diameter, iron wire.

CARRYING OUT: digging of the ditch: its width equal to one or more faggots, its slope 2%; preparation of the fascines, tied up every 30 cm, laying of the faggots: the ones placed on the bottom can consist of dead branches, while cuttings able to take root easily should be located on the top. Faggots are fixed to the ground by small living posts (5 - 10 cm in diameter, 60 cm long) about every meter, and covered with earth in order to enhance their taking.

If it is necessary to reach a greater depth in order to avoid surface stagnation of groundwater, digging should be deeper, and sufficiently filled with pebbles having decreasing granulometry, up to the level at which faggots can be placed.

USE: slopes where problems of water stagnation and surface erosion occur.

MAINTENANCE: this work needs periodical maintenance, which encourages the growth of plants from the faggots.

NEGATIVE EFFECTS ON ENVIRONMENT: negligible.

ECOLOGICAL ASPECTS: this kind of work has positive effects on the environment, as it favours growth of authoctonous vegetation.

COST: 20 Euros/m including willow-tree faggots, 2 to 5 cm in diameter, digging of the ditch, laying of the faggots and covering with wet ground.

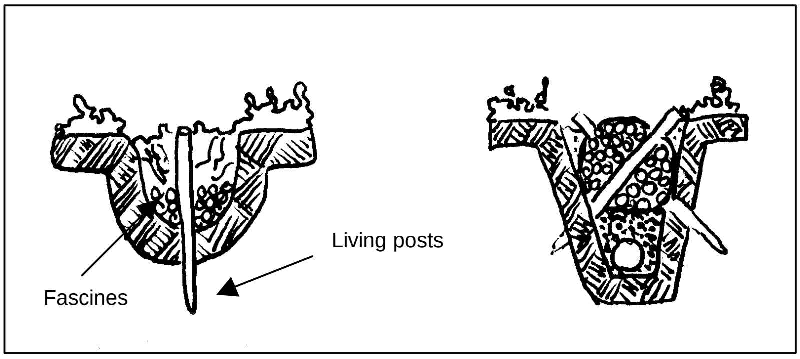


Figure 3.3.5.3.2.3 – Scheme of a drainage by fascines

Filtering Wedges

MATERIALS: coarse gravel, crushed stone, cuttings of willow-trees or of different species that easily take root, 5 - 8 cm in diameter and 1 m long.

CARRYING OUT: digging of the basis of the slope, shaping of the slope, filling with dry permeable material, placing of the cuttings (spacing of 70 cm), covering with back-filling.

USE: basis of slopes where runoff occurs.

MAINTENANCE: very little; check for rooting of the cuttings.

NEGATIVE EFFECTS ON ENVIRONMENT: totally negligible.

ECOLOGICAL ASPECTS: improvement of soil airing, solution to problems of root asphyxia.

COST: 90 Euros/m^3 including digging, filling with dry materials, laying of the cuttings and covering with back-filling.

3.3.5.3.2.4 Wattlings (Figure 3.3.5.3.2.4)

Arrangements of slopes to reduce surface erosion. The work consists of flexible pleached twigs and of cuttings of species which can take root. Wattlings are fastened to the ground by means of cuttings, plunged in the ground (2/3 of their length) and placed 0.5 - 1.0 m apart. Wattlings constitute horizontal alignments on the slope.

MATERIALS: twigs of willow-tree or of different flexible species, 3 – 5 cm in diameter, preferably longer than 3 m; cuttings 5 - 8 cm in diameter.

CARRYING OUT: placing of cuttings at 50-100 cm; the main cuttings are linked each other by pleaching 3-8 branches of willow-tree placed lengthside, fastened with galvanized iron wire; the wattling-end is covered with earth. The height of the cuttings is more than 30 cm, so that the cuttings can easily be planted and then take root, and physical stabilization of the ground is quickly attained. Spacing ranges from.1.2 to 2.0 m.

USE: eroded slopes, reclamation of small landslides and landslides. This work should be carried out where it is necessary to raise an obstacle to water, so that vegetation can grow again.

MAINTENANCE: wattlings do not last a long time, but they do not need any maintenance. If the work is duly made, when wattlings start deteriorating, vegetation is expected to be well grown and efficient.

NEGATIVE EFFECTS ON EVIRONMENT: wattlings are generally regarded as environmentally friendly.

ECOLOGICAL ASPECTS: the restoration of vegetable coverage – even if made out of non totally autochtonal species – should always be considered to be an improvement.

COST: 20 Euros/m including wattlings made out of pleached twigs of willow-tree, minimum 120 cm long, or of some other flexible material, which takes root easily, available on the spot and fastened to the ground by stakes 1 m long, 5 to 10 cm in diameter, planted about every 1 meter. The branches are pleached and fastened with galvanized iron wire.

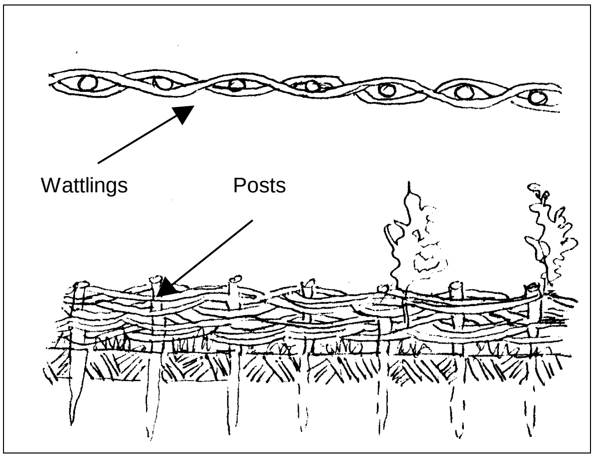


Figure 3.3.5.3.2.4 – Scheme of wattling

3.3.5.3.2.5 Bench-terraces (Figure 3.3.5.3.2.5)

Slope strengthening, i.e., carrying out of temporary bench-terraces built on slight counterslope: a bed made of earth and branchwood is prepared as the basis for willow-tree cuttings, which will subsequently be covered with the back-filling coming from the following terrace. This kind of arrangement plays a role of support and of drainage through the shaping of the slope and the strengthening from the roots.

MATERIALS: boles, 6 - 12 cm in diameter and more than 2 m long; cuttings of willow-tree, 3 - 10 cm in diameter and more than 60 cm long; conifer branchwood.

CARRYING OUT: digging of a horizontal bench, the depth of which varies according to the slope gradient, from a minimum of 35 cm to a maximum of 150 cm, where the minimum spacing between terraces is 2 m, and there is a counterslope upstream of 10%; laying of chestnut boles into the ditch, preparation of conifer bed and covering through a layer of ground of 10 cm, in which willow-tree cuttings are placed. These cuttings must be longer than the depth of the digging, so that they stick out at least 10 cm. Cuttings density ranges from 10 to 25 per meter; terraces are covered with the back-filling coming from the upper terrace.

USE: slopes where numerous landslides occur; soils with water stagnation.

MAINTENANCE: little; check of the growth of cuttings.

NEGATIVE EFFECTS ON THE ENVIRONMENT: as bench-terraces match the environment and are environmentally friendly.

ECOLOGICAL ASPECTS: the stabilization of small landslides allows rapid revegetation and the restoration of balance conditions.

COST: 30 Euros/m. It is rather high because of the labour needed. The work is carried out by digging the bench-terrace, then laying the boles; a bed of conifer branches is prepared, finally the terrace is covered with back-filling.

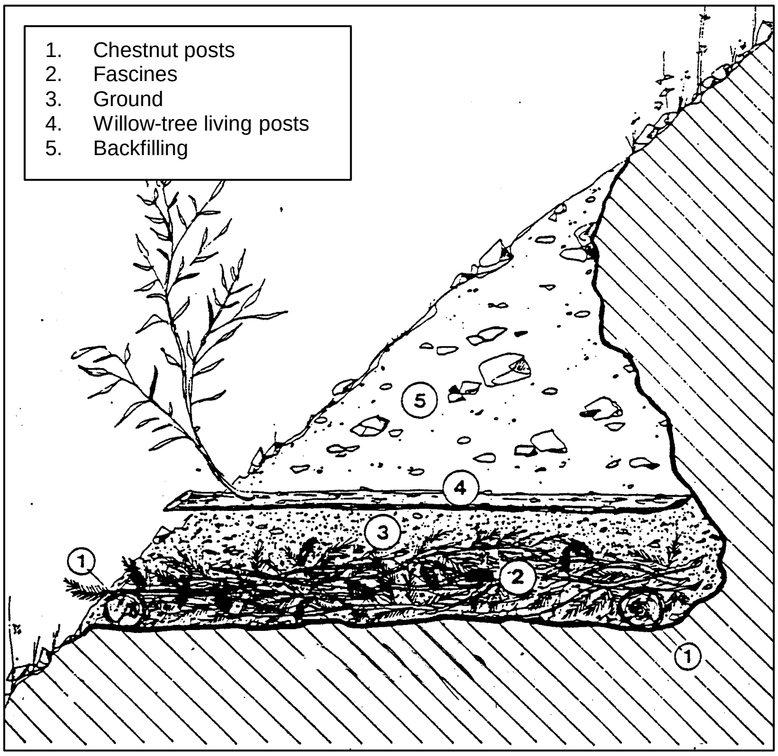


Figure 3.3.5.3.2.5 – Scheme of a bench-terraces

3.3.5.3.2.6 Stone Retaining Wall (Figure 3.3.5.3.2.6)

This is the pre-eminent handwork carried out to strengthen small-sized slopes; for many years it has been the basis of agricultural and forest arrangements, especially in rural areas where ground was sloping and the material was easily available, and where even a small conquest of arable soil was most valuable. This system is used in the following soil arrangements:

- contour plowing, executed in order to turn the surface along the contours of a slope, ranging from 25 to 50%, into horizontal embankments;
- terracing: small embankments based on a discontinuous dry-stone wall, the height of which varies according to the slope;
- terracing in forest rocky lands, where moon-shaped terraces sustain the weight of the soil at the basis of the single trees, avoiding that erosion bares their roots.

MATERIALS: stones.

CARRYING OUT: digging, laying of the stones available on the spot or deriving from the soil breaking, so that to carry out a vertical facing upstream, and an oblique facing downstream. The thickness at the top ranges from 50 to 80 cm., while the maximum height of the wall is 2 meters.

USE: all the times that it is necessary to strengthen small-sized slopes, or to change the gradient of slopes (terracing).

MAINTENANCE: this work needs steady maintenance, in order to replace the stones which might have collapsed and to remove vegetation, which might affect its stability.

NEGATIVE EFFECTS ON ENVIRONMENT: this kind of work is always visible, though it is small-sized, but as it is part of the historical landscape of rural environment, and since it is made out of natural materials, it can be regarded as environmentally friendly.

ECOLOGICAL ASPECTS: there are no important aspects to be stressed, besides the aesthetical ones already mentioned.

COST: 80 Euros/m^3 including the building of a retaining wall made out of stones of different sizes (preferably 30/40 cm), the digging and the laying of the stones, slightly countersloping upstream. Any other cost which is deemed as necessary to carry out this work duly is included.

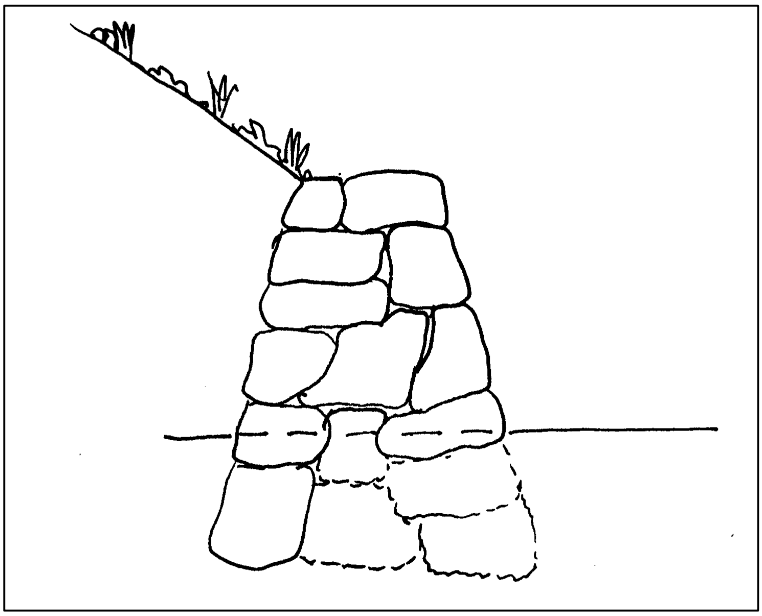


Figure 3.3.5.3.2.6 – Scheme of a stone retaining wall

3.3.5.3.2.7 Revegetation

This surface system aims at attaining durable and steady soil protection; thanks to it, sudden moisture variations are prevented, and vegetation development is enhanced. Moreover, revegetation plays an important aesthetical role in the arrangement of landslides or in case of highly eroded soils. There are many methods of revegetation: water-seeding, revegetation through turfs, broadcast sowing with chaff, laying of grass coverage. The following description will concern revegetation performed by means of water-seeding, which at the moment is the most diffused and the less expensive method, unless physical and chemical conditions require different specific methods. This system allows to completely revegetate bare soils, which are devoid of organic coverage.

Water-Seeding

MATERIALS: mixture constituted by water, seeds (10 – 150 gr/m^2), organic fertilizer (50 - 150 gr/m^2), ligands, soil ameliorating substances such as peat, clay and sand, and phyto-regulators to enhance root and microflora development.

CARRYING OUT: preparation of the seedbed, removal of stones, if necessary, spreading of the mixture by means of tankers equipped with motor pumps.

USE: coverage of bare areas, such as landslides, landslips, riversides, road escarpments, areas affected by excavation.

MAINTENANCE: mowing of the lawn-grass, additional seeding in case of poor taking-root or of thinning out of the lawn-grass; irrigation, if necessary, during germination and growth, in particular climates.

NEGATIVE EFFECTS ON ENVIRONMENT: this system fights the negative effects of erosion, and should be undoubtedly regarded as environmentally friendly.

ECOLOGICAL ASPECTS: improvement of the drainage condition of the soil, enrichment of organic matter, quick coverage and strengthening of the area.

COST: 2.5 Euros/m^2 including revegetation both on level and sloping areas by the method of water-seeding: i.e., spreading of a mixture of water, seeds, organic fertilizer, ligands and soil conditioners, by means of high-pressure sprinkling machines, called water-seeders. The preparation of the seedbed is not included.

3.3.5.3.2.8 Road system

Small arrangements, carried out to regulate water in rides and agricultural/forest paths, are described next. These are elements which should be taken into consideration because they are essential to carry out and to maintain effective road systems.

Channels

Side channels are built to canalize the water draining from the road. They can be built using different materials. They are executed along the road sides; the side downstream conveys the water coming from cross gutters.

CARRYING OUT: digging of side channels along the roadway, slightly counter-sloping upstream, possible coating with prefabricated plain concrete or with stones.

Cross Gutters (Figure 3.3.5.3.2.8)

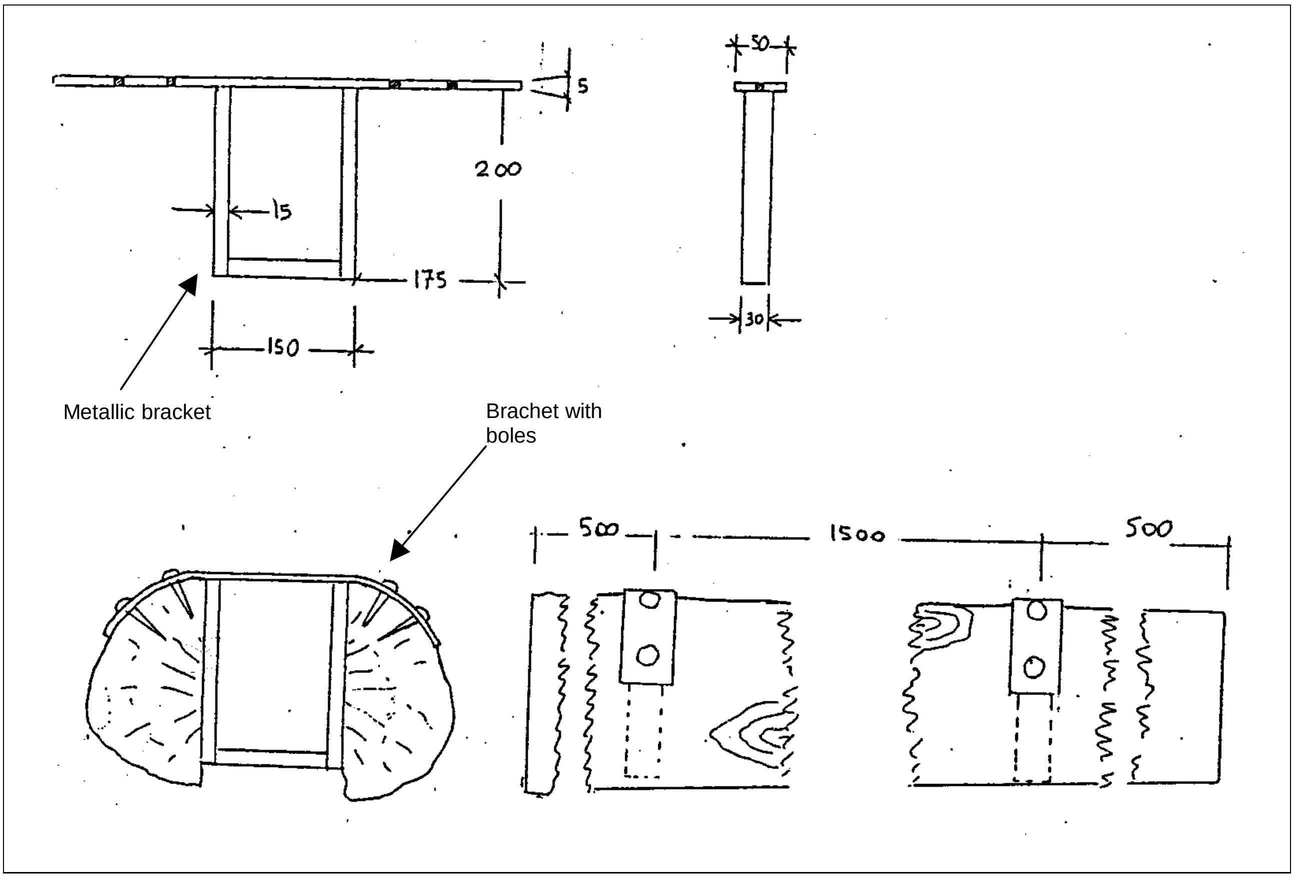
Gutters crossing the roadway, built to keep surface water away from the roadway itself, placed at variable distance and following the slope. They can be simple ditches of earth, or be timbered; their duration is quite long, even with little maintenance.

MATERIALS: chestnut or conifer boles (Douglas fir, silver fir), 25 - 30 cm in diameter, 4 m long, metal stirrups, nails.

CARRYING OUT: digging of the gutters, cutting of boles into halves, fastening of stirrups (three for each gutter), placing and fixing. Road drain wells have to be added to cross gutters and channels, in order to convoy water in natural valleys or to cross the roadway; in such cases, the road drain well upstream is linked to the one downstream by means of prefabricated concrete pipes of variable diameters.

MATERIALS: prefabricated road drain wells, 40x40x60 cm, prefabricated concrete pipes of variable diameter, 1 m long.

CARRYING OUT: digging of ditches for the road drain wells, upstream and downstream the roadway, digging of the road-bed (in case of crossing), laying and linking of the elements.



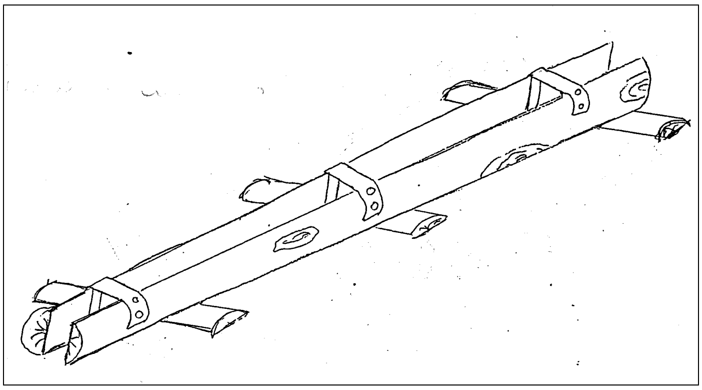


Figure 3.3.5.3.2.8 – Scheme of a cross gutter

4 PROJECT MANAGEMENT

4.1 CRITERIA FOR THE CHOICE OF INTERVENTIONS

The final step of this monograph, which has analysed the management of hydraulic problems in small-medium size basins prone to flash floods, corresponds to a proposal of some logical schemes in order to identify, among a number of possible solutions (both structural and non-structural), the most suitable solution/s for elimination or mitigation of inefficiencies of the hydrographic system responsible for the formation or amplification of the hydraulic risk conditions.

The choice of the best interventions follows a detailed study of the hydrographic basin for identification of the general aspects of the basin and of the main and additional causes of the hydraulic risk conditions.

On the basis of the indications highlighted during the development of Project PREMO'98 and the experience of each partner, the occurrence of flash alluvial events may be connected with the following general conditions:

- Extreme precipitation consequences;
- Strong aggradation, degradation phenomena and mass transport;
- Flood events and urbanistic interference.

Within these general basin conditions, the hydraulic risk may be linked to different aspects of a basin (e.g., typology of hydrographic network, land use, location of the human settlements, hydraulic structures) related to the formation, propagation and management of floods.

The best solutions for improvement of the hydraulic safety of the basin, that is, the identification of the best interventions, is the conclusive task that operators have to accomplish. The proposed schemes permit to articulate the choice of interventions on the basis of one or more factors that are responsible for the formation of alluvial events in relation to the peculiar aspects of each basin.

The proposed schemes consider both structural and non-structural interventions identifying the coupled application of both interventions, as best fits the correct management of the hydraulic risk conditions.

On the basis of the experiences matured in the development of the project, the application of structural interventions (hydraulic works) represents a solution that has to be evaluated in-depth, also concerning costs both for their construction and for their future maintenance, especially where the basin characteristics consent different solution typologies.

Another aspect of structural interventions refers to works that aim to modify the hydraulic characteristics of the basin (hydraulic-forestry and agricultural interventions). Though their result is surely positive, their overall application requires longer periods and the quantification of their effectiveness is hard to compute.

For prevention and protection of people from flood risks, particular attention should be paid to the identification and application of non-structural interventions concerning both the correct management of emergencies during the alluvial events and the global management of the whole basin (legislative bonds).

Finally, the application of the options that have been highlighted in the proposed schemes requires the carrying out of an ex-post evaluation in order to test the effectiveness of the applied interventions.

EXTREME PRECIPITATION CONSEQUENCES

Causes	**Aggravations**
Local precipitation **General wave front**	**Torrent stretches crossing urbanized areas (reduction of flow section, covering of the torrent bed)** **Inefficiency of hydrographic network (insufficient natural sections, no bank protections, etc.)** **Unfavorable morphometric conditions (excessive gradients, short delay times, etc.)**

INTERVENTIONS

STRUCTURAL INTERVENTIONS

Flood water retaining works	Controlled flooding areas Retention basins Natural flooding areas Pools for waste water retention Etc.
Remodeling and clearing of hydraulic cross-section	
Bank protection works	
Hydraulic-forestal and hydraulic-agricultural works to increase retention and to slowing down meteoric water flow into the stream	Check dams Sills Small draining ditches Etc.
Correction works on stream longitudinal profiles	Check dams Sills Etc.
Hydraulic-forestal interventions for slowing down meteoric water flow on basin slopes	Terracing Draining ditches Small channels Hydraulic interventions on forest roads Etc.

NON STRUCTURAL INTERVENTIONS

Adjustment of town planning tools to the highlighted hydraulic risk conditions	
Individuation of obligations and land securing of eligible areas for interventions of protection	
Obligation of fluvial pertinence areas	
Management of emergency phases following alluvial event	Local civil protection plans Civil protection measures Etc.
Insurance	
Tele-alarm	
Systems and procedures for alerting people living near the river	Precipitation-survey network Meteorological data processing and checking Quick alerting systems Etc.

STRONG AGGRADATION, DEGRADATION PHENOMENA AND MASS TRANSPORT

Causes

Presence of upstream erosive phenomena (basin scale)
Incorrect land-use management in hilly and plain areas (agricultural and natural areas)
Incorrect management of land use in mountainous areas (woods, pastures)

INTERVENTIONS

STRUCTURAL INTERVENTIONS

Intervention	Measures
Correction works of stream longitudinal profiles in order to limit stream erosive power	Check dams Sills Bed lining and bank protection Etc.
Vegetal covering works in extensive erosion areas	Re-vegetation interventions Rush matting Bio-mats Etc.
Rearrangement interventions in localized erosion areas	Terracing Draining ditches Small channels Rush matting Bio-mats Etc.
Reduction of solid transport	Traps Screen dams Sedimentation pool Silting up
Correct management of hilly areas	Rational management of soil vegetal cover Carrying out and maintenance of agricultural interventions Carrying out and maintenance of draining ditches Etc.
Correct management of wooded areas	Re-vegetation Rational wood-cutting Rational use of pasture Etc.
Hydraulic-agricultural structures to increase retention and to slow down meteoric water flow into the stream	Check dams Sills Draining ditches Surface water draining systems Etc.

NON STRUCTURAL INTERVENTIONS

Intervention	Measures
Prescriptions concerning measures in agriculture and forestry aiming to prevent the formation of erosion areas	
Systems and procedures for monitoring potential and active erosive phenomena	Precipitation survey network Solid discharge gauging stations Field survey of potential or actual erosional areas Etc.
Prescriptions for cultivation and irrigation activities	
Plans for the correct management of cultivated areas	
Prescriptions for forest and grazing activities	
Plans for the correct management of forest and grazing areas	
Management of emergency phases following the formation of gravity mass transport	Local civil protection plans Civil protection measures Etc.
Insurance	
Tele-alarm	

FLOOD EVENTS AND URBANISTIC INTERFERENCE

<u>**Causes**</u>

Torrent stretches constrained in urbanized areas (occupation of torrent pertinence areas)
Incorrect global water management during flood events (management of artificial basins)
Excessive urbanistic pressure (surface impermeabilization, covering of natural torrent, etc.)

INTERVENTIONS

STRUCTURAL INTERVENTIONS

Correct management of flood water retaining works	Controlled flooding areas Retention basins Natural flooding areas Pools for waste water retention Etc.
Management of drained meteoric water in impermeabilized urban areas	Pools for retention of drained waters in impermeabilized areas Etc.
Adjusting of hydraulic sections with correction structures of stream longitudinal and transversal profiles	Remodeling, clearing and enlargement Channel lining Bank protections Sills Etc.

NON-STRUCTURAL INTERVENTIONS

Preparation of coordinated management plans of the reservoirs and retention facilities along the stream systems and procedures for monitoring critical meteoric phenomena and flood waves	Meteorological forecast network Precipitation-survey network Gauging stations network Etc.
Emergency phase management following the formation of gravity mass-transport	Local civil protection plans Civil protection measures Etc.
Adjustment of town planning tools to the highlighted hydraulic risk conditions	
Individuation of obligations and land securing of eligible areas for interventions of protection	
Alerting and monitoring systems for extreme floods	Precipitation-survey network Gauging stations Etc
Insurance	
Tele-alarm	

4.2 PROJECT MANAGEMENT IN STYRIA

Guidelines for the granting of subsidies:

The fundamental principles determining the granting of a state subsidy are contained in the Act on Hydraulic Engineering Works of 1985. One of the main objectives of this Act, which intends to favour a balanced hydrologic budget, is protection against damage caused by water, avalanches, mudslides and landslides.

In the Directives for the Federal Hydraulic Engineering Board, the goals and operational framework for protective hydraulic engineering intervention are set in consideration of both social requirements and the need to protect forms of life and economically relevant premises. Particular importance is attributed to the securing of retention and flood discharge areas along water courses. At the same time, protection of water courses and protection from them have to be harmonized and enacted by a modern protective hydraulic engineering branch.

Catalogue of "nature-friendly hydraulic engineering" measures:

In 1982, the Catalogue of "nature-friendly hydraulic engineering" measures triggered a far-reaching revision process of river control practices in Styria. At that time, besides the introduction of organizational improvements, recent environmental findings and new principles of nature and landscape protection were integrated in river control projects. When the Catalogue started to be implemented, a series of new experiences was made in the legal, technical and organizational fields, calling for a revision of the Catalogue of measures in 1986.

Procedural Steps (Figure 4.2):

Interest is expressed by a subject:

Subjects can express their interest at the implementation of protective hydraulic engineering measures by addressing a written request to the relevant authority. Beneficiaries of subsidies can be people living along the water course, communes representing the people living along the water course, water associations and co-operatives.

Pre-planning phase:

In the pre-planning phase, the person responsible for drawing up the project is chosen, planning costs are calculated, financial means are secured and timetable and agenda are laid down.

Basic water management evaluation:

Basic water management evaluation is based on technical material and data gathered to favour more effective water provision and on the description of the interrelationship between hydraulic factors, situations and their effects on public health, national economy, regional planning and environmental protection. These phenomena are considered globally, as a chain of events, and are then examined in their local occurrence, with respect to specific basins, and from a technical point of view, i.e., protective water management, water reserves and water quality.

General project:

A general project is possibly drawn up before the detailed project. It is a draft project roughly outlining how a certain measure is to be implemented and consisting in descriptions, comparisons between alternatives, sketches, drawings and calculations on the basis of available water management data.

Detailed Project:

A detailed project is drawn up before implementation. It accurately illustrates the planned measures that are now ready to be implemented through descriptions, plans, calculations and other material.

Implementation:

Protective hydraulic engineering measures can be carried out either directly by the federal authorities or by private enterprises.

Approval Procedure:

Technical and Financial Approval of the Project:

After receiving the seal of endorsement by the relevant regional authorities, the project is submitted to the Federal Ministry of Agriculture and Forests for technical and financial approval. The seal of endorsement is the proof that the project has been technically and scientifically verified according to present technical standards and that it is in line with the provisions of the Directives for the Federal Hydraulic Engineering Board.

Technical and Financial Approval of the Measure:

Financial approval of the measure means acknowledgement of the necessity of the measure and granting of federal subsidies or support. It is, therefore, a prerequisite for the allocation of federal means up to a fixed amount. A prerequisite to the financial approval is that both the regional and the applicants’ share of the financial burden have been secured.

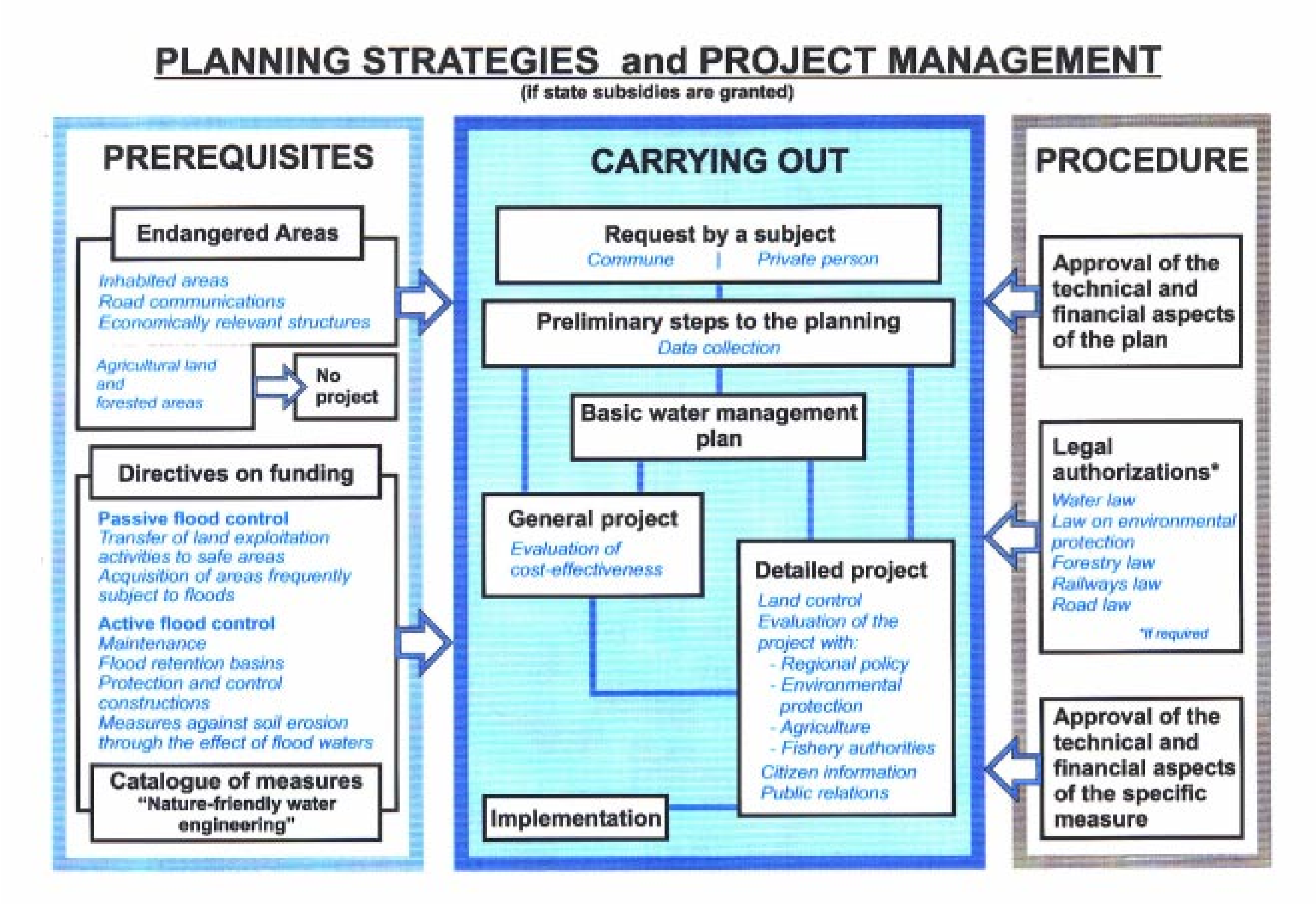


Figure 4.2 – Project management in Styria

5 MONITORING AND EX-POST EVALUATION

A comprehensive or targeted monitoring program should be required of major projects, plans or programs, and the resultant information should be used in ex-post evaluation. "Comprehensive monitoring" could include elements related to environmental media (air, surface- and/or ground-water, soil), biological features (plants, animals, habitats), visual resources, social impacts, and human health. Pertinent elements should be selected based on the project type, baseline environmental sensitivity, expected impacts, and monitoring objectives.

Ex-post evaluation or post-project analysis refers to environmental studies undertaken during the implementation phase (prior to construction, during construction or operation, and at the time of abandonment) of a given activity after the decision to proceed has been made (ECE 1990). Such studies can include comprehensive or targeted monitoring, evaluation of the collected data and information, decision making, as appropriate, and implementation of the management decisions.

Examples of responsible project-, plan-, or program-management decisions which can be based on monitoring data, and which can be beneficial in terms of minimizing adverse impacts and enhancing environmental management include: changing surface-water reservoir levels and water-release patterns to optimize dissolved-oxygen concentrations in the water phase during various seasons. Floral- and/or faunal-species-monitoring data can be used in environmental management: (1) to establish a basis for the sustainable use of populations, (2) to minimize the detrimental environmental impacts, and (3) to provide data which can be used as a scientific basis for conservation.

In U.S., two basic types of monitoring are defined as follows (US Department of the Army, 1988): 1) Enforcement Monitoring, which ensures that mitigation is being performed as described in the project document; 2) Effectiveness Monitoring, which measures (quantitatively) the success of the mitigation effort and effects.

Sadler and Davies (1988) have delineated three types of monitoring: 1) Baseline monitoring, which determines existing conditions, ranges of variation, and processes of change; 2) Effects or impact monitoring, which determines the changes that may have occurred as a result of the project; 3) Compliance monitoring, which ensure that conditions are observed and standards are met. Ex-post evaluation includes the last two.

Monitoring can be useful in distinguishing between natural change and those changes caused directly or indirectly by the project. Monitoring can also serve as a basic component of a periodic regulatory auditing program for a project (Allison 1988). In this context, "auditing" can be defined as a systematic, documented, periodic, and objective review, conducted by regulated entities, of facility operations and practices related to meeting environmental requirements (U.S. EPA 1986).

Regarding methodology for ex-post evaluation of non-structural interventions, two approaches are possible and suitable. On one hand, a "top-down" procedure, based on the observation/follow-up of the recommendations and proposals set before, usually/normally by the State. On the other hand, a "bottom-up" mode, based on observation on how local authorities integrated those recommendations in their own regulations and ordinances and how well those non-structural actions were effective in the prevention of floods. Any methodology should include both types of approach.

Special attention is due to the changes in land use within the water basin and in the way the zoning and restrictions were effective during the more recent floods. One of the critical aspects to be considered is the evolution of the urban land and corresponding changes in soil permeability and water quality, using aerial photos and photo-interpretation to scales up to 1:2000. Another useful information can be measured by the evolution of the local population and real estate (number of buildings).

Concluding, local authorities do not have a long tradition in long-term preventive actions since they are faced, everyday, with the necessity for short-term interventions. When the urban demand is high, the price for land goes up very quickly and the corresponding pressures at the decision-maker level represent a distorting factor with this respect. The public and the responsible institutions are generally not well informed.

GLOSSARY

English	German	Italian	Portuguese
Lateral Retention Basins	Künstliche Uberflestungsflächen	Casse di Espansione	
Basin Plan	Plan des Einzugsgebietes	Piano di Bacino	Plano de Bacia Hidrografica
Bench-terraces – Layer of Willow Cuttings	Weideneinlage	Cordonate	Socalcos, Degraus
Bio-Engineering	Ingenieurbiologie	Ingegneria Naturalistica	Engenharia Biofisica
Bottom outlet	Grundablass	Uscita di Fondo	Descarregador de Fundo
Catchment, Basin, Watershed	Einzugsgebiet	Bacino Idrografico	Bacia Hidrografica
Check Dam with a Fixed Outlet	Sperrenbauwerk mit fixiertem Ablaufquerschnitt	Briglia a Bocca Tarata	Barragem com Descarregador de Fundo Fixo
Deep flow – Subsurface Flow	Unterirdischer Abfluss	Deflusso sotterraneo	Escoagmento Subterrâneo
Delay Time, Concentration Time	Verzögerungszeit, Anlaufzeit	Tempo di Corrivazione, Tempo di Concentrazione	Tempo de Concentraçao
Ditches made out of Timber and Stones	Grabenverban aus Holz und Steinen	Canalette in legname e pietrame	Canais de Madeira e Pedra
Discharge (Maximum)	Abfluß, max Abfluß	Portata (massima)	Caudal (maximo)
Drainage by fascines	Faschinendrain	Drenaggio con fascine	Faxinagem
Filtering wedges	Filterkeil	Cunei filtranti	Cunha Filtrante
Flood	Hochwasser	Alluvione	Cheia
Food event	Hochwasserereignis	Evento di Piena	Cheia
Hydraulic-Forestal Intervention	Hydraulisch Wirksamer Forstlicher Eingriff	Interventi Idraulico-Forestali	Intervenção Hidraulico-Florestal
Hydraulic Risk	Hydraulisches Risiko	Rischio Idraulico	Risco Hidraulico

Hydrogeological and Hydraulic Rearrangement	Hydrogeologische und Hydraulische Neuordnung	Sistemazioni Idrogeologiche ed Idrauliche	Sistematizaçao Hidrogeologica
Natural Floodplain Areas	Natürliche Überflutungs Flächen	Aree Naturali di Esondazione, Aree di Pertinenza Fluviale	Leito de Cheia
Rainfall Intensity	Niederschlagsintensität	Intensità di Pioggia	Intensidade de Precipitaçao
Retention Basin	Rückhaltebecken	Bacino di Trattenuta delle Acque di Piena	Bacia de Retençao
Return Time	Wiederkehrzeit	Tempo di Ritorno	Periodo de Retorno
Regulating effect	Regulierunswirkung	Effetto Regimante	Efeito Regulador
Revegetation	Berasung (Begrünung)	Inerbimento	Revegetação
Runoff	Abfluss	Deflusso	Escoamento Superficial
Solid Transport	Feststofftransport	Trasporto Solido	Transporte Solido
Spillway	Hochwasserentlastung	Sfioratore (Troppo-pieno)	Descarregador de Cheias
Timbered ditches	Grabenverbau in Holz	Canalette in legname	Canais de Madeira
Water-seeding	Hydrosaat	Idrosemina	Hidro-Sementeira
Wattlings	Flechwerk	Graticciate	Entrelaçado

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