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THE USE OF INDEXES OF *RIPARIAN VEGETATION STATUS* AND *RIVER ECOLOGICAL FUNCTIONALITY* TO SUPPORT THE DORA BALTEA RIVER MANAGEMENT IN AOSTA VALLEY (ITALY)

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THE USE OF INDEXES OF *RIPARIAN VEGETATION STATUS* AND *RIVER ECOLOGICAL FUNCTIONALITY* TO SUPPORT THE DORA BALTEA RIVER MANAGEMENT IN AOSTA VALLEY (ITALY)

1. INTRODUCTION

1.1 Riparian Vegetation

The riparian *zone* is the place where aquatic systems merge with the terrestrial environments. Only since the beginning of the Eighties some studies have really begun to reveal the intimate relationship between aquatic systems and the riparian zone (Bunn 1993).

Riparian vegetation is composed by those formations growing along and in the proximity of a river. The establishment and growth of this vegetation is largely controlled by the hydro-geomorphic processes of the rivers, determining under natural conditions a typical belt progression from herbaceous (on river banks) to woody species, controlled by water regimes and sediment-transport dynamics (not by climate).
The riparian broadleaf forest is mainly constituted by softwood trees, with trees growing above the mean summer flow regime and, especially along rivers flowing in the plains, by hardwood trees, with trees growing in the floodplain above the maximum summer flow regime area and fed by the water table during the dry season (Mayer, 1974). However, the natural formations of riparian vegetation are often replaced by non-riparian species because of human intervention.

The riparian vegetation dynamics inside the river channel is mainly controlled by two factors: the dynamics of the vegetation itself and the dynamics of the fluvial ecosystem. So, riparian communities are the result of an intense interaction between biotic and abiotic factors over time and across space. Riparian vegetation grows in particular under several limiting factors strongly related to the river characteristics.

Most important fluvial limiting factors are linked to the stream power, which defines the vegetation belt boundaries all across the river. Other limiting factors usually act locally and are referred to riverbed particle size, nutrient availability, radiation, water temperature, debris. Edaphic factors (e.g. water nutrients) are very important for riparian vegetation development, influencing belt boundaries definition along the river. Riparian vegetation is characterized by several specific adaptations such as the morphologic adaptations that allow the plants to grow over unstable debris and in hydrological saturated soils. These strategies let the vegetation resist to mechanical disturbance such as fractures and burial**.** Within the morphological adaptations *aeriferus parenchyma* are the most widespread, compared to secondary roots, shaft and roots flexibility, seed characteristics, hydrodynamic leafs. Physiological adaptations especially give resistance to root anoxia to the plants. Main physiological adaptations can be mainly referred to the control of the alcoholic fermentation, to oxygen transport efficiency, to leaf permeability, *pneumatofora.* Instead, reproductive adaptations assure the reproductive success despite the difficult environmental conditions of the river: the main reproductive adaptations are asexual reproduction, different seed dispersion types and dimensions, seed dormancy periods, seed longevity, high seed production etc. All these adaptations let some species colonize the hostile river environments: woody species can grow on dead wood, pioneer species can grow in bare soils, hydrophytes can colonize water-saturated spots, seeds and vegetative fragments can survive inside the gravel; many other species have developed a mechanical resistance for surviving in the riverbed.

In general, river habitat present rather difficult conditions for vegetation growth and often the colonization process starts from *safe sites*, e.g. portions of the riverbanks where germination is optimal, the fluvial dynamics fits with the plant development cycle, and animal disturbance is low or absent.

Riparian species act several survival strategies which can be grouped as follows:

- invader species able to produce enormous amounts of seeds, dispersed following wind and water stream dynamics;
- endurer species sprouting easily even if them are silted-up or fragmented;
- species tolerant to the stream power for weeks via a flexible structure properties.

Rivers can be considered complex multi dynamic systems: the most common colonization model of the river banks is the lateral-transversal one. In this model, corridor species grow in parallel belts along the river. Different plant communities take place in different water channels located following river morphology, stream power and fluvial dynamics. The adaptation capabilities of species define several levels of ecological spatial overlapping, following local gradients of the river morphology. The main vegetation zonation patterns for fluvial ecosystems are sketched below [figure n. 1].

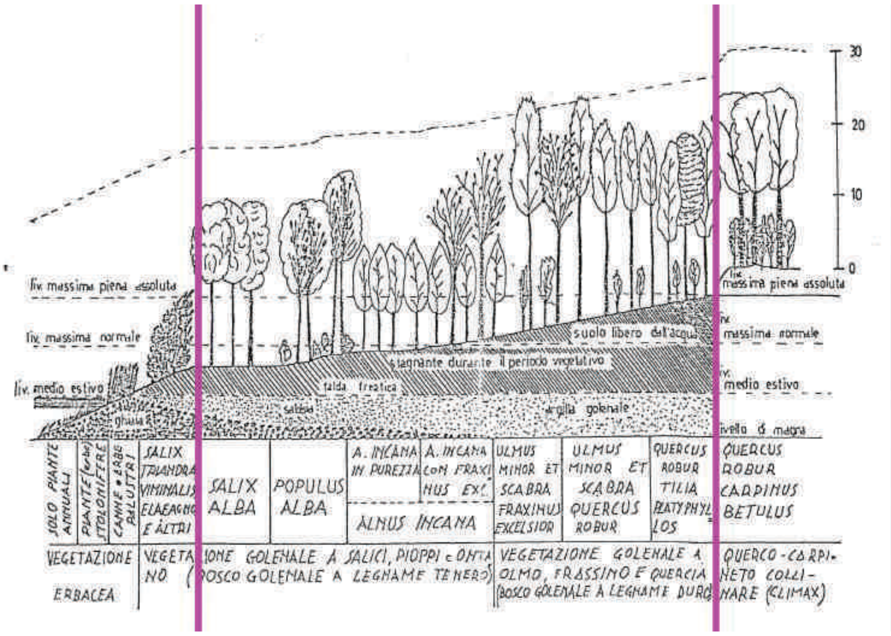

Figure 1 *Species in the vegetation zonation pattern for fluvial ecosystems [taken and modified from Minciardi (2009)].*

Following the lateral/transversal settlement model we can distinguish different riparian plant species types:

- Hydrophytes: plants that grow completely submerged or on the water surface. (Submerged: *Chara, Fontinalis, Ceratophyllum*. Rooted floating: *Nuphar, Potamogeton, Ranunculus*. Non rooted-floating: *Lemna, Trapa)*;
- Anphyphytes: hydrophytes that can survive also in substrates above water level. (*Sagittaria, Alisma)*;
- Helophytes: plants with roots in the water but with their main parts above the river level. *(Phragmites, Carex, Cyperus, Scirpus, Juncvus, Iris,Typha)*. Helophytes can be distinguished into 2 sub-classes:
  -Geophytes: perennial grass with bulbs, tubers or root stocks as subsoil buds carried by special adaptations.
  -Hemy-cryptophytes: high perennial grass with buds on the soil level, covered with leafs.
- Terophytes: seasonal grass, with bulbs, tubers or root stocks as subsoil buds carried by special adaptations;
- Phanerophytes: shrubs, trees, creepers, with buds situated well above the water level (up to several meters) and often enshrouded in modified leafs *"perulae";*
- Chamephytes: dwarf shrubs, with buds at 30 cm from the soil max surrounded by leafs and branches.

The vegetation colonization pattern has also a longitudinal gradient well-defined by several components such as the valley depth, the stream power, the slope of the river, the characteristics of substrate particles, the distance from the sea and the groundwater level.

Often along the longitudinal development of a river it is possible to find significant variations in the complexity of the riparian colonization methods caused by an alternation between confined riverbed and presence of floodplain. Several studies on vegetation patterns show that there is always an increase in the number of species following the mountain-valley gradient. Considering the colonization process of the river banks, the temporal succession cannot be described with a traditional “climax” model, being edaphic factors crucial for colonization dynamics. In particular, riparian vegetation never reaches a single and stable “final stage” because many processes can alter the colonization patterns. Colonization dynamics in rivers are complex and not easily predictable because several events may occur also in a casual manner in the river system: very often vegetation formations are erased by a single and isolated flood event and different environmental factors can interact with vegetation dynamics.

Different colonization patterns may also be detected considering the vertical gradient: plant communities with intrinsic structural complexity confer to wetland habitats poly-stratification and vertical levels, as herbaceous, shrubs and trees layers. Therefore, a fluvial ecosystem can be considered as a multidimensional and complex system, with species distribution described in the four dimensions: lateral, longitudinal, vertical and temporal.

In this view plant communities can be considered a “dynamic mosaic” of the river, and are driven by the fluvial ecosystem dynamics (water and riparian factors acts together). Vegetation dynamics allow plant communities to survive and to be conserved by fluvial dynamics.

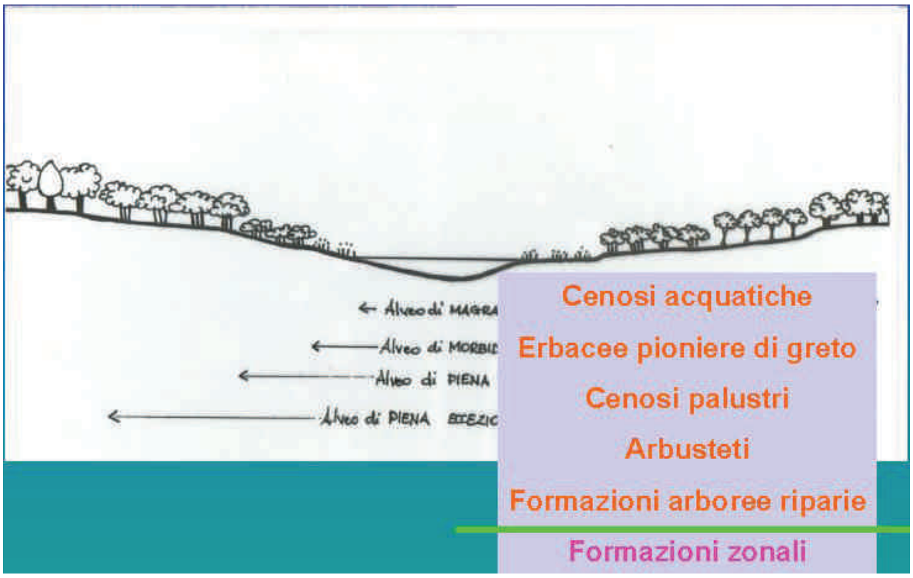

Figure 2 *The lateral/trasversal vegetation zonation pattern for fluvial ecosystems [taken and modified from Minciardi (2009)].*

The plant communities distinction along a river can be done following a simplified model [figure n.2] including:

- **Water and wetlands communities**. Hydrophytes and helophytes, develop in flooded areas where there is almost no stream and where can constitute the herbaceous layer for the development of a riparian forest. The wetland communities are usually constituted by: *Phragmiytes, Carex, Scirpus, Juncus, Cyperus, Typha.* [figure n.3].

Figure 3 *Wetland Communities [taken and modified from Minciardi (2009)].*

- **Herbaceous pioneers communities of the shore**. Terophytes and geophytes with a short vegetative period, adapted to live in high xeric conditions [figure n.4].

Figure 4 *Herbaceous pioneers of the shore [taken and modified from Minciardi (2009)].*

- **Riparian shrub communities**. They occur just outside the wet channel, and are constituted by several species of *Salix* and *Populus* [figuren. 5].

Figure 5 *Riparian Shrub Communities [taken and modified from Minciardi (2009)].*

- Riparian trees communities. Situated in the border of the riparian buffer. They are less disturbed by the river dynamics than the other species. Often non-riparian species of trees are mixed together in the flat lands, creating a continuum between riparian and non-riparian portions of land [figure n.6].

Figure 6 *Riparian trees communities [taken and modified from Minciardi (2009)].*

Land use and human disturbances have altered the riparian and perifluvial vegetation in most European countries: in the Alpine region, in the Nineties, only about 10% of the most important rivers were still considered pristine or in a natural condition (Martinet and Dubost, 1992). Most of the landscapes changes from natural to regulated and engineered conditions have been performed mainly based on practical and short-term economic considerations. The alteration of mountain slopes and riparian forests, the construction of bank protections or the channel straightening and canalization, river flow regulation and hydropower, as well as the increasing presence of infrastructures along the rivers are main factors that in recent times are carefully weighted more than in the past in relation to their potential long-term impacts on economy and environment. The attention to riparian environments is increasing over time: environmental agencies and land managers, driven by set of laws, are interested in characterization and assessment activities to address decision making and regulatory processes.

The main functions of riparian vegetation are listed below:

- reduction of the hydraulic load on the river (Askey-Doran *et al.,* 1996);
- inhibition of bank erosion (Cummins 1993);
- interception and speed reduction of water surface runoff and reduction of peak flows;
- food source and habitat for both aquatic and terrestrial fauna (Parson 1991; Campbell and Doeg, 1989) maintenance of stream and foreshore stability (Warner 1982);

- pollutant removal (infiltration, deposition, filtration, adsorption and absorption functions) (Quinn *et al.,* 1993);
- nutrients retention (Hairsine & Grayson 1992; Allen 1978).

The state of knowledge of riparian vegetation in the Aosta Valley Region can still be considered incomplete because most of available studies and monitoring activities are mainly focused on other river ecosystems components (fish, macrozoobenthos, algae, etc.). A first attempt for a general characterization of the riparian-vegetation conditions along the Dora Baltea river and tributaries was officially performed in 2006 within the River Basin Management Plan - *Piano Regionale di Tutela delle Acque (PTA, 2006*). River management needs, clearly show the importance of deepening present state of knowledge on riparian ecosystems also in relation to official set of laws. The present thesis addresses these needs and develops viable solutions considering the existing scientific approaches and the available resources.

1.2 Indexes to assess river ecological functionality and riparian vegetation status

The riparian vegetation evaluation has been developed together with the methodologies for the aquatic habitat characterization. The first characterization of the riparian-perifluvial vegetation is in fact found within the methods proposed for homogeneous stretches of watercourses, developed in Europe (Petersen, 1992) and in the Anglophone countries (Platts et al., 1986; Leonard et al., 1992). The following evolution of these inventory methods has been the definition of indexes allowing data elaboration and quality assessment, thus becoming useful for the decision-making process (Siligardi & Maiolini, 1993; Boon et al., 1997; Raven et al., 1998; Agences de l'Eau, 1998).

Then, the specification of the privileged quality values (naturalness, functionality, ecological integrity, biologic or physical diversity, etc.) has become necessary, together with the necessity of expressing judgments more and more linked to the ecological condition.

Two spatial scales were considered for this thesis: the regional and the local scale.

The use of a regional-scale approach for the riparian vegetation assessment is necessarily based on satellite images, aero photogrammetric images and GIS analysis. Consequently, an index applied at the regional scale must allow the evaluation of the riparian vegetation by using aero photogrammetric images, GIS analysis and already available thematic maps. These approaches generally require both less time and less human resources (resulting generally less expensive) than the methods at the local scale which are largely based on field surveys and involve more people. At the regional scale the analysis mainly relies on the detection of quantitative attributes of width, extension and distribution of the riparian/perifluvial vegetation, whereas at the local scale it is possible to focus on vegetation physiognomy, on vegetation structure and functionality. The use of local-scale methods allows a detailed analysis of riparian/perifluvial ecosystems, but imply a large use of field surveys and more human resources.

The potentially useful methods and indexes for the riparian vegetation assessment have been studied evaluating both the scientific and the literature produced in environmental agencies. In case of several versions of the same method or index, the most recent and updated versions were considered as the more suitables. Moreover, some methods and indexes that were defined for specific environments were excluded if they were considered not suitable nor adaptable to the Alpine environment. The reviewed indexes are mainly from Southern Europe (Italy and Spain) but most of them come from Anglophone countries. Some indexes are present with different names but rely on the same or on a similar methodology (e.g. for Italy, 5 indexes rely on the IFF or on its previous method, the RCE-2).

The selected methods and indexes were analyzed for their general characteristics, mainly focusing on the potential fitness to the photo interpretation approach [tables n.1 and 2]. Therefore a special attention was given to the evaluation of the Alpine suitability of the indexes, to the quantity of input data, to the human resources required and to the usefulness of the index for photo interpretation. The review includes simple and complex indexes where the riparian vegetation may have a different weight in determining the final scores of the index or in influencing the final evaluation of the ecological status of the riparian environments. Some index like IQM or Ausrivas are in fact mostly thought as integrated approaches (filed surveys and photo interpretation) for the riparian environment monitoring of the hydro-morphological and geo-morphological features.

The synthetic characterization of each method was performed by means of an evaluation (a judgment given on three levels for several characteristics) that allow to understand how the most performing methods were selected. At the end of the reviewing process of tables 1 and 2 (last row), a final evaluation was given to all indexes and methods considering their usefulness for the regional-scale assessment of riparian vegetation by means of a photo interpretation approach.

Acronym	RCEs-IAR	IDRI	IFF 2007	WSI	BSI
Role of PV (Perifluvial Vegetation) assessment within the index	PV influences half of the index	PV mostly influences the index	PV influences only part of the index	PV influences part of the index	PV influences part of the index
Reference Environment of index application (macroscale)	All italian environments	All italian environments	All italian environments	Easten Italy	Eastern Italy
River typology (high-medium-low reaches)	M,L	Any	Any	Any	Any
Alps suitability (1=low; 2=medium; 3=high)	2	3	3	3	3
Kind of input data	Ortophoto, land use map, vegetation map	Ortophoto 1:10.000, Land use map	-	-	-
Quantity of input data (1=low; 2=medium; 3=high)	2	1	1	1	1
Field survey need	-	Only for audit	X	X	X
Field sampling effort (1 to 3)	1	1	3	3	3
Data elaboration effort (1 to 3)	2	1	1	2	2
Human resources required (1=Low; 2=medium;3= high)	1	1	2	3	3
Reference value	Functionality	Functionality	Functionality	Naturality	Functionality
Environmental parameters evaluated	Woody riparian vegetation, Infrastructures	Perifluvial vegetation (tipology, width and continuity) and morphology (integrity)	Land use, perifluvial vegetation (tipology, width abd continuity) and morphology (heterogeneity, erosion), acquatic communities	Landscape characteristics, river hydrogeomorphology, riparian vegetation conditions, characteristics and structure, manufacts and infrastructures	Natural tree vegetation, soil humus and texture, shrub cover, complexity and structure of non tree and non shrub vegetation; riverbed width, slope and texture; bank height and slope; meanders, ponds, pools
Is it useful for a comprehensive assessment of riparian vegetation at the regional scale (by means of orthophoto)? (No / Yes)	**YES**	**NO**	**NO**	**NO**	**NO**

Table 1 List of the most important characteristics of the reviewed indexes [taken and modified from: Abati and Leonelli (2011)].

Acronym	SREFF	IQM	QBR	RQI	AusRivAS	RCI
Role of PV (Perifluvial Vegetation) assessment within the index	Complex index: PV influences only part of the index	PV mostly influences the index	PV mostly influences the index	PV mostly influences the index	Complex methodology: PV influences part of the index	PV influences the whole index
Reference Environment of index application (macroscale)	Italy	All italian environments	Mediterranean climate (Catalonia), also adaptable to mountain environment	All european environment	Any environment, Australia, Ireland	Canadian environments
River typology (high-medium-low reaches)	M,L	Any	Any	Any	H,M,L	M,L
Alps suitability (1=low; 2=medium; 3=high)	3	3	2	2	3	2
Kind of input data	Ortophoto 1:10.000, Hydrographic network	Aerial images , Infrastructure map	-	Hydrological regime	Aerial photographs, hydrology records, GIS maps, previous data collected	Ortophoto, GIS analysis
Quantity of input data (1=low; 2=medium; 3=high)	1	2	1	2	2	2
Field survey need	Only for audit	X	X	X	X	-
Field sampling effort (1 to 3)	-	3	3	2	2	-
Data elaboration effort (1 to 3)	3	2	2	1	3	2
Human resources required (1=Low; 2=medium; 3= high	1	3	3	2	3	1
Reference value	Functionality and conservation value	Naturality	Naturality	Functionality	Naturality	Naturality
Environmental parameters evaluated	Formation typologies, kind of ecosystemic units, density, structures presences	Hydrogeomorphological conditions of the rivers, presence of river works , perifluvial width and longitudinal continuity of riparian vegetation	Riparian vegetation, infrastructures	Riparian and perifluvial vegetation (width, longitudianl continuity, composition, regeneration), hydromorphology	Assessment and evaluation of streammorphology and physical habitat; includes the USEPA HAI index for the riparian vegetation assessment	Forest patch morphology
Is it useful for a comprehensive assessment of riparian vegetation at the regional	**YES**	**NO**	**YES**	**YES**	**NO**	**NO**

Table 2 *List of the most important characteristics of the reviewed indexes [taken and modified from: Abati and Leonelli (2011)].*

1.2.1 Indexes choice for the study area

The indexes considered consistent with the objectives of a regional-scale assessment of the riparian vegetation were considered complete as they are ready to use after some modifications (like the adaptation to the photo interpretation approach). Only indexes evaluated positively at the end of tables 1 and 2 were considered sufficiently complete. This further synthetic review on a subset of riparian indexes previously evaluated in tables 1 and 2 was done considering the possibility of all their parameters to be analyzed by means of photo interpretation.

The indexes used for this research activity are:

- **IFF**, *Indice di funzionalità fluviale, APAT (Siligardi et al. 2007).*
- **RCEs-IAR**, R*iparian channel environment simplified, human impacts on rivers, (Beltrame et al. 1993).*
- **SREFF**, *Metodo per lo Screening delle Risorse Ecosistemiche delle Fasce Fluviali a supporto della pianificazione, APAT (Ferrarato et al. 2003).*

Even if the majority of the indexes were considered not useful for a comprehensive assessment of the riparian vegetation at the regional scale, most of the reviewed indexes presented some interesting parameters or variables for the characterization of the riparian vegetation with photo interpretation. For example the IQM index was positively evaluated for its photo-interpretative approach to the riparian vegetation cover and to vegetation longitudinal continuity with respect to an optimal condition (both parameters evaluated in a GIS environment) but these characterizations are related only to two questions of a much more complex geomorphologic index, as well as the QBR and RQI indexes could not be applied in our region because they requires infrared images which are not already available for the Aosta Valley Region. Other indexes are too much based on a field approach and even if in general they are more ecologically correct and can describe at best the riparian-vegetation status, they would require much more human resources and time (this is the case e.g. of IFF or of Ausrivas, this latter based on the US-EPA HAI field approach for the riparian vegetation assessment).

In Aosta Valley the river functionality index IFF (Indice di Funzionalità Fluviale, Siligardi *et al.,* 2007) has been applied by the Regional Environment Protection Agency (ARPA) and by the hydropower company CVA (*Compagnia Valdostana delle acque*) in the Dora Baltea river, being so far the official index applied to assess riparian vegetation conditions, an index that needs field surveys for being applied.

The IFF index can be considered fully exhaustive but it is time and resources consuming and it needs also trained staff for being applied. In particular, IFF derives from the RCE-I (Riparian Channel Environmental inventory; Petersen, 1990) that was first developed by the Limnology Institute of the Lund University (Sweden). Later, the RCE-I has been modified in order to fit it to the Italian context (especially the Alpine context), thus creating the RCE-2 index (Siligardi and Maiolini, 1993). In 1998 several other modifications have been brought to the RCE-2 index during the national meeting organized by APAT (agenzia per la protezione ambientale di Trento), thus creating the first version of IFF (Siligardi *et al., 2000*). Over time, some changes have been brought up to the last version introduced in 2007 *(Siligardi et al. 2007).*

The IFF index has been thought for being applied to every kind of rivers, from the source to the mouth. Before starting to apply the method in the field it is important to gather information regarding the major pressures in the catchment, data about the hydrological regime and biological and chemical analysis, aerial pictures and maps, in order to have a better understanding of the threats and lengths of the area under evaluation (see official sampling sheet in chapter 5.2). The river should be divided into homogenous stretches.

The river stretches range between 20-100 of meters and some kilometers. For each stretch, the IFF form is divided into 14 questions related to the river ecological characteristics and drives to a final score through four possible answers.

- Land use pattern of the surrounding area.
- Vegetation of perifluvial zone (it is possible to distinguish a primary belt, with perifluvial vegetation growing under natural conditions, allowing lateral water fluxes and exchanges between the river and the surrounding land, and a secondary belt with vegetation growing within artificial riverbed or banks with interruption of the lateral continuity.
- Extension of the perifluvial vegetation zone.
- Continuity of the perifluvial vegetation zone.
- Water conditions on the river bed.
- Stream bank structure.
- Retention structures of trophic matter.
- Erosion.
- Cross-section.
- River bed structure.
- Riffles, pools or meanders.
- Vegetation in the riverbed (periphyton, macrophytes cover).
- Detritus.
- Macrobenthonic community.

IFF provides a total score (as sum of the scores related to the single questions) related to the functionality state of each river side. The scores are divided in 9 classes from an optimum state (300 points) to a poor state (18 points), and are associated to specific colors from blue to red, respectively, to be used in representation. The application of the IFF index needs to collect a lot of data and to do field observation which needs, as mentioned above, a team of trained observers [figure n.7].

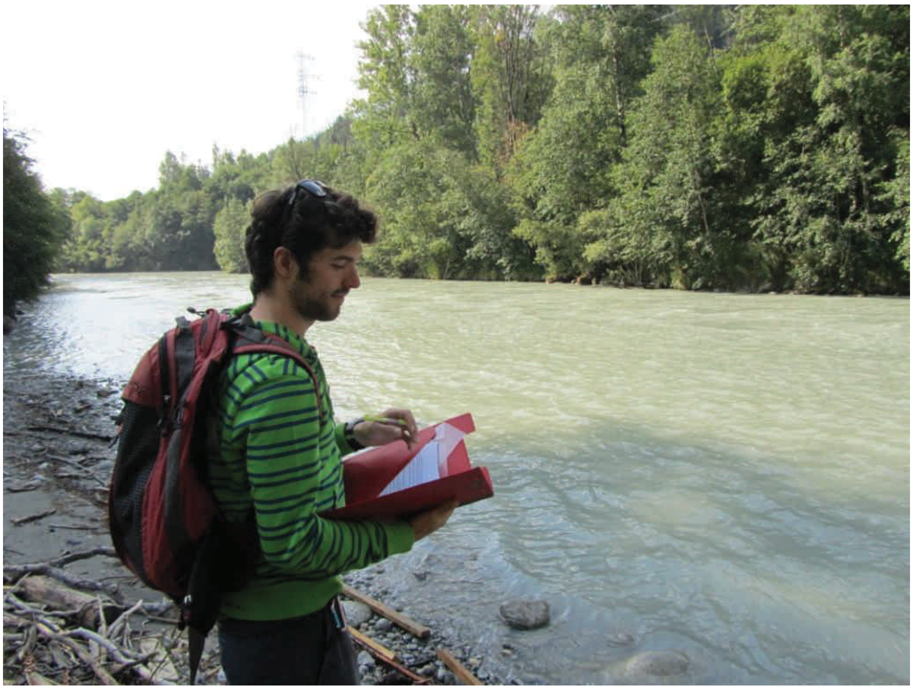

Figure 7 *IFF survey on the Dora Baltea river [personal archive].*

RCEs-IAR index is based on a photo interpretative approach snd it can be applied at any altitude and evaluates both riparian vegetation and impacts of human activities on the river. During the meeting “Progetto di ricerca sui paesaggi fluvial in Emilia Romagna, 1993” the first Italian photo interpretation index was created, derived directly from RCE-I and RCE-2 and first applied to the pilot case of the Enza river in Regione Emilia Romagna. This index is based on simple considerations:

- the possibility to use the land use topographic maps derived by aerial images;
- the possibility to have other kind of topographic maps (e.g. human impacts, buildings and riverbed hydraulic works).

For these reasons the related form is divided in two parts that vary in function of scores derived from a simplified field method (RCE-s) and from scores derived from some pressure indicators for riparian environments (IAR), the complete scoring form is listed in chapter 5.3 of this work.

Therefore the RCEs-IAR index can be useful also to describe changes occurred over time along riversides and related environments organized in two main parts. The first part is expressly made to describe and quantify the surrounding ecological state of the considered stretch in a more simple way than the RCE-2 method: only six questions over fourteen have been maintained. The scores related to the riparian vegetation may vary from 1 (e.g. worst conditions) to 15, 20, 25 or 30 (e.g. best conditions) for different indicators:

- Naturalness of the riverbed (natural to artificial); Kind of riparian vegetation (distinction between tree-shrub-herbaceous vegetation); Riparian zone width (with some reference values below 30 m and above 30 m); Longitudinal integrity of the riparian vegetation (from not interrupted to strongly impacted); Riparian vegetation stability (from stable to seasonal vegetation); Surrounding land (from forest-natural to urban environment).

Same scores for the questions have been maintained from RCE index, ranging from a minimum of 6 to a maximum of 150, the best ecological state for a river.

The second part of the index is built in order to describe the human activities and the potential sources of diffused pollution. The scores related to the pressures on the riparian environment (IAR, impacts of human activities on river banks) vary from 1 (low pressure) to 5, 10, 15, 20 or 25 (high pressure) for different indicators:

- Distance of agricultural activities from the banks (with some reference values below 10 m and above 1 Km); Kind of agricultural vegetation (fields, trees, seasonal); Distance of pits from river banks; Longitudinal extension of pits in relation to river section; Kind of pits; Distance of urban environments from river banks; Longitudinal extension of urban environments in relation to river section; Kind of urban areas; Distance of roads from river banks; Kind of roads.

In this section as well, scores range from 6 (lower impact) to 150 (higher impact). For the final evaluation of the river state the observer will remove from the sum of the RCEs scores the sum of the IAR scores: the final value obtained will be based on a scale that goes from a minimum of -144 (worst conditions) to a maximum of 144 (best conditions) (see chapter 5.3, table 7). This index have to be applied on each side of the river like the IFF index and to stretches with a variable length that considers an undifferentiated morphology.

SREFF index is based on 5 sub indexes calculated from the geo-informatics software:

- the "geomorphologic index" (Ig), derived from the scores of the "natural landforms index" (Ing) and the "sinuosity index" (Is);
- the "vegetation index" (Iv), derived from the scores of the "natural vegetation index" (Inv) and the "biotope variety index" (Ivb). the Ivb sub index has the correct objective to describe the fluvial corridor mosaic, whereas the Inv is less performing in this sense;
- the "filter effect index" (Ief), derived from the scores of "kind of riparian vegetation" (Tv) and the "natural riparian vegetation integrity index" (Ivr))the filtering effect can effectively reduce surface non-point source movement of pollutants to streams) (Schultz et al., 2004);
- the "human impact index" (Iia);
- the "riverbed alteration index" (Ima).

This method has been conceived expressly for photo-interpretation and its application is more rapid and economic if compared to indexes requiring field surveys as IFF. SREFF considers a 300 m buffer from the river banks and stretches of variable length, it is applied up to 500 m a.s.l. or up to the area where a flood plain is present. River stretches are created in a GIS environment: a new polygon for each side of the river is drawn and split in several sub-areas constituting the surfaces of main natural values or land uses [figures n. 8 and 9]. The evaluation of the total impact is made by cross-linking the state index and the impact index in a table and obtaining as response a 10-classes range, ranging from level 1, absence of degradation, to 10, maximum degradation (tables and scoring methods are available in chapter 5.4). This index relates the perifluvial buffer to the surrounding areas and gives a fair evaluation of pressures. This method shouldn't be applied in narrow valleys with embedded rivers.

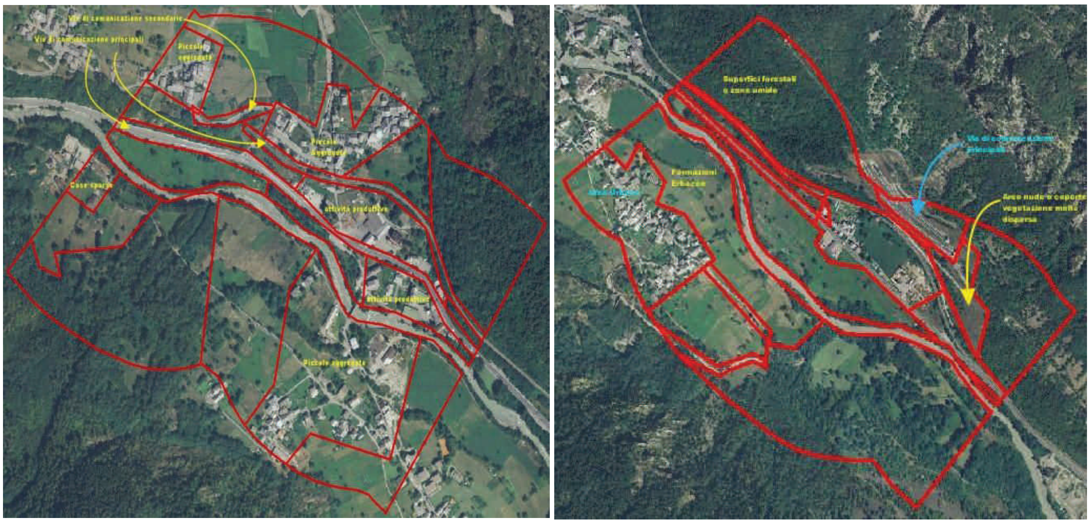

Figure 8 and 9 *Application of the SREFF index, different land uses areas [taken and modified with ESRI ArcMap® software].*

The synthetic analysis of the different indexes referred in table 1 and table 2 let us select the SREFF index as the most complete for the riparian vegetation assessment potentially to be applied at the regional scale, as required for our work. The SREFF index is a method developed by APAT in 2003. It is composed by indicators[1] that constitutes the index[2]. With this method it is possible to perform a preliminary quantitative evaluation of the ecological factors related to the riparian environments. SREFF evaluates the intrinsic value of vegetation, its functionality and the fluvial dynamics. The method is explicitly built for the environmental evaluation by means of photo-interpretation and has to be applied in a GIS environment, with large use of thematic maps.

[1] A parameter composed by sub-parameters which supplies information about a phenomenon that goes further than the information directly associated to that parameter.

[2] A *set of indicators that can be measured and observed.*

2. NORMATIVE AND SET OF LAWS

2.1 National and international scale: Water Framework Directive, 2000-60-CE

The Water Framework Directive (2000/60/CE) briefly named WFD, is the main set of laws referring to river ecosystems status committing European member states to reach good qualitative and quantitative status of all water bodies by 2015.

The WFD was received in the Italian national legislation within the frame of the Legislative decree 03/04/2006 n°152 (S.O. n°96/L of GU n° 88, 14/04/2006), which constitutes a comprehensive set of rules for environmental regulation in Italy. The first transposition at the Italian level was incomplete, therefore further integrating provisions were issued, especially with regard to the technical annexes.
The Decree of the Minister of the Environment n. 131/2008 (S.O. n°189/L of GU n° 187, 11/08/2008) defined with a better detail the geographical section of the directive implementation, giving the technical specifications for identifying on the Italian territory the hydro-eco regions (HER) and the water body typologies.
The decree 56/2009 (S.O. n°83/L of GU n° 125, 30/05 /2009) defined the procedure to be used in order to build a monitoring net and to establish a sampling program.
The last document completing the normative integration of the Directive annexes in Italy was approved at the end of 2010 (Decree of the Minister of the Environment n. 260/2010 - S.O. n°31 of GU n°30, 07/02/2011) and describes the methodologies for defining the biological communities, the hydro-morphological features and the general chemical and physic-chemical parameters to evaluate the good ecological status. The methods at present under approval are new for Italy and it is therefore necessary to start a procedure to train the technicians working in the Regional Environmental Protection Agencies, who are operatively involved in the surveys. This could cause a delay in the application of the monitoring activities and may impact the reliability of the data to be used for land planning activities.
The official publication of a manual including the methods will be published soon by ISPRA (Institute for Environmental Protection and Research).
Concerning the classification of the chemical status in accordance to the WFD, the decree law 219/2010 was recently approved for the transposition at the Italian level of the Directive 2008/105/EC about environmental quality standards in the section of water policies, and of the Directive 2009/90/EC, establishing technical specifications for the analysis and monitoring of pollutants.

The approach of the WFD is to assess beside water quality and chemical status, also the ecological integrity of surface waters referring to biological, hydro-morphological and general physic-chemical quality elements. This means that different and specific ecological characteristics have to be considered. Thus, the assessment has to be done on the basis of the specific reference status ("very good" ecological status) that generally matches with an undisturbed water body. The 'good ecological status' is defined as the minor deviation to the reference status. Water bodies too distant from natural conditions, because of bank

and soil constructions, channeling, tunneling etc., or those of artificial nature in a whole, are declared "heavily modified" with the objective to reach a good ecological potential *(GEP)*, assumed to be as far as possible the status of the most comparable water body.
For the classification of running waters the assessment of the following quality elements are mandatory.

Biological quality elements

- Phytoplankton
- Macrophytes and phytobenthos
- Benthic invertebrate fauna
- Fish fauna

Hydromorphological quality elements

- Hydrological regime
- River continuity
- Morphological conditions

Physico-chemical quality elements

- General conditions: nutrient concentration, salinity, pH, oxygen balance, acidity and temperature conditions and specific synthetically and non-synthetically pollutants

Currently, the riparian vegetation is considered within hydro morphological elements only in the assessment of "high ecological status" water bodies (WFD, All. V, tab 1.2.1).

2.2 Regional scale: River Basin Management plan and other available information

The River Basin Management plan literally named Regional Plan For Water Protection (PTA, *Piano Regionale di Tutela delle Acque*, 2006) represents the main document in the study area for the analysis and protection of river and water resources.
Several assessment of indicators have been developed in the plan technical report to describe status, pressures and critical river situations related to running waters of Dora Baltea river and main tributaries. These indicators are mainly thought to represent and produce maps and charts related to:

- **River Ecosystem Quality:** the main indicator considered is called "synthetic indicator of ecosystem quality of regional significant superficial water courses" (*Indicatore sintetico di qualità ecosistemica dei corsi d'acqua significativi superficiali regionali)*.
  This indicator is related to general ecologic conditions of Dora Baltea river and it is composed by two separated indicators (riparian vegetation quality and water biological quality merging macrozoobenthos and the fish population).

- **Diffused and local pressures on river network,** the developed indicators are five:

  Local pressure on river: the indicator considers the presence and the number of points of local waste pollution and water abstraction.

  Diffused pressure on river: the indicator considers the presence and width of surface with soil use coverage potentially related to pollutants input (urban surfaces, agriculture and farming, factories).

  Riverbed modifications: the indicator considers number, length and typology of riverbed modifications.

  Total pressure on river: this indicator combines the previous ones.

  Natural discharge alteration: this indicator considers the natural discharge alteration grouping it in 5 classes for every stretch.

- **Critical conditions of river network;** The main indicator considered is called "synthetic indicator of criticality on water courses" (*Indicatore sintetico di criticità sui corsi d'acqua)*. It is related to the general ecologic conditions of the Dora Baltea river and it is composed by two separated indicators (riparian vegetation quality and water biological quality, merging macrozoobenthonic and fish population). Both indicators are split in five quality symmetric classes.

The information coming from the use of these indicators are generally affected by several informative gaps as shortly explained below:

- PTA and related informative layers consider the riparian vegetation mainly in terms of presence, absence and continuity without specifying quantitative parameters to be applied.
- Informative bases used are rather old: in particular, aerial images used to elaborate the indicators are of 1999 and do not consider the strong modification occurred after exceptional flood of Autumn 2000. At the same time, following the application of WFD set of laws and related new indicator set, the formerly considered biological, physical and chemical indicators will progressively be no more valid and legally binding.
- The set of indicators doesn't consider the IFF elaboration because the index-derived information was available only for a limited number of stretches on the whole Region.
- The indicators framework, the inner algorithms, the methods of elaboration and aggregation modes are not always evident nor sufficiently defined to allow a real replication and update of the assessment plans.
- Additional biological datasets and indicators to assess river ecosystem quality are old and cannot be considered updated (e.g. fish populations status).

- Sand and gravel extraction has not been considered among the pressures even if it is an important factor along the Dora Baltea.
- Riverbed artificial modifications do not refer to a real census nor to an updated aerial-derived information, considering in particular the strong modifications occurred after the exceptional flood of Autumn 2000.
- The river natural asset of the study area seems to be mainly limited to some residual stretches and grouped in big sections in critical situations without the possibility of detailing intermediary classes.

We consider this information worth of quotation in the present study, however it will not be further developed as methodological or informative layer. The complete PTA normative is available at the RAVA website[3].

3. OBJECTIVES OF THE THESIS

- Review of methods and tools to evaluate and assess the natural capital represented by the river wet channel and the riparian ecosystems of the Dora Baltea river, potentially exposed to anthropogenic pressures.
- Determination of a method, index and/or metric of index that fits better to IFF (Indice di Funzionalità Fluviale, *Siligardi et al*., 2007) being less time and resources consuming for the alpine river network of Aosta Valley Region; IFF index holds official references in Aosta Valley river management set of laws.
- Definition of a possible new index (TH, *TeleHybrid* index) based on aero photogrammetric images and GIS analysis (using metrics and sub- indexes derived from the reviewed methods) and on hydrological parameters.

[3] http://notes1.regione.vda.it/DBWeb/PTA/FAQPTA.nsf/Presentazione?OpenForm&lng=ita

4. STUDY AREA

The Dora Baltea basin includes an important hydrographic network that stretches from the Piedmont Region up to the entire North-Western Region of Valle d'Aosta, with a basin of over 3.261 km^2. The Dora Baltea is one of the five major tributaries of the Po river with an average annual contribution of 110 m^3/sec. The river originates with its two branches (the Dora of Veny Valley and the Dora of Ferret Valley) from the Mont Blanc glaciers. From the confluence of the two Dora rivers at the mouth into the Po river, the Dora river has a length of about 152 km [figure n.10].

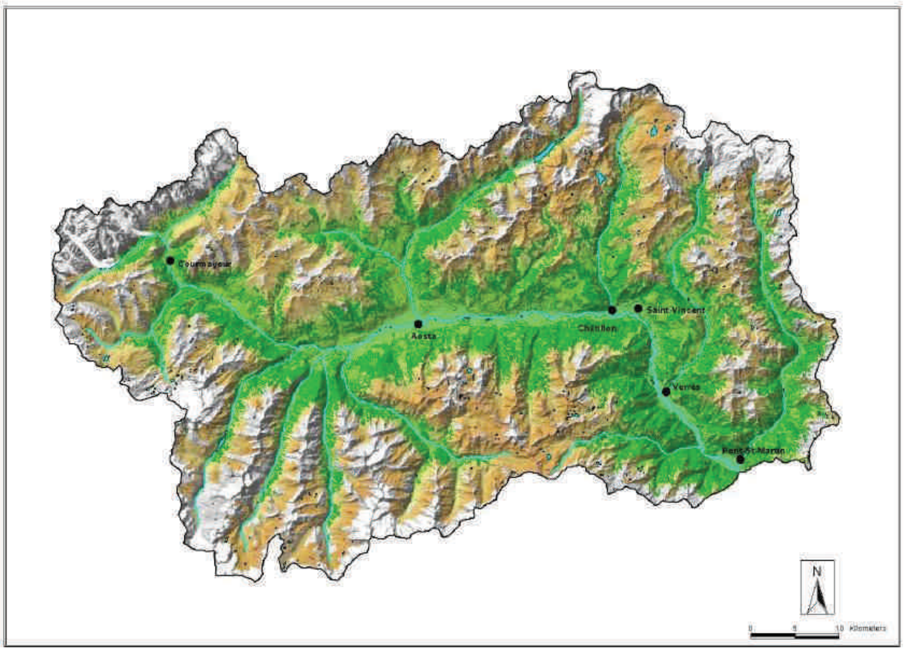

Figure 10 *The Dora Baltea river basin included in the Aosta Valley Region [taken and modified from RAVA-PTA (2006)].*

The track is initially directed from northwest to southeast, shortly before Aosta it assumes west-east trend up to Saint Vincent, where it is directed south-east, keeping this direction up to the confluence with the Po river. The Dora river receives numerous tributaries on both sides and flows with sinuous patterns, locally sub-straight, in a valley carved with rather steep rock slopes.

The Dora Baltea river basin is characterized by the presence of the highest mountains of Europe [e.g. Mont Blanc (4810), Cervino (4474), Grandes Jorasses (4208), Gran Paradiso (4061), Lyskamm (4477)] distinguished by the presence of perpetual glaciers, but also by the presence of a central plane that is developed at 300 m a.s.l. These characteristics contribute to keep the natural conditions of a large part of the territory although the deep anthropization of the Dora Baltea plane. Due to the great amount of land located above 1500 m a.s.l. (about 80% of the basin), the 40% of the Dora Baltea river basin presents a rocky or icy surface, the 51% is covered by forests and pastures and only the 9% support the human settlements: this part is essentially the central plain.

In geomorphologic terms the mountain basin of the Dora Baltea can be divided into three different areas:

- High basin of the Dora Baltea river - including the highest basin area, which stretches from the Mont Blanc to the plain of Aosta;
- Middle basin of the Dora Baltea - including the plain area that extends between Aosta and Montjovet;
- Low basin of the Dora Baltea - from Montjovet to the plain of Ivrea.

For the land cover characterization is available the Land Cover chart prepared for the CORINE Land Cover project. This is the most recent and updated information regarding the Aosta Valley land coverage, based on satellite images of year 2000. The land cover map at 1:100,000 scale with a legend of 44 items, is referred to homogeneous spatial units clearly distinguished from units that surround them. In the Dora Baltea river basin there are the land cover typologies shown below [table n.3].

CORINE code	typology	area [Km^2]
111	Continuous urban fabric	1.621
112	Discontinuous urban fabric	35.143
121	Industrial or commercial units	6.808
124	Airports	0.424
131	Mineral extraction sites	0.258
133	Construction sites	2.150
142	Sport and leisure facilities	0.652
211	Non irrigated arable land	0.739
221	Vineyards	3.443
222	Fruit trees and berry plantations	2.477
231	Pastures	112.468
242	Complex cultivation patterns	20.647
243	Land principally occupied by agriculture, with significant areas of natural vegetation	119.590
311	Broad-leaved forest	78.448
312	Coniferous forest	609.601
313	Mixed forest	91.176
321	Natural grassland	351.789
322	Moors and headland	156.967
324	Transitional woodland-shrub	354.694
332	Bare rocks	725.340
333	Sparsely vegetated areas	425.034
335	Glaciers and perpetual snow	149.265
411	Inland wetlands	1.049
511	Water courses	0.187
512	Water bodies	3.318

Table 3 *The CORINE land cover typologies of the Dora Baltea river basin. [taken and modified from RAVA-PTA (2006)].*

The development map produced for the Aosta Valley River Basin Management Plan, *RAVA(2006)* has simplified the map CORINE Land Cover aggregating certain types, such as continuous and discontinuous urban fabric which have been reunited in one type [urban fabric]. From the reworking of the surfaces were obtained the following results expressed in Km^2 and percentages [table n.4].

Land Cover typology	**area [Km^2]**	**Percentage**
Urban fabric	36.765	1.130
Industrial or services units	10.035	0.308
Mineral extraction sites	0.258	0.007
Agricultural surfaces	146.158	4.492
Pastures	113.208	3.479
Forest	779.225	23.951
Natural and high altitude grassland	508.756	15.638
Transitional woodland-shrub	354.694	10.902
Bare rocks	725.340	22.295
Sparsely vegetated areas	425.034	13.064
Glaciers and perpetual snow	149.265	4.588
Water courses and bodies	4.554	0.139

Table 4 *Simplification of CORINE Land Cover typologies for the Aosta Valley River Basin Management Plan. [excerpted and modified from RAVA-PTA (2006)].*

The map of land cover modified from the CORINE Land Cover 2000 for the Dora Baltea river basin is shown below [figure n.11].

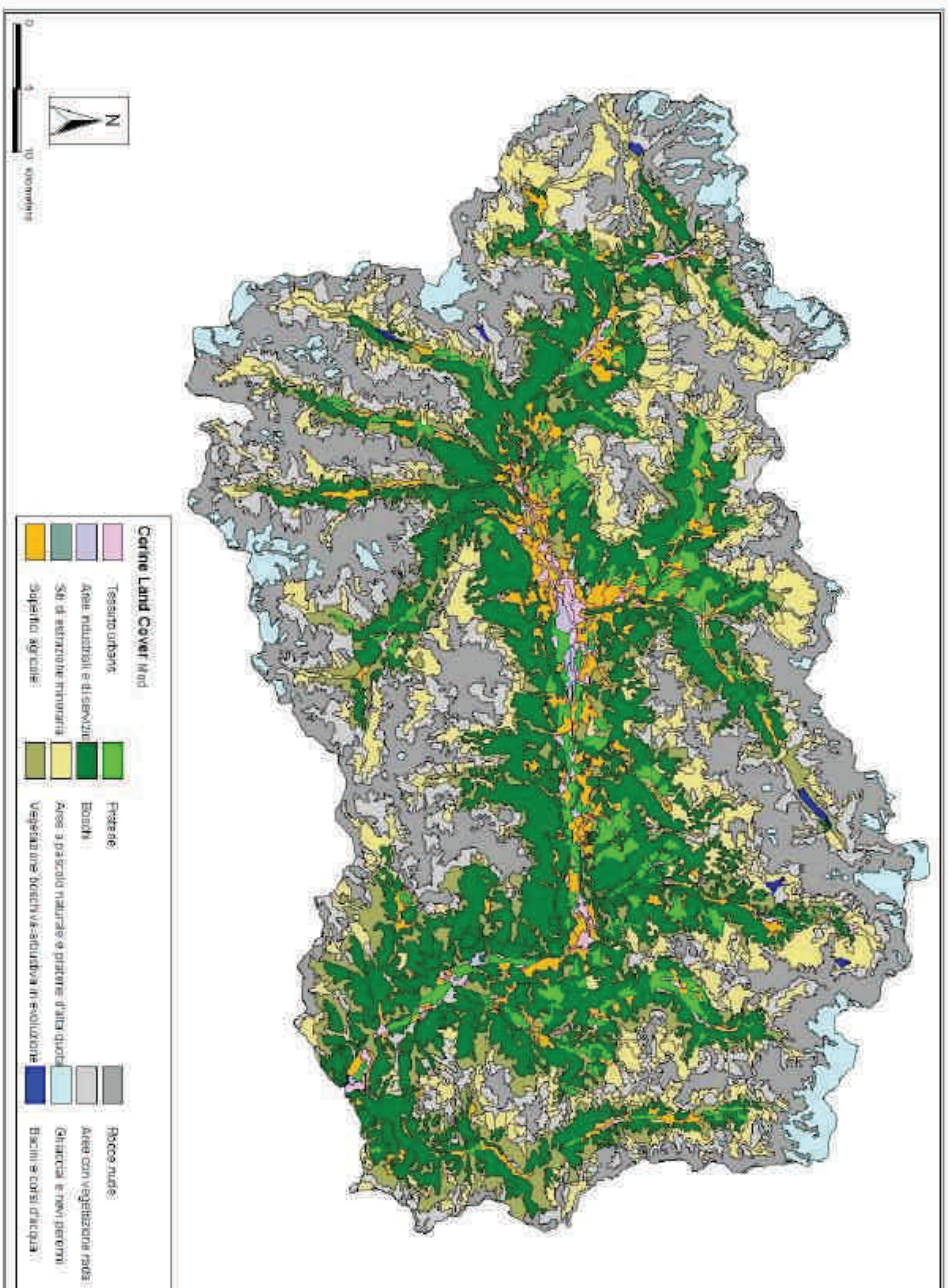

Figure 11 *map of land cover modified from the CORINE Land Cover 2000 for the Dora Baltea river basin [taken from RAVA-PTA (2006)].*

The presence of glaciers heavily influences the Dora Baltea flow regime with pronounced winter minimum and summer maximum in accordance with the period of maximum glacier ablation.

The Dora Baltea basin is classified as an inland alpine basin up to the confluence with the Lys tributary. The mountain ranges offer a direct protection against humid air from the Atlantic and therefore have rather modest rainfall totals.

The main meteo-climatic characteristics of the Dora Baltea river basin are:

- A thermal distribution that faithfully follows the mountain elevation gradient with the mean temperature value of 10°C in the plan, the mean temperature of 0°C at the altitude of 2500 m a.s.l. and the mean temperature of -5°C at 3400 m a.s.l. *(Mercalli et al., 2003)* [figure n.12].
- A distribution of precipitations that shows yearly average values of 500 mm/y in the central part of the basin and yearly average values of 2000 mm/y in the North-West and South-East sectors.

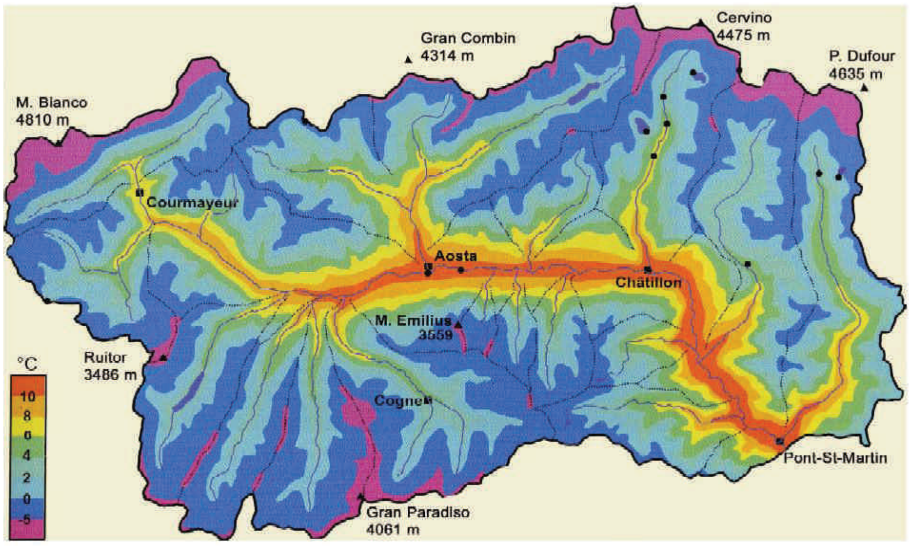

Figure 12 *The yearly average isotherm chart (in °C) of Dora Baltea river basin [from Mercalli et al.(2003)].*

From the hydrological point of view the transformation of inflows in runoff is strongly influenced by these characteristics and in particular by the presence of snowfields and glaciers. In fact, since the mountain basin consists of vast areas above 2000 m a.s.l., the rainfall occurs for a long part of the year mainly as snow and does not contribute immediately to the river flow. The distribution of flow trends shows the maximum from June to July (coinciding with snow and ice melting), and the minimum in winter.

Floods generally occur between late spring and early autumn, when the snowfall is proportionally low. Sometimes, especially in late spring, the presence of a still substantial snowpack causes a significant increase in the contribution of flood for the effect of snow melting at high altitudes.

In this geographical area, a typical inland alpine basin, often the occurrence of critical floods does not correspond to the maximum intensity values of rainfall recorded by the rainfall stations, but to the coincidence of a number of negative factors (in addition to high intensity rainfall) including essentially the occurrence of abnormal temperature rises and the presence of a large blanket of snow.

In the secondary basins frequent floods are caused by rain or storms of great intensity but low extension. In these cases there may be significant increase in the sediment transport.

4.1 Hydropower exploitation

In the Dora Baltea river basin there are 178 HP plants different for typology and power [data source Aosta Valley Region - data updated to 2009]. Of these 31 are of Aosta Valley Water Company [CVA] property [figures n.13 and 14], the others managed by private institutions.

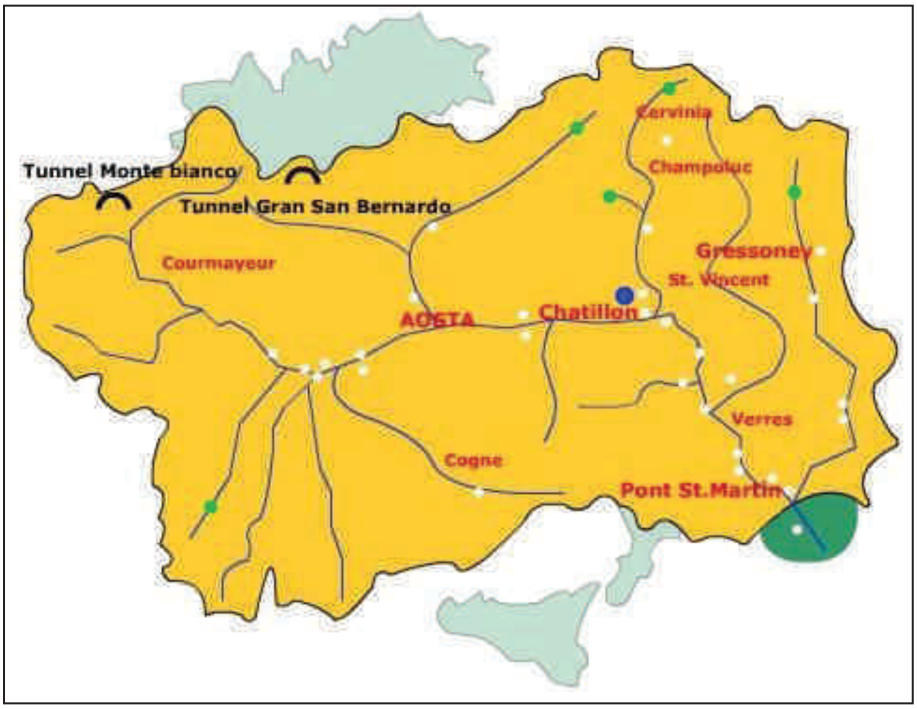

Figure 13 *Aosta Valley Water Company HP plants. White dots are run-off hydropower facilities, green dots are dams and reservoirs [taken and modified from the Aosta Valley Water Company website] http://www.cva-ao.it/*

The efficient power of the installed plants on the entire basin is 900 MW: 830 MW for CVA plants [Figure 13] and 70 MW for private investment over 70 kW [data source: Aosta Valley Regional Energy Plan, RAVA – 2003].

The annually hydropower produced throughout the Dora Baltea river basin amounted to 2609 GWh in 2003 [data source: Aosta Valley Regional Energy Plan, RAVA – 2003].

Figure 14 *La Salle intake and Montjovet intakes [taken and modified Regional Energy Plan, RAVA – 2003].*

4.2 Drinkable water

In the Dora Baltea river basin, the underground water are present in:

- mountain zone - where the water is picked-up by wells;
- valley bottom - where there are water tables, exploited by industrial and drinking wells.

Under the Legislative Decree 152/99, the institutional monitoring of water tables was started in 2003 and included the four water tables shown below [figure n.15] with an extension of approximately 60 km^2. In 2009 two important European Directives [2000/60/CE and 2006/118/CE] have been received by the new Legislative Decree 30/09 about the protection and monitoring of groundwater tables.

In 2003, the Dora Baltea river flows has been analyzed (Triganon et al., 2003) to highlight the leaks and the exchanges between the Dora Baltea river and the groundwater tables.

The result of this analysis separates the valley bottom of Dora Baltea river in several sub-zones. In some of these it is evident that the Dora Baltea river feeds the groundwater tables, whereas in other portions it drains them.

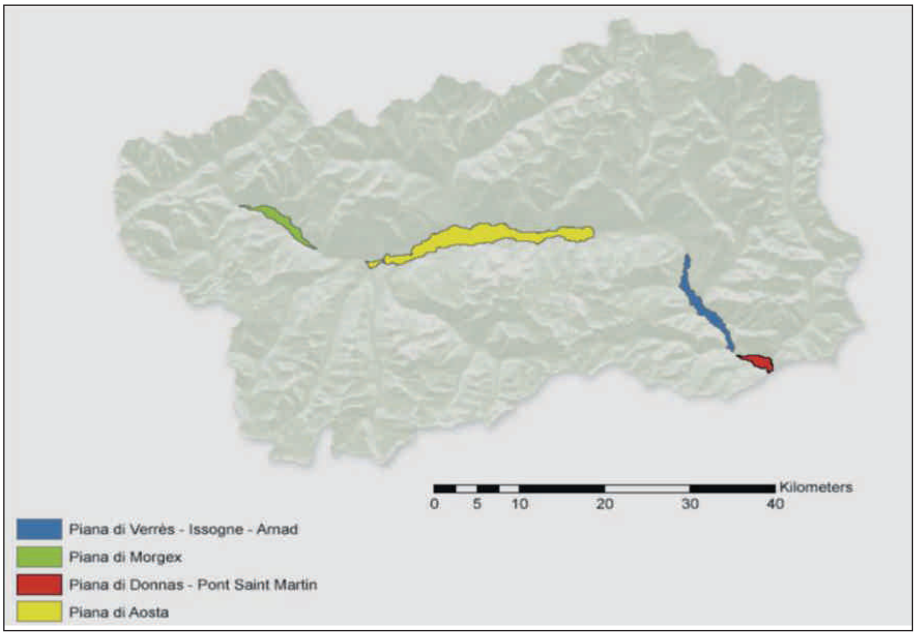

Figure 15 *Map of groundwater monitoring areas on the Dora Baltea river Basin [taken and modified from RAVA (2010)].*

4.3 Naturalistic fruition and fishing

The Dora Baltea river basin torrential environment offers several opportunities of naturalistic fruition: geomorphosites such as gorges and ravines, and damp zones with a rich riparian vegetation and wildlife associated with these environments [e.g. insects, amphibians, fish and birds], already attract many visitors and tourists every year.

The touristic management of fisheries is regulated by specific laws (R.L. May 10th, 1952, n. 2 – R.L. August 11,1976, n. 34th, R.L. September 2nd, 1996, n. 30) under the control of the Regional Consortium for protection, increase and practice of fishing activities in the Aosta Valley Region. The Consortium is the representative body for the Aosta Valley Region fishermen who become members by paying annual fees.

Also the operations of fish restocking are performed by the Consortium staff (partly dependent and partly voluntary). Through the voluntary fish guards, finally the Consortium monitors the compliance of existing legislation on fisheries both supervisory and fish restocking. The Consortium also determines the criteria, guidelines and directives for its operation and draw their business plans through the adoption of internal rules. The fishing regulation in the Aosta Valley Region is covered each year through the enactment of the “Fish Calendar” and its attachments by special decree of Farming and Natural Resources councilor.

The “Fish Calendar” defines:

- The opening and closing dates for fishing.
- The equipments and permitted and illegal baits.
- The catches (minimum size, mode and quantitative).
- The surveillance.
- The special fishing arrangements.
- The documents necessary for the fishing.
- The types of permits.
- The cost of permits.
- The specific prohibitions.

4.4 Water Sport

In the Dora Baltea river basin different water sports are practiced, attracting thousands of tourists every year: rafting, canoeing, kayaking, hydro-speeding and canyoning. The most interesting paths along which different disciplines can be applied are showed in the following figures [figures n.16 and 17].

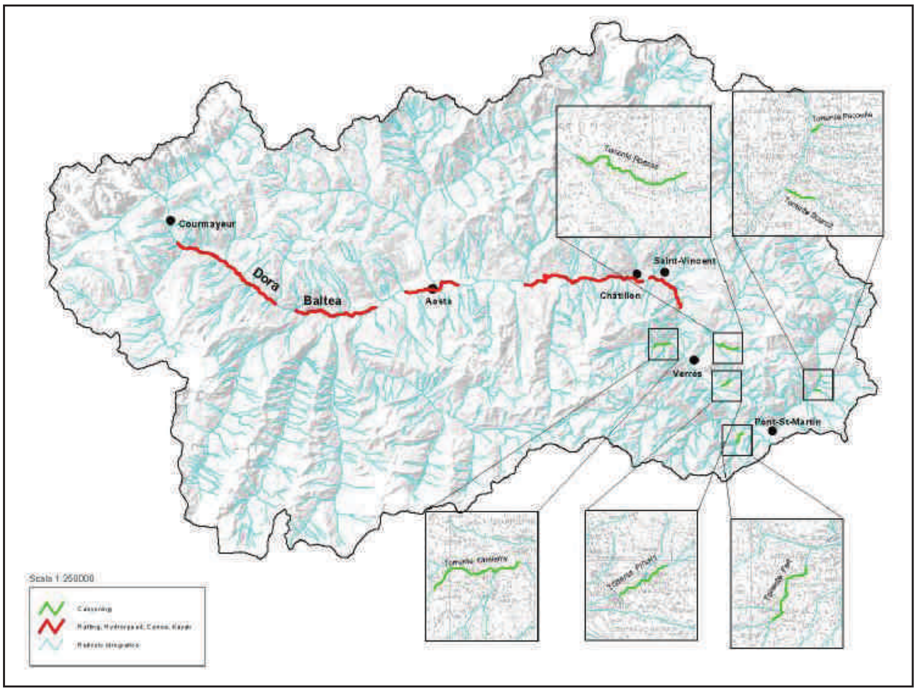

Figure 16 *Map of water sport distribution on the Dora Baltea river Basin [taken and modified from the Aosta Valley River Basin Management Plan. 2006].*

Figure 17 *Images of water sport on the Dora Baltea river basin [taken and modified from the Aosta Valley River Basin Management Plan. 2006].*

4.5 Land use and riverbed modifications

The land use is the complex of human activities, exploited on the study area. In document "surface waterbodies characterization" (*Tipizzazione dei corpi idrici superficiali*) - ARPA - Aosta Valley Region [Draft, 2010], a spread-pressure classification has been created based on a scale divided into seven classes. The land use categories are ordered from 1 to 7 according to an increasing anthropization [table n. 5].

	Land Use	**Pressure Value**
STEEP AREAS	No anthropization	1
	Farming anthropization	2
	Small urban anthropization	3
FLAT AREAS	Farming anthropization	4
	Touristic and small urban anthropization	5
	Touristic and middle urban anthropization	6
	Factory and big urban anthropization	7

Table 5 *Land use categories [taken and modified from the document: "Tipizzazione dei corpi idrici superficiali" – ARPA (2010)].*

Through the analysis of CTR 1:10.000 maps, aerial photos and through spot checks, ARPA Valle d'Aosta has applied the land use classification to each stream dividing the river where necessary [figure n.18].

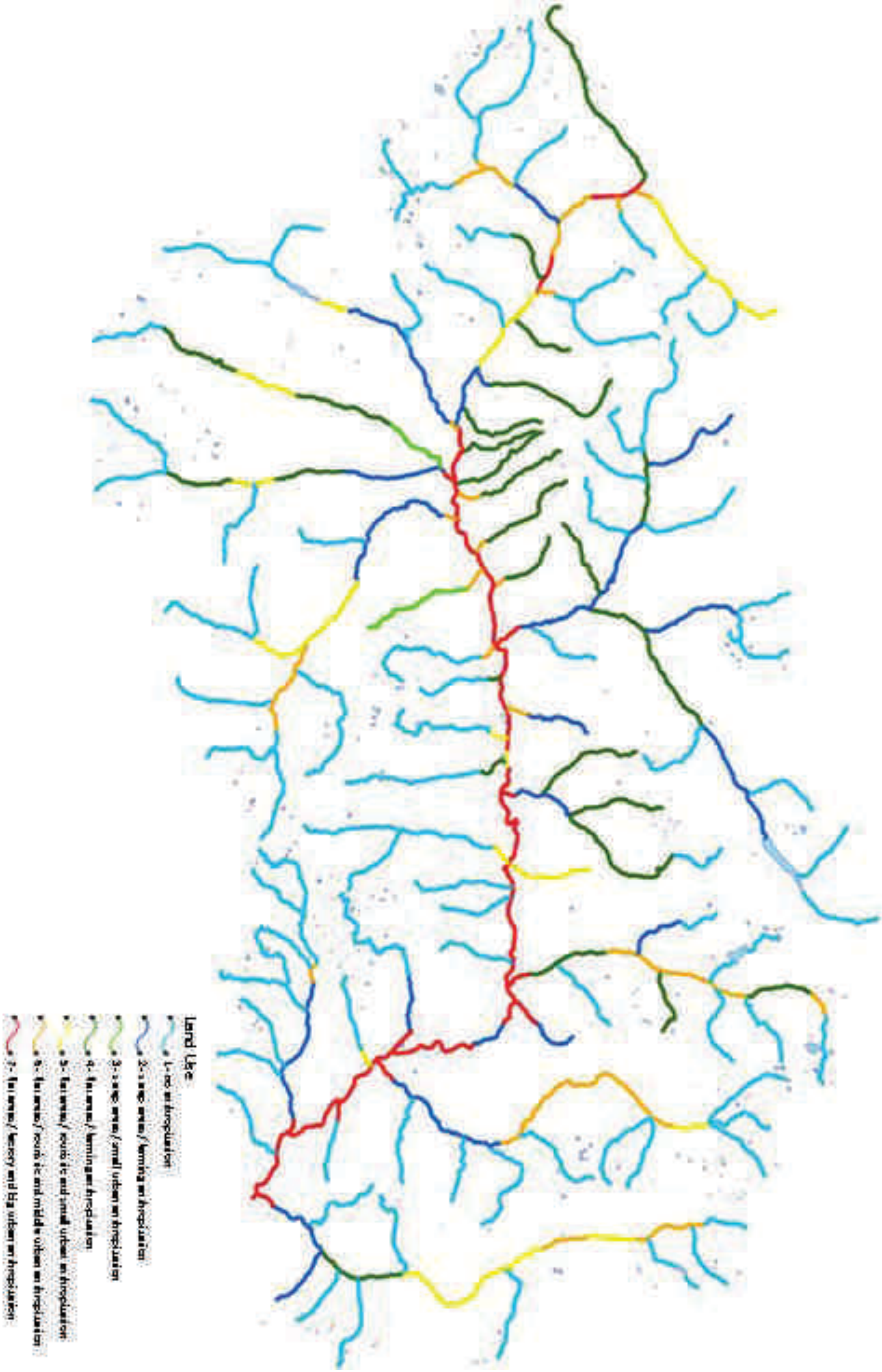

Figure 18 *Final monitoring network for 2010 [taken and modified from the document: "Tipizzazione dei corpi idrici superficiali" – ARPA (2010)].*

The Dora Baltea river is exposed to several kinds of pressures, outside and inside the riverbed. The census of the hydraulic works on the Dora Baltea evidenced the presence of 632 artificial works. The most common works found inside the river are bridges, perimeter walls, weirs, thresholds and hydropower structures.

Figures from n.19 to 22 shows different kind of hydraulic works along the Dora Baltea river.

Figure 19 *Hydraulic works along the Dora Baltea river [taken from ARPA Valle d'Aosta census of the hydraulic works (2012)].*

Figure 20 *Hydropower plant building along the Dora Baltea river [taken from ARPA (2012)].*

Figure 21 *Hydropower facilities along the Dora Baltea river [taken from ARPA (2012)].*

Figure 22 *Hydropower facilities along the Dora Baltea river [taken from ARPA (2012)].*

4.6 Factory wastes

In the Dora Baltea river basin are present 33 factory plants with 35 discharges into watercourses (2 plants are equipped with two discharges in the river bed). Most discharges are located in urban areas of the Aosta Valley Region or at least productive in water bodies characterized by urban pressure more or less widespread. The 60% of discharges, corresponding to 21 production plants, are located in Dora Baltea urbanized areas [table n.6]

AUTHORIZED SUBJECT	TOWN	WATERCOURSE	MAXIMUM AUTHORIZED FLOW [l/s]	CLASSIFICATION
Cogne Acciai speciali SpA	Aosta	Dora Baltea	333.333	Steel factories – water cooling
Cogne Acciai Speciali Srl	Aosta	Dora Baltea	1111.110	Steel factories – water cooling
Iseco SpA	St. Marcel	Dora Baltea	0.069	Indirect water cooling
Rossignol Ski SpA	Verrayes	Dora Baltea	0.417	Indirect water cooling

Valdostana Carni srl	Pollein	Dora Baltea	3.889	Indirect water cooling
Eltek Plast SpA	Hone	Dora Baltea	5.556	Indirect water cooling
Ge.Ca. Srl	Pollein	Dora Baltea	8.000	Indirect water cooling
C.V.A. SpA	Hone	Dora Baltea	42.222	Indirect water cooling
Mongas Srl	Issogne	Dora Baltea	1.666	Car wash and rinse off
Veralco Srl	Verrès	Dora Baltea	0.003	Several productions
Rossignol Ski SpA	Verrayes	Dora Baltea	0.694	Several productions
Nuova Ceval Srl	Nus	Dora Baltea	1.389	Several productions
Verrès SpA	Verrès	Dora Baltea	22.222	Several productions
Heineken Italia S.p.A.	Pollein	Dora Baltea	36.111	Several productions and water cooling

Table 6 *Main factory point pressures on the Dora Baltea river [taken and modified from the document: "Tipizzazione dei corpi idrici superficiali" – ARPA – Aosta Valley Region. Draft, 2010].*

The main factory in the region of Aosta, as shown by table 6 is the “Cogne Acciai Speciali Spa”, a steel factory, which is located on the river banks of Aosta town area [figures n.23 and 24].

Figure 23 “Cogne Acciai Speciali” [photo: A. Mammoliti Mochet].

Figure 24 *Cogne Acciai Speciali” [photo: A. Mammoliti Mochet].*

4.7 Garbage dumps

Garbage dumps are located in the Aosta Valley plane, very close to the river. The main garbage dump is located in Brissogne, a town south-east from Aosta. Another dump for "*special waste*" is located in Pontey [figures n. 25 and 26].

Figure 25 *The special waste dump of Pontey [photo: A. Mammoliti Mochet].*

Figure 26 *The Brissogne dump for common waste [google earth snapshot].*

4.8 Sand and gravel pits on the river banks

Sand and gravel pits are located on Dora Baltea river banks, all over the length of river and directly in contact. Examples are reported in figures n.27 and 28.

Figure 27 *Sand and gravel pits on Dora Baltea river [personal archive].*

Figure 28 *Sand and gravel pits on Dora Baltea river [personal archive].*

4.9 Natural and protected areas

Conservation areas are located on the Dora Baltea river such as the “Marais” area in Morgex and “Les Iles” area in Brissogne as shown in figures n. 29 and 30.

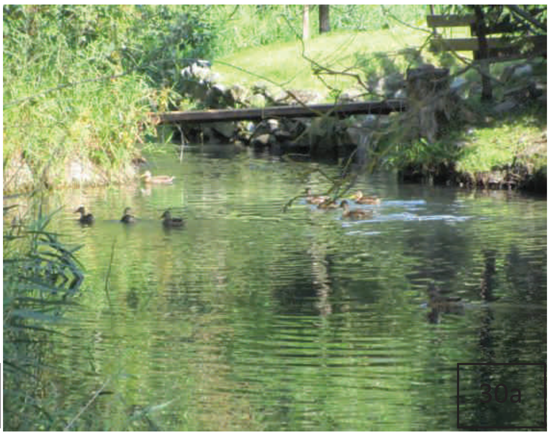

Figure 29 *The “Les Iles” protected area located in Brissogne [photo A. Mammoliti Mochet].*

Figure 30 a,b,c *The “Marais” conservation area located in Morgex [photo A. Mammoliti Mochet].*

5. MATERIALS AND METHODS

As written in section 1.2.1 the indexes used for this thesis are:

- **IFF**, "Fluvial Functionality Index" (*Indice di funzionalità fluviale (Siligardi et al., 2007).*
- **RCEs-IAR**, "R*iparian channel environment simplified, human impacts on rivers" (Beltrame et al., 1993).*
- **SREFF**, "method for the screening of the ecosystem resources of the rivers" *Metodo per lo Screening delle Risorse Ecosistemiche delle Fasce Fluviali a supporto della pianificazione, (Ferrarato et al., 2003).*

SREFF and RCEs-IAR indexes have been applied with the help of a GIS software (*Geographic Information Software*); 90 stretches for each side of Dora Baltea river have been created and analyzed by a single observer, starting from Courmayeur down to Pont Saint Martin. These stretches strictly correspond with the 90 IFF stretches previously identified following the field investigations needed by the IFF method.

The calculation of SREFF, RCEs-IAR indexes has been performed using the available data sources listed below:

- IFF dataset of the Dora Baltea river – from Courmayeur municipality to Morgex municipality (data owner: ARPA Valle d'Aosta).
- IFF dataset of the Dora Baltea river – from Morgex municipality to Pont Saint Martin municipality (data owner: CVA S.p.A.).
- IFF monitoring dataset for the higher portion of the Dora Baltea river (data owner: ARPA Valle d'Aosta).
- Aosta Valley Region aerial images (years 2000 and 2006) (data owner: Aosta Valley Region Administration).
- Raster and numeric topographic GIS layers (data owner: Aosta Valley Region Administration).
- Census of the Dora Baltea hydraulic works (data owner: Aosta Valley Regional Environment Protection Agency).
- River Basin Management Plan thematic indexes (data owner: Aosta Valley Region Administration).

5.1 Application of indexes

The following section illustrates the step by step application of the SREFF, RCE-s-IAR methods using ESRI GIS (Arc Map®, Arc Catalog®) and IFF field application method.
In relation to SREFF and RCEs-IAR the section is articulated as a complete "how to" for allowing further applications and/or repetitions of the indexes calculation.

In relation to IFF we took the application and calculation methods from the official handbook; the results have been mapped using Arc Map® and elaborated using Microsoft Excel®.

5.2 IFF calculation

IFF index has been applied by a team of observers in several days of field surveys defining 90 river stretches supported by the analysis of aerial images. As written before, the same 90 stretches have been considered for the SREFF and RCEs-IAR indexes calculation.

The sampling work consists in walking all along the river banks, from downstream to upstream filling the IFF form. For each stretch a IFF form, is composed by an headline as shown in figure n.31 that the observers have to fill with the location data and 14 questions [figures n.32, 33]. There are 4 possible answers for each question.

Basin…………………………………Stream name……………………………………………
Location……………………………………………………………………………………………
Stretch (metres)…………… high flow river width (metres)……… altitude…………
date……………record no…………………… photo no……………… code………………

Figure 31 *Headline of the IFF form [taken from The use of the fluvial functioning index for river management, P.Negri et al. 2009].*

side	Left		Right
1) Land use pattern of the surrounding area			
Undisturbed forests, woods and/or natural wetlands	25		25
Meadows, pasture, woods, a few areas of arable and uncultivated land	20		20
Mainly seasonal cultivation and/or mixed arable and/or permanent cultivation	5		5
Urbanised area	1		1
2) Vegetation of primary perifluvial zone (fluvial zone around watercourse)			
Arboreal riparian formations	30		30
Shrub riparian formations (shrubby willow thicket) and/or reeds	25		25
Non-riparian arboreal formations	10		10
Non-riparian bushes or grass or no vegetation	1		1
2b) Vegetation of secondary perifluvial zone			
Arboreal riparian formations	20		20
Shrub riparian formations (shrubby willow thicket) and/or reeds	15		15
Non-riparian arboreal formations	5		5
Non-riparian bushes or grass or no vegetation	1		1
3) Extention of the perifluvial vegetation zone			
Perifluvial vegetation zone >30 m	20		20
Perifluvial vegetation zone 5-30 m	15		15
Perifluvial vegetation zone1-5 m	5		5
Perifluvial vegetation zone absent	1		1
4) Continuity of the perifluvial vegetation zone			
Perifluvial vegetation zone without interruption into vegetation	20		20
Perifluvial vegetation zone with interruption in vegetation	10		10
Frequent interruption or only continuous and consolidated herbaceous growth	5		5
Soil without or with thin herbaceous vegetation	1		1
5) Water conditions of the river bed			
Width of the annual peak flow bed less than three of the wet river bed		20	
With of the annual peak flow bed more than three times that the wet river bed with discharge fluctuations with seasonal return		15	
With of the annual peak flow bed more than three times that of the wet river bed with discharge fluctuations with frequent return		5	
Wet river bed non-existent or almost non-existent or presence of impermeabilisation of the river bed		1	
6) Stream bank structure			
Bank with arboreal vegetation and/or stones	25		25
Bank with grass and bushes	15		15
Bank with a fine grass layer	5		5
Bare banks	1		1
7) Retention structures of trophic matter			
River bed with large boulders and/or old trunks firmly embanked or presence of reeds or hydrophytes		25	
Boulders, cobbles and/or branches present with depositing of sediment or scarce and not extensive reeds or hydrophytes		15	
Retention structures free and mobile during flood events or absence of reeds or hydrophytes		5	
River bed with sandy sediment without hydrophytes or smooth artificial profile with uniform current		1	

Figure 32 *Questions 1-7 of the IFF index [taken from: The use of the fluvial functioning index for river management, P.Negri et al. 2009].*

8).Erosion			
Little evident and not important	20		20
Only at bends and/or narrow passages	15		15
Frequent with cutting of the banks and of roots	5		5
Very evident with undercutting of banks and landslips or presence of artificial intervention	1		1
9).Cross-section			
Natural		15	
Natural with some artificial intervention		10	
Artificial with some natural elements		5	
Artificial		1	
10) River bed structure			
Diversified and stable		25	
Movable in stretches		15	
Easily moveable		5	
Cemented		1	
11) Riffles, pools or meanders			
Clearly distinguished and recurrent		25	
Present at different distances and at irregular intervals		20	
Long pools which separate short riffles or vice versa, few meanders		5	
Meanders, riffles and pools absent, straightened path		1	
12) Vegetation in the wet river bed			
Periphyton: only noticeable on touching and/or low covering of macrophytes		15	
Periphyton: visible and/or limited covering of macrophytes		10	
Periphytion: fair, presence of filamentous algae and/ or high coverage of macrophytes		5	
Periphyton thick and/or or very high coverage of macrophytes		1	
13) Detritus			
Presence of leaves and woods, vegetable fragments recognisable and fibrous		15	
Leaves and woods scarce, vegetable fragments fibrous and pulpy		10	
Pulpy fragments		5	
Anaerobic detritus		1	
14) Macrobenthonic community			
Well structured and diversified, appropriate to the fluvial type		20	
Sufficiently diversified but with altered structure as compared to what expected		10	
Poorly balanced and diversified with a prevalence of taxa tolerant of pollution		5	
Absence of a structured community, presence of few taxa, all tolerant of pollution		1	
Total Score			
Fluvial Functioning Level			

Figure 33 *Questions 8-14 of the IFF index [taken from: The use of the fluvial functioning index for river management, P.Negri et al. 2009].*

5.2.1 The calculation of the functionality levels

The sum of the score of the single answers gives the final evaluation of the functionality of the right and left side of the river stretch. This total score represent the IFF value which can vary from 18 to 300 corresponding to a coded color as shown in the following table [figure n. 34].

FFI Value	Functionality level	Functionality evaluation	Colour
261 – 300	I	High	Blu
251 – 260	I-II	high – good	Blu-green strips
201 – 250	II	Good	Green
181 – 200	II-III	Good – moderate	Green – yellow
121 – 180	III	Moderate	Yellow
101 - 120	III – IV	Moderate – scarce	Yellow – orange
61 – 100	IV	Scarce	Orange
51 – 60	IV – V	Scarce – bad	Orange – red
14 – 50	V	Bad	Red

Figure 34 *The final evaluation table for IFF [taken from P. Negri et al., 2009].*

The results of the IFF method can be directly displayed on maps using a GIS software [figure n.35].

Figure 35 *Example of a GIS mapping of IFF values along Dora Baltea river [taken and modified from Gis software].*

5.3 RCEs-IAR calculation

As above mentioned, the RCEs-IAR index is applied with the help of a GIS analysis software. The same 90 stretches length of the IFF and SREFF indexes have been considered. This method resulted to be much faster than the SREFF method but less exhaustive and less fitting to the Aosta Valley context.

The calculation of the RCEs-IAR index is made answering to 12 questions. The different phase of RCEs-IAR index elaboration are split as follow:

- Aerial images are loaded in the software with the linear shapefile composed by the stretches of interest of the Dora Baltea river.
- A Microsoft Excel table has been prepared in order to obtain an automated method, as shown in table 14 where each line represents a stretch defined by a progressive number named *SHARE_ID*, and each column corresponds to a question of the RCEs-IAR method.

Questions are divided into 2 sections:

RCE (riparian channel environment) section:

- Question 1: River bed naturalness, going from 30 points for a completely natural stretch down to 1 point for a completely artificial stretch.
- Question 2: Riparian vegetation, forest = 25 points, shrubs = 20 points, grassland = 5 points, no vegetation = 1 point.
- Question 3: Riparian vegetation width, over 30m = 30 points, between 5 and 30 m = 20 points, between 1 and 5 m = 5 points, no riparian vegetation = 1 point.
- Question 4: Riparian vegetation integrity, no interruption of the riparian vegetation = 20 points, interruption of over 50 m = 10 points, many interruptions and erosion = 5 points, riparian zone completely altered = 1 point.
- Question 5: Riparian vegetation stability, well-established vegetation = 30 points, vegetation under evolution = 20 points, unstable vegetation = 5 points, seasonal vegetation = 1 point.
- Question 6: Surrounding territory state, forests or completely natural = 15 points, grasslands = 10 points, intensive farming = 5 points, urbanized = 1 point.

IAR (human activities impacts) section:

- Question 1a: distance of cultivations from the river, more than 1 km = 1 point, between 300 m and 1 km = 5 points, between 100 and 300m = 10 points, less than 100m = 20 points.
- Question 1b: longitudinal extension of cultivations, less than 25% of the considered stretch = 0 points, between 25 and 50% = 1 point, between 50 and 75% = 3 points, more than 75% = 5 points.

- Question 1c: cultivation typologies, grass lands = 0 points, mixed vegetation typologies = 1 point, woody species = 3 points, seasonal cultures = 5 points.
- Question 2a: gravel pits distance from the river, over 1 km = 0 points, between 500m and 1 km = 5 points, between 100 and 500m = 10 points, less than 100m = 15 points.
- Question 2b: gravel pits development on the river, less than 25% of the total length of the stretch = 0 points, between 25 and 50% = 1 point, between 50 and 75% = 3 points, more than 75% = 5 points.
- Question 2c: gravel pits typologies, re-established gravel pits = 0 points, non re-established gravel pits = 3 points, working gravel pits = 5 points, grinders = 10 points.
- Question 3a: urban areas distance from the river, over 2 km = 1 point, between 500m and 2km = 5 points, between 100 and 500m = 10 points, less than 500m = 15 points.
- Question 3b: urban areas development on the river, less than 25% of the total length of the stretch = 0 points, between 25 and 50% = 3 point, between50 and 75% = 5 points, more than 75% = 10 points.
- Question 3c: urban areas typology, rural district = 0 points, residential complex = 1 point, mixed urban areas = 3 points, industrial areas = 5 points.
- Question 4a: road system distance from the river, over 2 km = 1 point, between 500m and 2 km = 3 points, between 100 and 500m = 5 points, less than 100m = 10 points.
- Question 4b: road system typology, foothpath = 0 points, town roads = 3 points, dual carriage way = 5 points, highways and railways = 10 points.
- Question 5: human vegetation, only natural vegetation = 1 point, public parks and gardens = 5 points, re-established gravel pits = 10 points, no vegetation = 15 points.
- Question 6: urban activities on the river, no activities = 1 point, hydraulic works = 10 points, touristic activities = 15 points, garbage dumps = 25 points.

Scores are attributed by analyzing and interpreting the aerial images on GIS software and reported in the Excel table.
After the attribution to each stretch of questions scores, the method requires the partial sum of all the RCE scores and the one of all IAR scores. The results of these addition are then subtracted (RCE scores minus IAR score).
The final result is a score going from -144 to +144 on a seven classes range gives a judgment of the river quality for each stretch as shown in table n.7.

SCORE	QUALITY
BETWEEN 144 AND 98	EXCELLENT
BETWEEN 97 AND 51	GOOD
BETWEEN 50 AND 4	DECENT
BETWEEN 3 AND -3	SUFFICIENT
BETWEEN -4 AND -50	POOR
BETWEEN -51 AND -97	BAD
BETWEEN -98 AND -144	EXTREMELY BAD

Table 7 *Quality classes of the RCE-s-IAR index.*

5.4 SREFF calculation

Concerning the SREFF application, each river stretch has been mapped and analyzed as shown in figures 8 and 9, section 1.2.1. The SREFF method needs practice to be correctly applied and understood. Then, some GIS tools used for the application of this index need software extensions. The calculation has been performed following the steps listed below.

5.4.1 Preparation of the file for each stretch of the river

This phase is split as follow:

- Aerial images and shapefiles (.shp extensions) for Dora Baltea have to be loaded in the software.
- Selection of stretch of interest and creation of a new layer from the selected features, named *SREFF_n*, where n represent a progressive number, going from 1 to 90.
- Application of a 300m buffer (Arctoolbox→buffer→300m) named *SREFF_n_Buffer*.
- Start editor →create new feature (target *SREFF_n_Buffer*)→ cut 1 polygon for each side of the river which includes the 300 m buffer all over the length of the stroke of interest.
- A new polygon defined by a progressive number and a side attribute (sx or dx) has been created.

5.4.2 Sub-indexes calculation method

The calculation of SREFF sub-indexes pass through the elaboration of several minor sub-indexes. This phase is split as follow:

- **IG** (ndice geomorfologico - geo-morphological index) is composed by 2 minor sub-indexes:
  - ING (indice naturalità morfologica - geo-morphological naturalness index) considers the number of different geo-morphological elements in the considered stretch (river

islands, meanders, crossing channels, section variability…). ING score has to be defined by counting the number of different geo-morphological elements available in the considered stretch (more than 2 = 10 points, 1 or 2 = 6point, no elements = 2 points).
- IS (indice di sinuosità - sinuosity index) evaluates the sinuosity of the river stretch (low sinuosity = 1 point, high sinuosity = 2 points).
Add a field in the table of *SREFF_n* shape file and add the IG value for every considered stretch.

IG=ING*IS

- **IV** (indice vegetazionale- vegetational index) is composed by 2 minor sub-indexes:
  INV (indice naturalità vegetazionale - natural vegetation index): it evaluates the biotypes in the considered buffer.
  Divide the polygon into sub-areas defined by their biotype (see image 8, chapter 1.2.1).
  Editor → Start editing → Cut polygons features on SREFF_n_Buffer in the considered area for every biotype considered by the sub-index (forests and wetlands= 10 points, hedges= 6 points, shrubs= 5 points, grasslands= 4 points, naked soils= 3 points).
  Add a field on SREFF_n_Buffer shape file with the natural parameter given for every considered biotype (field name: VAL_NAT).
  Add a new field called *Area* and calculate the area (→ right click calculate geometry) for every new segment that has been created.
  Add a new field called *Inv* and load the formula *Inv_SREFF* and update the total area (→ calculate geometry).

  INV = Σ (Area/Tot Area) * VAL_NAT

  IVB (indice di varietà biotipica - index of biotype variety) is based on the presence of different biotype units in the considered buffer (6 different biotype units or more= 1.3 points, 4 or 5 biotype units = 1.2 points, 2 or 3 biotype units = 1.1 points, 1 biotype units = 1 point).
  Add a new field in the table SREFF_n_Buffer shape file containing the Ivb score.
  Summarize the INV values in a new db table for every stretch and add a new field to calculate **IV** index with following formula.

  IV=INV*IVB

- **IEF** (indice effetto filtro - filter effect index) considers the typology of areas in 30 and 100 meters buffers of the river banks [figure n.36]; it is composed by 2 minor sub-indexes:

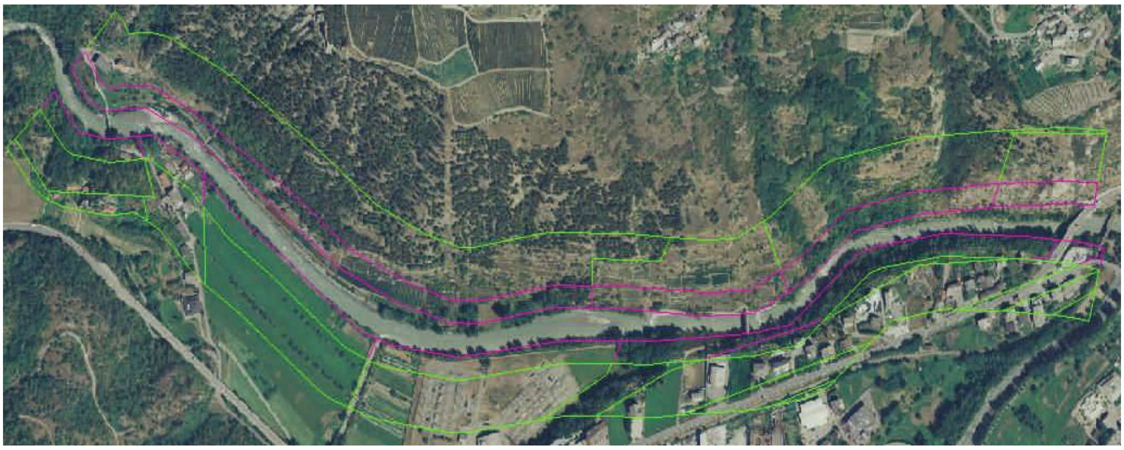

Figure 36 *The 30 m (in purple) and 100m (in green) buffers created for the application of the IEF sub-index. [taken and modified from GIS analysis software].*

TV (tipo di vegetazione nella zona riparia - typology of riparian vegetation)

The 30 meters buffer refers to the following scores: dense forest = 10 points, sparse forest = 8 points, shrubs = 7 points, grassland = 2 points;

The 100 meters buffer refers to the following scores: dense forest = 7 points, sparse forest = 4 points, shrubs = 2 points, grassland = 1 point.

Two different layers have to be considered: the SREFF_n_Buffer shape file and the river polygon (named *SHARE_ID river*).

Make a multiple ring buffer on *SHARE_ID river* with 30 m and 100 m as values.

Open the Multiple buffer shape file

Select the 30 m buffer.

Open the clip function from Arctoolbox and clip it with the INV polygon created previously (SREFF_BUFFER_CLIP_TRENTA).

Do the same for the 100 m buffer.

Repeat it for each side of the river.

Update areas for each clipped table.

Now in the 2 new shape files for each side of the river, add a new field named *"Biotype"* and insert the TV values for each polygon.

Summarize the TV sub-index values and save as a new table named *SREFF_n_Ief*.

Summarize the results of the TV value for both buffers.

IVR (integrità della vegetazione riparia natural - integrity of the natural riparian vegetation)

The IVR sub-index refers to the following scores: woody cover between 100% and 80% = 1.5 points, woody cover between 79.9% and 60% = 1.4 points, woody cover between 59.9% and 30% = 1.3 points, woody cover lower than 30% = 1.2 points, woody cover absent = 1 point.

Open *SREFF_n_Ief* table and add a field named *IVR*.

Insert the IVR score for each stretch.

Add a new field called IEF, and load the *SREFF_IEF* following formula:

IEF=TV*IVR

- **IIA** (indice impatto antropico - human impacts index)
  The IIA sub-index refers to the presence of human activities which can create impacts on the river in the 300 m buffer. The activities weights have been calculated with the AHP (*Analytic Hierarchy Process*) (Saaty,1980; Bona et al., 2000).
  Add new field in *SREFF_n_BUFFER* named *IIA_Weight*.
  Insert the IIA value for every polygon previously defined.
  Open Xtools Pro extension package in ArcMap[4]
  Click on Feature conversion → shapes to centroids
  Name the new shapefile *LIA_n*.
  Add the distance coefficient for every IIA polygon: 3 points if the centroid is under 30 meters from river banks, 2 points if the centroid is between 30 and 100m from river banks, 1 point if the centroid is over 100m from river banks.
  Multiply every IIA value with the distance coefficient and summarize them in a new table named *SREFF_n_IIA*.

  IMA (indice di modificazione dell'alveo - modification of the river bed index)
  The IMA sub-index refers to the presence of hydraulic works on the river, going from 0.1 points in stretches with no works on the river bed up to 1 point where the river bed is completely artificial.
  Add the value of IMA index in a new field of the *SREFF_n_BUFFER table*.

5.4.3 Sub-indexes normalization

Different sub-indexes have to be normalized on a 0 - 1 scale to combine them in a **State index** (taking into account **IG, IV** and **IEF** sub indexes) and a **Pressure index** (taking into account **IIA** and **IMA** sub indexes)[table n.8]. Please note that IMA sub-index is already normalized.
Sub - indexes from each stretch have been collected in a new Microsoft Excel®table.

SREFF sub-indexes	SREFF indexes
IG, IV, IEF	State Index
IIA, IMA	Pressure Index

Table 8 *SREFF sub-indexes to be considered for elaborating SREFF state and pressure indexes.*

[4] http://www.xtoolspro.com

The normalization functions to be used are reported below.

- **IG** normalization functions:
  If **IG** sub-index value is lower than 19.32 the function to be used is:
  $$Y=0.05x$$
  where Y is the normalized value of IG and x is the IG original value (not normalized).

  If the **IG** sub-index value is value higher than 19.32 the function to be used is:
  $$Y=0.0019x + 0.9295$$
  where Y is the normalized value of IG and x is the IG original value (not normalized).

- **IV** sub-index normalization functions:
  If the **IV** sub-index value is lower than 8.3 the function to be used is:
  $$Y=-0.0035x^2 + 0.146x - 0.0216$$
  where Y is the normalized value of IV and x is the IV original value (not normalized).

  If the **IV** sub-index value is higher than 8.3 the function to be used is:
  $$Y=0.0176x + 0.8235$$
  where Y is the normalized value of IV and x is the IV original value (not normalized).

- **IEF** sub-index normalization function:
  $$Y=-0.0015x^3 + 0.0285x^2 - 0.0378x + 0.0311$$
  where Y is the normalized value of IEF and x is the IEF original value (not normalized).

- **IIA** sub-index normalization function:
  $$Y=-0.00009x^3 + 0.0022x^2 + 0.0408x$$
  where Y is the normalized value of IIA and x is the IIA original value (not normalized).

5.4.4 Sub-indexes aggregation

In the following step **IG, IEF** and **IV** sub-indexes are calculated with the given formula in order to obtain the value of the **State Index**:

STATE INDEX= IG * 0.2 + IV * 0.35 + IEF * 0.45

IIA and **IMA** sub-indexes are then calculated with the following formula in order to obtain the value of the **Pressure Index**:

PRESSURE INDEX = IIA * 0.7 + IMA * 0.3

State and pressure indexes range (going from 0 to 1) allows to assign a class as reported in the following table [table n.9].

Class	value
HIGH	> 0.8
MEDIUM-HIGH	0.61 – 0.8
MEDIUM	0.41 – 0.6
MEDIUM-LOW	0.21 – 0.4
LOW	< 0.2

Table 9 *Classes for state and pressure indexes values.*

5.4.5 Final degradation evaluation method

The final step of SREFF calculation includes the crossing of the State Index class with the Pressure Index class with the given table defining a 10-classes degradation status [tables n.10 and 11].

	state index class					
		high	**medium - high**	**medium**	**medium - low**	**low**
pressure index class	**high**	7	8	8	9	10
	medium – high	6	7	8	8	9
	medium	5	6	7	7	8
	medium – low	3	4	5	6	7
	low	1	2	3	4	5

Table 10 *Table for the final evaluation.*

degradation classes	
1	NO DEGRADE
2	INSIGNIFICANT DEGRADE
3	LOW DEGRADE
4	MEDIUM-LOW DEGRADE
5	MEDIUM DEGRADE
6	MEDIUM-HIGH DEGRADE
7	HIGH DEGRADE
8	VERY HIGH DEGRADE
9	EXTREMELY HIGH DEGRADE
10	MAXIMUM DEGRADE

Table 11 *Degradation classes.*

5.5 Processing of indexes

5.5.1 Indexes elaboration

Indexes have been calculated all over Dora Baltea river separately. The layout maps are based on the IFF colors chart. The limit scores of each class of the three used indexes have been normalized and graphically represented in chart n. 1. Colors have been decided on the base of the IFF values, SREFF index has the same colors of IFF index but one more class, the number "X" (tenth) class, that has been colored in black. RCEs-IAR is composed by seven classes, the colors have been decided in order to minimize the variances between indexes and to have a comparable representation method.

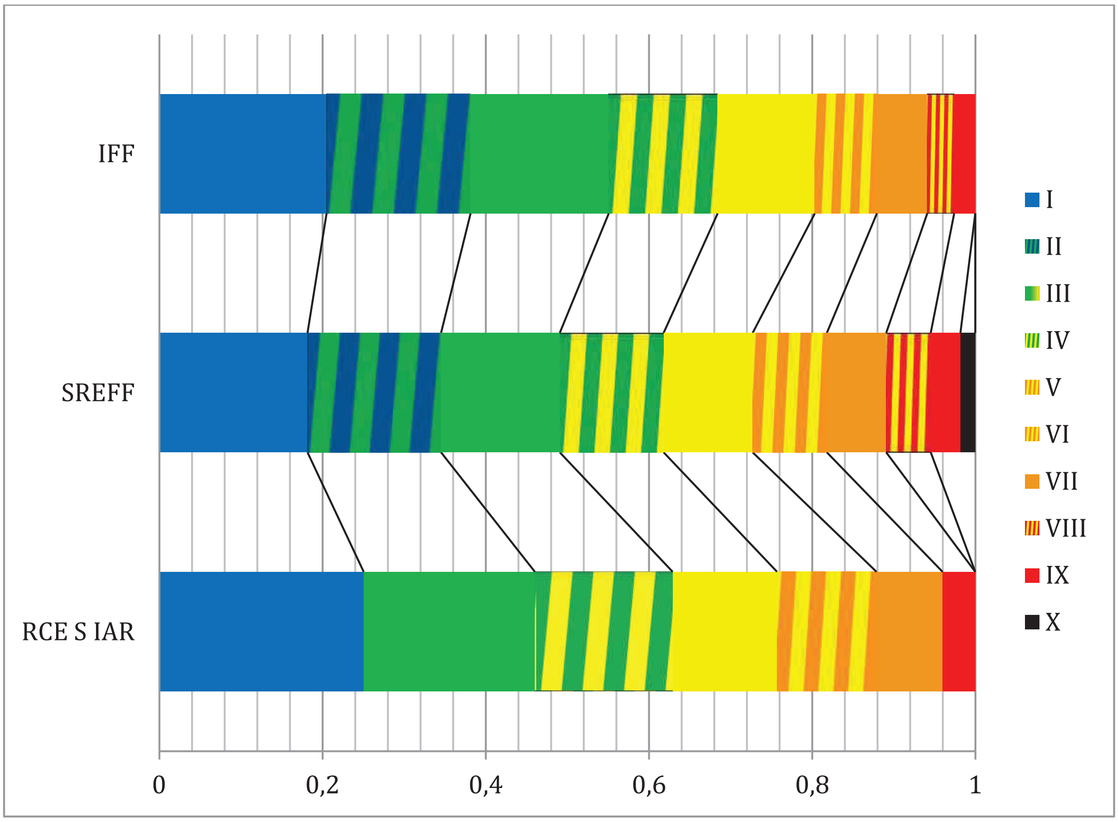

Chart 1 *SREFF, IFF, RCEs-IAR classes ranges.*

Successively indexes scores have been reported in Microsoft Excel® tables as left bank and right bank values and as average score for each stretch.

Indexes scores have been compared by means of correlation coefficient (cross correlation) and synchronicity indexes, namely the GLK index and the t-value.

Cross correlation is a standard method of estimating the degree to which two series are correlated.

GLK index, (from the German "Gleichläufigkeit") is a tool than calculates the percentage of parallel variations between two data series. The Gleichläufigkeit (GLK index) is frequently used in dendrochronology to compare couples of time series (Schweingruber, 1988), however it can be used also to compare any couple of data series: the scores range from 0 (no synchronicity) to 100 (full synchronicity).

T-value, the t-test is used to assess whether the means of two groups are *statistically* different from each other.

The obtained values for the three progressive and contiguous groups of reaches are shown in the results chapter.

5.5.2 The *TeleHybrid (TH)* index creation

A reasoned selection of sub-indexes of SREFF and RCEs-IAR has been done extracting the ones better corresponding to IFF main components represented in the official index questions. The selected sub- indexes are listed below:

- SREFF sub-indexes: **Iia** (indice di impatto antropico) and **Ima** (indice di modificazione in alveo)
- RCEs-IAR sub indexes: **question 1**: river bed naturalness, **question 2**: riparian vegetation, **question 3**: riparian vegetation width, **question 4**: riparian vegetation integrity, **question 5**: riparian vegetation stability.

SREFF index and RCEs-IAR index values have been collected in spreadsheets and multiplication weight coefficients for each considered sub-index have been used as shown in table n. 12. The main method consisted in a iterative process of calibration of a new index named *TeleHybrid (TH)* in order to obtain a new tool to be applied by means of photo interpretation to better predict the IFF values.

	Ig	Iv	Ief	Iia	Ima		RCE Domada 1	RCE Domada 2	RCE Domada 3	RCE Domada 4	RCE Domada 5	RCE Domada 6	IAR Domanda 1 abc	IAR Domanda 2abc	IAR Domanda 3abc	IAR Domanda 4 ab	IAR Domanda 5	IAR Domanda 6	TOTALE IFF	THINDEX
INDEX VALUE	0,0	0,0	0,0	0,0	0,0		0	0	0	0	0	0	0	0	0	0	0	0		
WEIGHT	0,0	0,0	0,0	10,0	10,0		1,5	1,7	1,0	10,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0		
STRETCH n.	0,1	0,6227	0,1518	0,3584	1,0		0	1	1	1	5	1	1	13	25	13	1	1	79	60,63

Table 12 *The TH index iterative approach example.*

The complete equation of *TeleHybrid (TH)* is reported below:

$$\begin{aligned} TH\ index = {} & [(Ig * weight) + (Iv * weight) + \ (Ief *\ weight) \\ & +\ (RCE\ question\ 1 *\ weight) +\ (RCE\ question\ 2 *\ weight) \\ & +\ (RCE\ question\ 3 *\ weight) +\ (RCE\ question\ 4 *\ weight) \\ & +\ (RCE\ question\ 5 *\ weight) +\ (RCE\ question\ 6 *\ weight)] \\ & - [\ (Iia *\ weight) +\ (Ima * weight)\ (IAR\ question\ 1\ abc *\ weight) \\ & +\ (IAR\ question\ 2\ abc *\ weight) +\ (IAR\ question\ 3\ abc *\ weight) \\ & +\ (IAR\ question\ 4\ ab *\ weight) +\ (IAR\ question\ 5 *\ weight) \\ & +\ (IAR\ question\ 6 *\ weight) + k] +\ (flow\ weight * flow\ z - score) \end{aligned}$$

where “k” is intended as an additive coefficient used to lessen the constant offset between TH and IFF. Please note that when weight coefficient is equal to 0, the related sub index is not considered.

5.5.3 The Dora Baltea river natural discharges dataset

Following first plotting of IFF and TH indexes data, an upstream – downstream gradient of differences between indexes was in evidence, as shown in chart n.2.

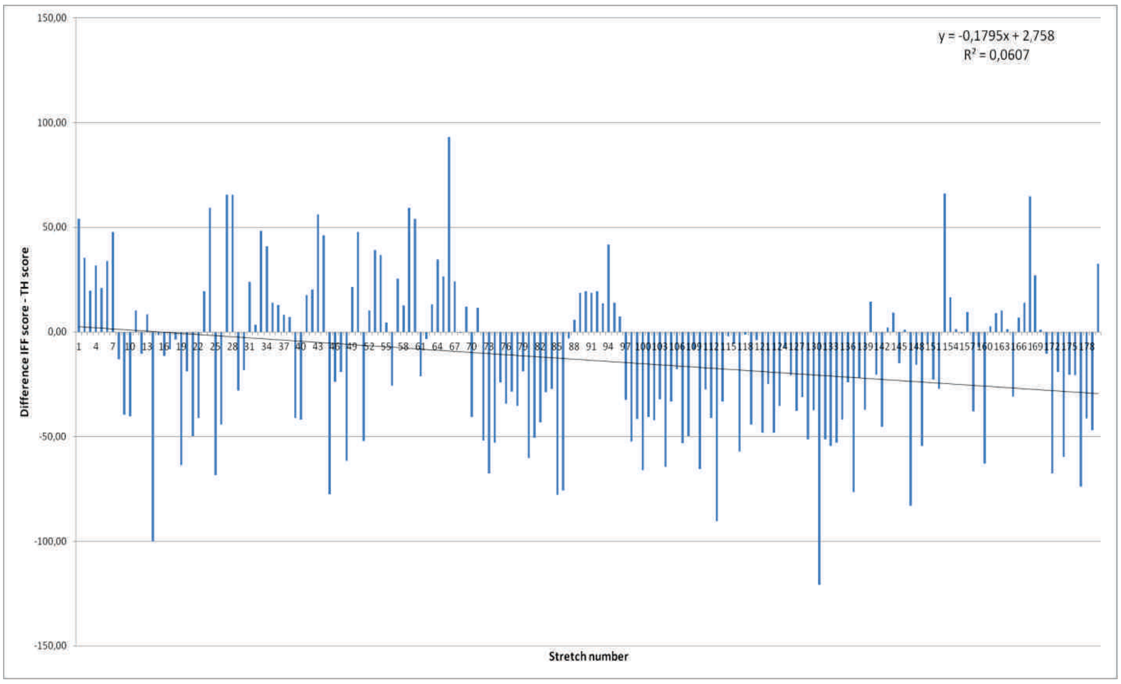

Chart 2 *Differences between IFF scores and original TH scores: a negative trend is evidenced by the interpolated linear equation.*

For this reason, an investigation about possible natural gradient oriented factors was performed considering environmental parameters as flood plain presence and width, average elevation of the stretches and average natural discharges influencing river shape. Only the last one showed significant fitness with the upstream- downstream gradient previously noticed.

Monthly data of natural discharges have been considered using datasets collected by 6 official monitoring stations over Dora Baltea located in Hone, Pontey, Nus, Pollein, Champdepraz and Pré Saint Didier as shown in figure 37.

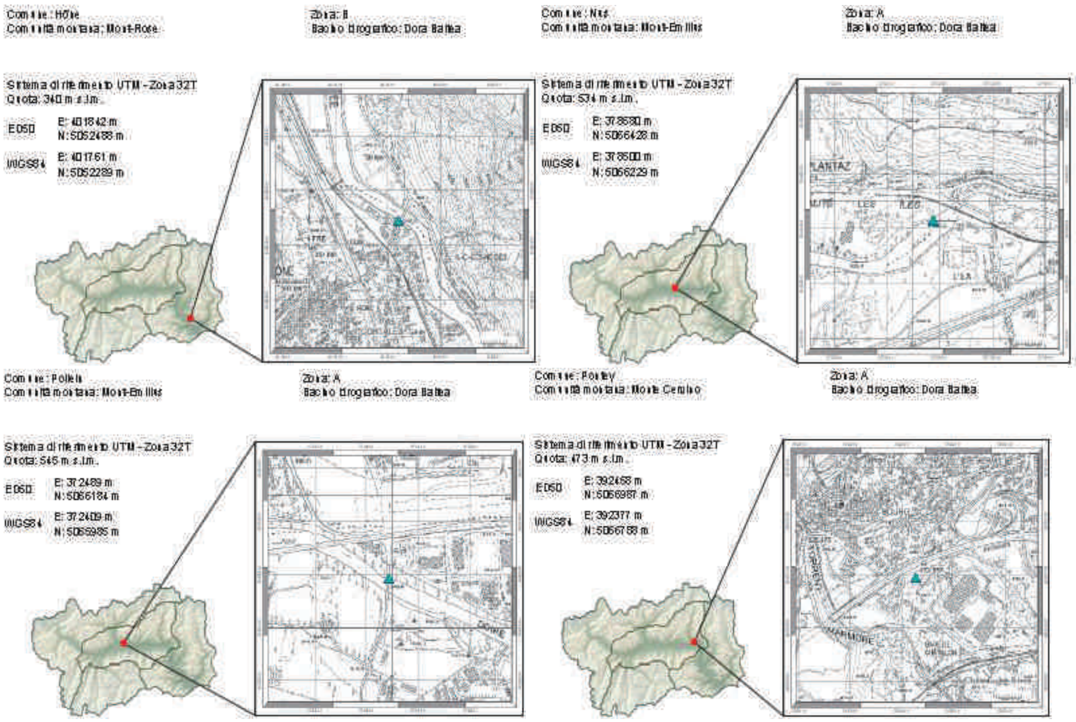

Figure 37 *The Pontey, Pollein, Nus and Hône natural discharges monitoring stations. [taken and modified from RAVA (2001)].*

The dataset time range considered vary from 2001 to 2010 representing last decades typical flow average monthly patterns as shown in chart n.3.

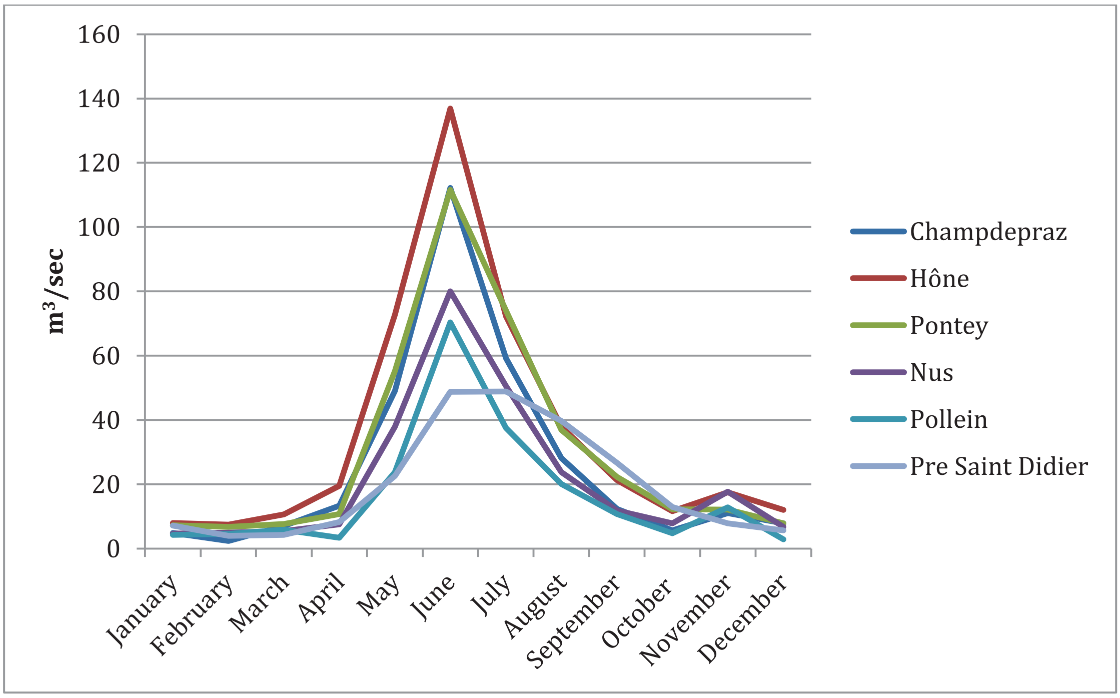

Chart 3 *Average monthly flows on Dora Baltea river [taken and modified from RAVA (2001)].*

The average monthly discharge of June has been considered as the most influencing the Dora Baltea shape and several natural components monitored by indexes. In fact, June flows are the highest of the year and the less influenced by frequent and diffused modifications such as hydropower facilities presence and consequent heavy flow alteration and hydraulic works.

The maximum values of June monthly flows for every monitoring stations have been inserted in chart n.4, considering the stretch location of each discharge monitoring station and the related mean June discharge.

A line of tendency has been drawn and his equation has been used to derive the flows of each stretch over Dora Baltea river, also considering the results of regionalization curves of River Basin Management Plan.

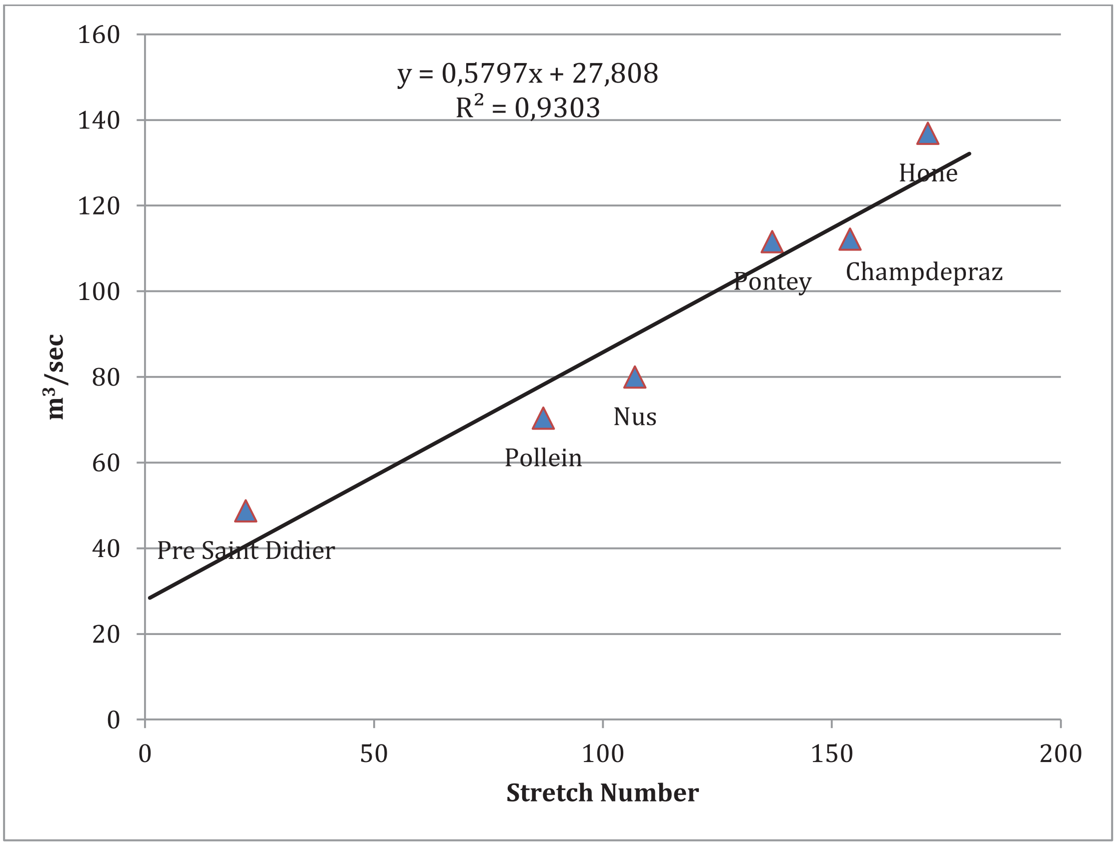

Chart 4 *Tendency of the flows monitoring stations over Dora Baltea river.*

For each stretch, the obtained flow values have been transformed in their z-scores showing how many standard deviations are above or below the mean. Z-scores values have been finally used as additive factors to be inserted in the equation of TH index calculation.

IFF original values and TH corrected values with flows z-scores differences between indexes are represented in chart n.5

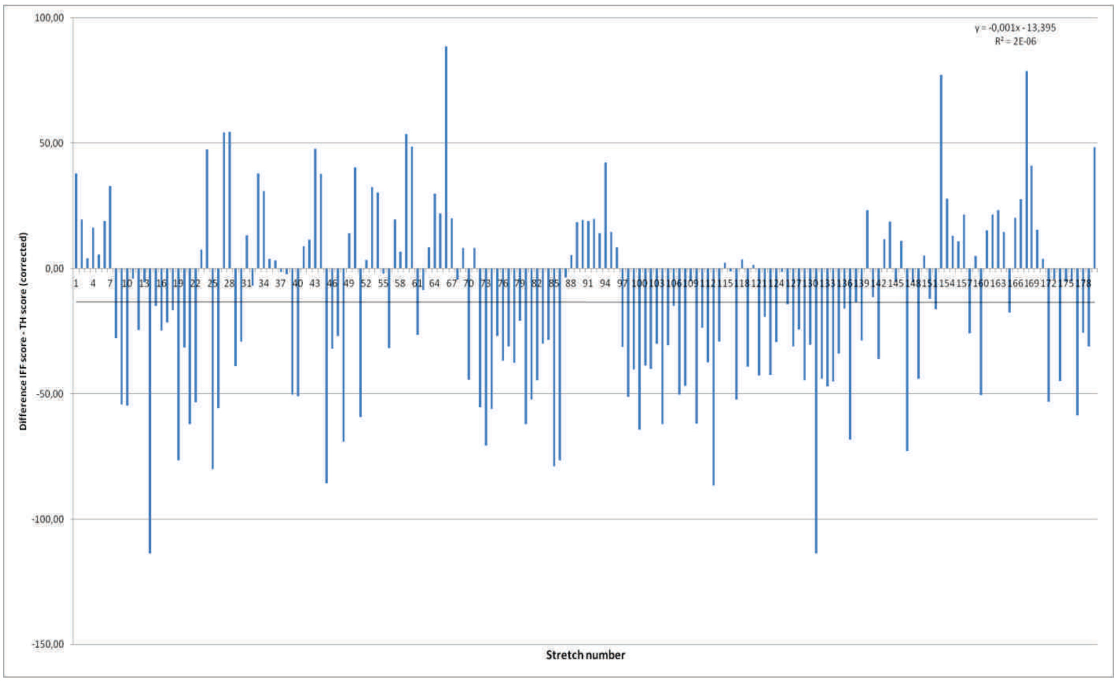

Chart 5 D*ifferences between IFF scores and TH corrected values with flows z –scores: an almost neutral trend is evidenced by the interpolated linear equation.*

Consequently the natural average June discharges obtained z-scores have been used to finely tune the TH index dataset.

6. RESULTS

For each stretch and related river bank the values of SREFF, RCEs-IAR and IFF indexes and related sub-indexes have been listed and are available in the appendix A chapter.

The same values have been plotted in different colors corresponding to indexes classes in the figures below.

The values of every index considered show a lower quality in the central part of Dora Baltea river (from Sarre to Quart) corresponding to the most urbanized perifluvial sector of the study area. In this sector IFF values seems to be more homogenous while SREFF and RCEs-IAR values are more variable.

North western sector (from Courmayeur to Sarre) generally shows the highest values for all indexes, excepted the first seven upstream reaches (from the source of Dora Baltea to Pré Saint Didier), displaying a low quality and corresponding level of conservation of riparian areas in addition to strong riverbed modifications.

South eastern sector (from Quart to Pont Saint Martin) commonly shows good values stretches sometimes interrupted by lower quality stretches mainly due to the presence of hard modified reaches, hydropower facilities and perifluvial urbanization.

Results are shown in figures n. 38, 39 and 40 and in related n. 13, 14 and 15 tables, detailing the number of stretches for each index class.

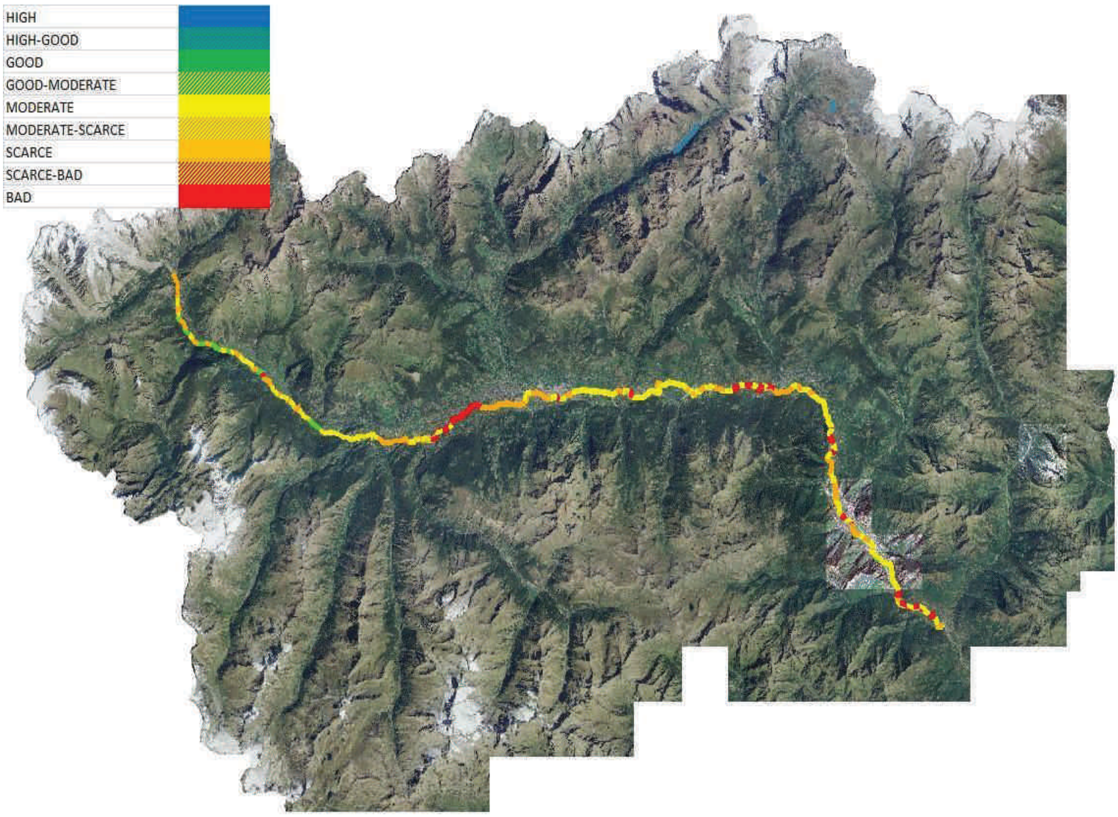

Figure 38 *IFF representation map.*

IFF	N. STRETCHES
II GOOD	12
II-III GOOD-MODERATE	6
III MODERATE	40
III-IVMODERATE-SCARCE	27
IV SCARCE	65
IV-V SCARCE-BAD	24
V BAD	6

Table 13 *Number of stretches for each IFF class.*

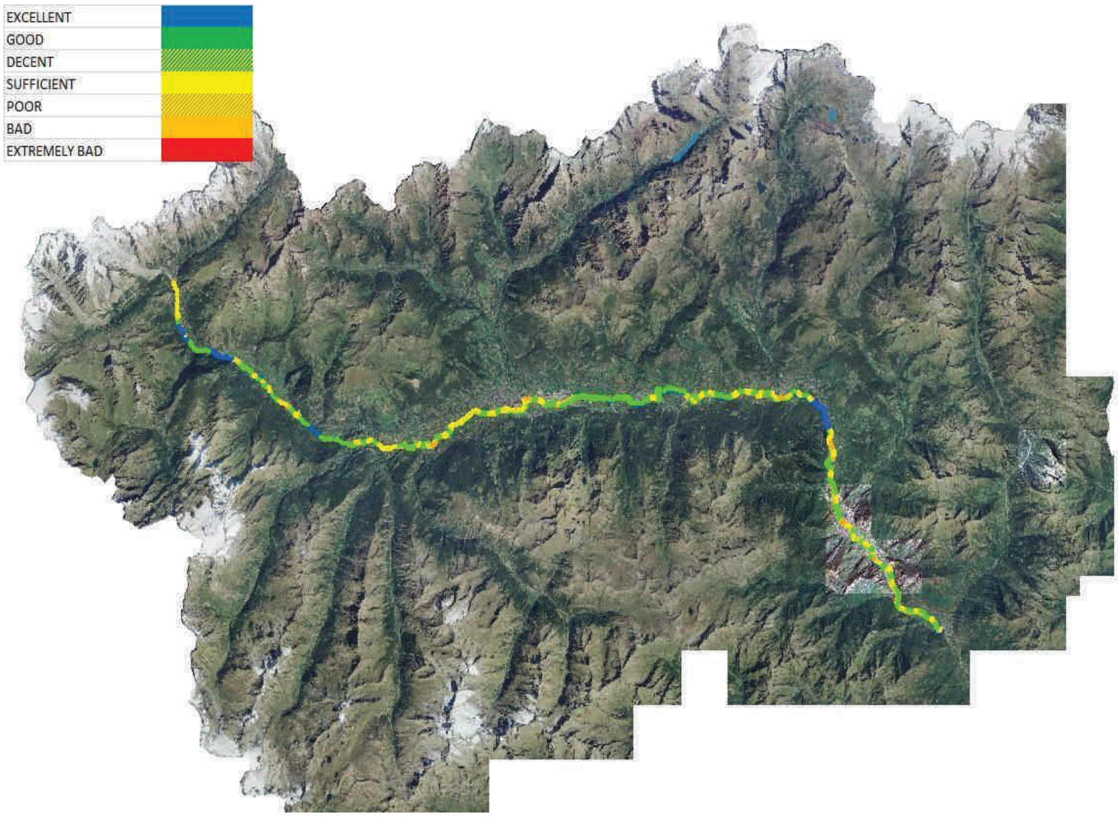

Figure 39 *RCEs-IAR representation map.*

RCES-IAR	N. STRETCHES
EXCELLENT	29
GOOD	53
DECENT	60
SUFFICIENT	7
POOR	30
BAD	1

Table 14 *Number of stretches for each RCEs-IAR class.*

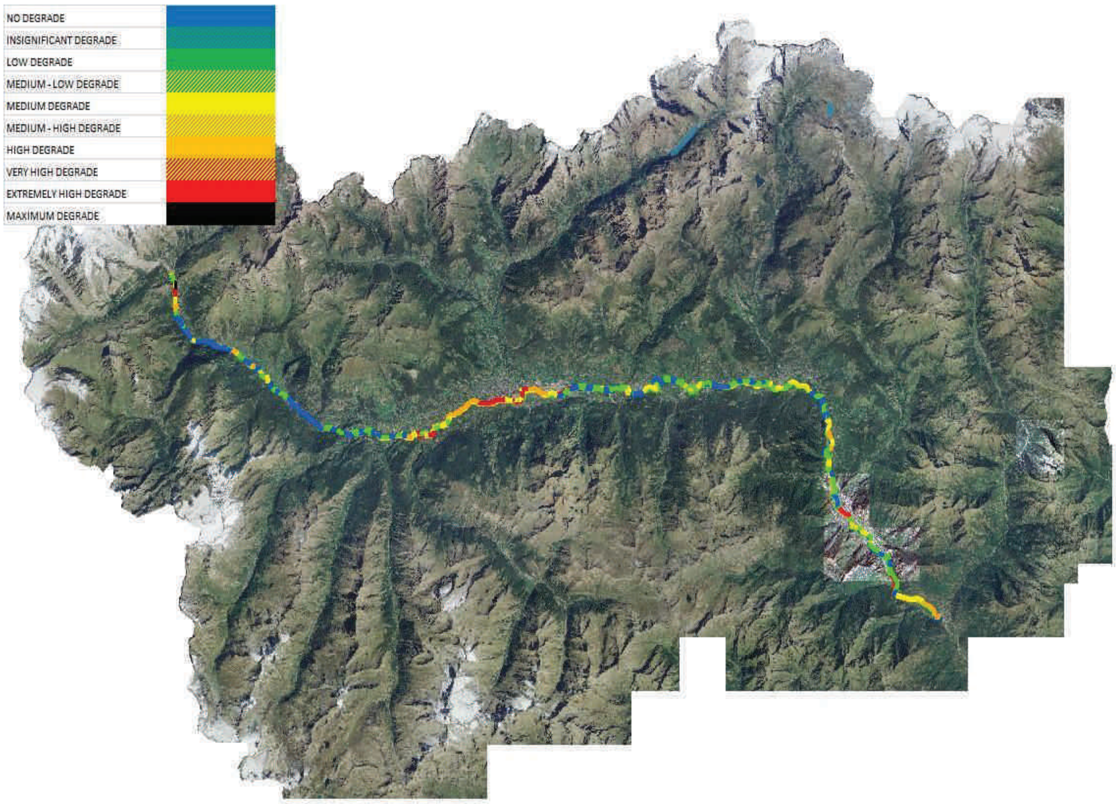

Figure 40 *SREFF representation map.*

SREFF	N. STRETCHES
NO DEGRADE	35
INSIGNIFICANT DEGRADE	42
LOW DEGRADE	21
MEDIUM - LOW DEGRADE	29
MEDIUM DEGRADE	13
MEDIUM - HIGH DEGRADE	13
HIGH DEGRADE	12
VERY HIGH DEGRADE	5
EXTREMELY HIGH DEGRADE	9
MAXIMUM DEGRADE	1

Table 15 *Number of stretches for each SREFF class.*

The comparison of trends of different indexes has been done coupling each index data series of the entire river and for the two different sub regions above mentioned (north western sector and south eastern sector) [table n. 16]. The central sector wasn't considered for the comparison due to evident mismatching of indexes values.

TRATTO COMPLETO		IFFnum				SREFFnum			
		GLK	GSL	%CC	t-value	GLK	GSL	%CC	t-value
	IFFnum	100	-	100	100				
	SREFFnum	67	***	56	9	100	-	100	100
	RCEIARnum	77	***	50	7,8	79	***	64	11,2
TRATTO 1-72		IFFnum				SREFFnum			
		GLK	GSL	%CC	t-value	GLK	GSL	%CC	t-value
	IFFnum	100	-	100	100				
	SREFFnum	74	***	65	7,2	100	-	100	100
	RCEIARnum	82	***	69	8	81	***	72	8,7
TRATTO 97-180		IFFnum				SREFFnum			
		GLK	GSL	%CC	t-value	GLK	GSL	%CC	t-value
	IFFnum	100	-	100	100				
	SREFFnum	65	**	43	4,3	100	-	100	100
	RCEIARnum	76	***	43	4,3	84	***	70	8,9

Table 16 *The application of GLK, T-value and cross correlation statistical tools. The performance of each index has been compared with the other analyzed indexes.*

In general, all the comparisons over the entire study area resulted statistically highly significant ($P<0.001$) meaning a good synchronicity between the series.
In the entire study area the comparison between IFF and SREFF, IFF and RCEs-IAR showed the higher values of synchronicity (up to 77%) between IFF and RCEs-IAR. However, highest values were found between SREFF and RCEs-IAR (up to 79%). In the south-eastern sector, as generally shown from the maps, SREFF and RCEs-IAR showed again high values of synchronicity (up to 84%) but IFF trend is better synchronized with RCEs-IAR (76%) than with SREFF (65%).

For each stretch and related river bank also the values of TH index were calculated, as shown in figure n.41. Highest scores are located in the north-western part of Dora Baltea river, worst situations are mostly present in the south-eastern part of the river. The Aosta plain values are higher if compared to the IFF scores on the same stretches.

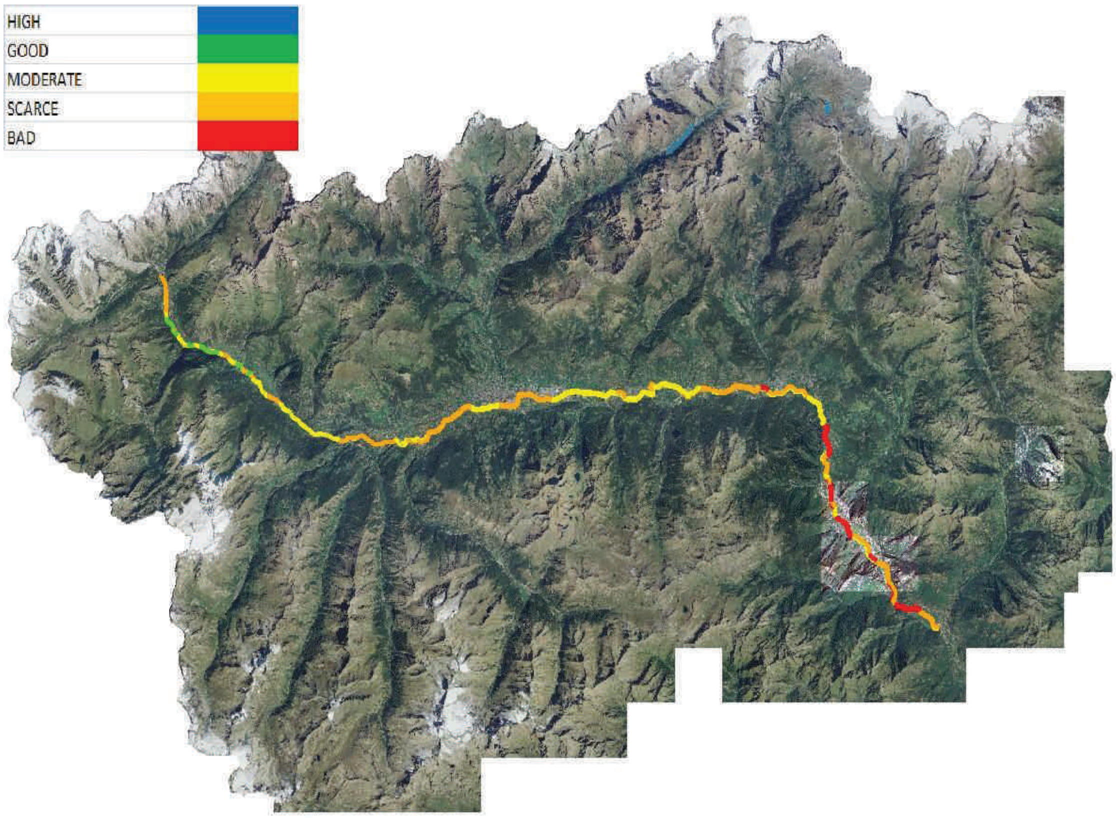

Figure 41 *TeleHybrid (TH) index representation map.*

Chart n.6 represents both IFF index scores and TH index scores in the 180 stretches (going from 1 Courmayeur to 180 Pont Saint Martin). The two indexes show a good synchronicity, especially in the higher and lower portions of the Dora Baltea river. It's also possible to notice a good matching in the respective indexes classes.

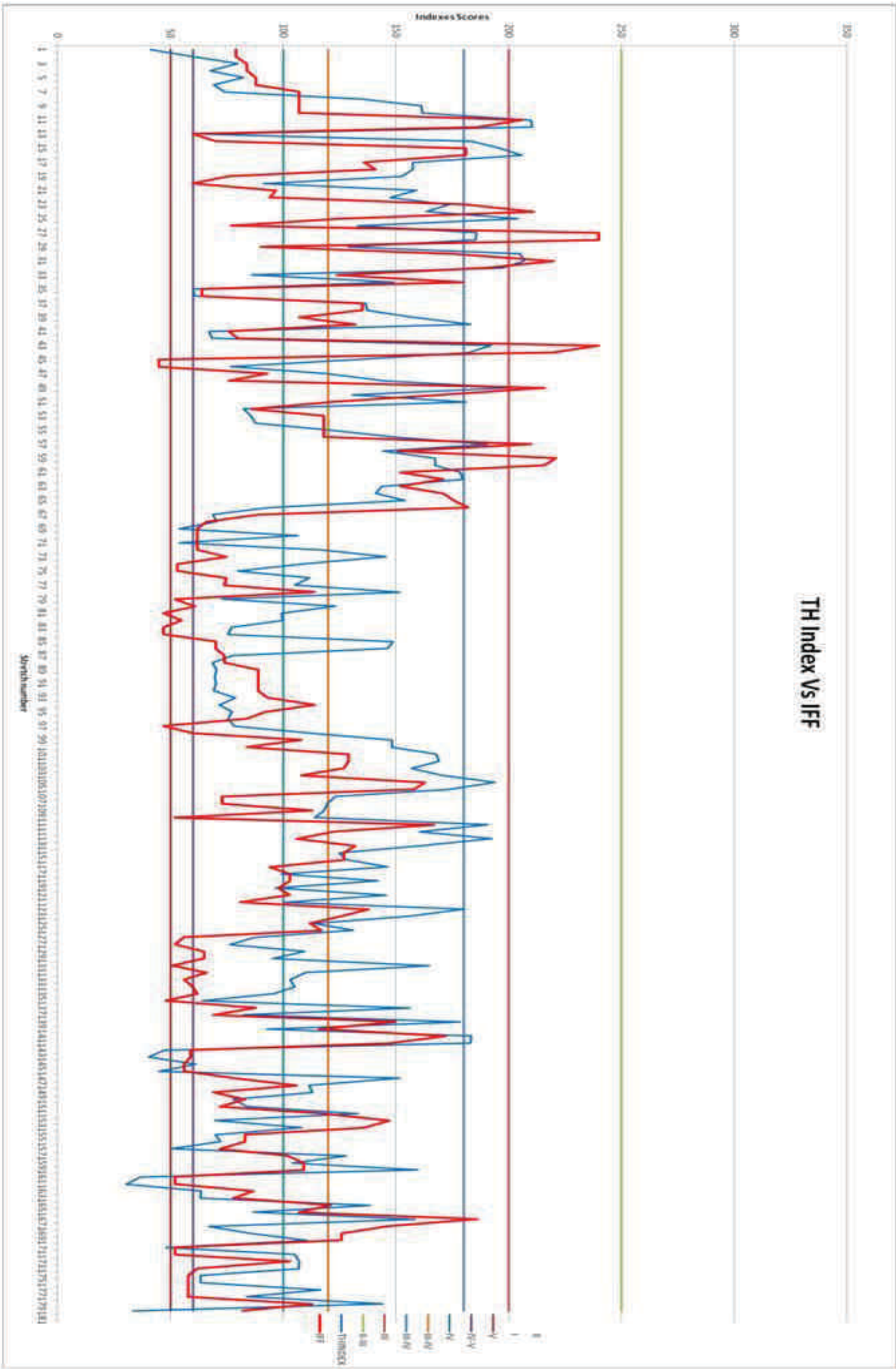

Chart 6 *IFF scores and TH scores over the Dora Baltea river, horizontal lines define the indexes class limits, see figure n.32 in materials and methods chapter.*

The calculation of synchronicity indexes between the two series revealed that IFF and TH indexes have highly significant synchronous changes , up to 72% on the whole river, cross correlation and t-values are respectively 69% and 12,8 [chart n.7]. Higher synchronicity was found in the higher portion of the river, stretches 1 to 72. The lower part of the river (stretches 97 to 180) showed a lower synchronicity but still highly significant ($p<0.001$).

COMPLETE		IFFscore			
		GLK	GSL	%CC	t-value
	IFFscore	100	-	100	100
	THscore	72	***	69	12,8
STRETCHES 1 - 72		IFFscore			
		GLK	GSL	%CC	t-value
	IFFscore	100	-	100	100
	THscore	76	***	72	8,8
STRETCHES 97 - 180		IFFscore			
		GLK	GSL	%CC	t-value
	IFFscore	100	-	100	100
	THscore	69	***	64	7,5

Chart 7 *Synchronicity indexes calculated for IFF Vs TH series.*

The calculation of the Pearson's correlation coefficient between TH and IFF indexes on a window of 31 stretches shifted of one stretch at the time, revealed that in the central part of the study area, corresponding to the town of Aosta, the correlation coefficient drops down to zero (no correlation). Chart n.8 shows also that in the higher part of the Dora Baltea river the correlation between the two indexes is more stable than in the lower part of the river. Moreover it passes from values ranging from about 0,7-0,8 to values ranging about 0,5-0,8.

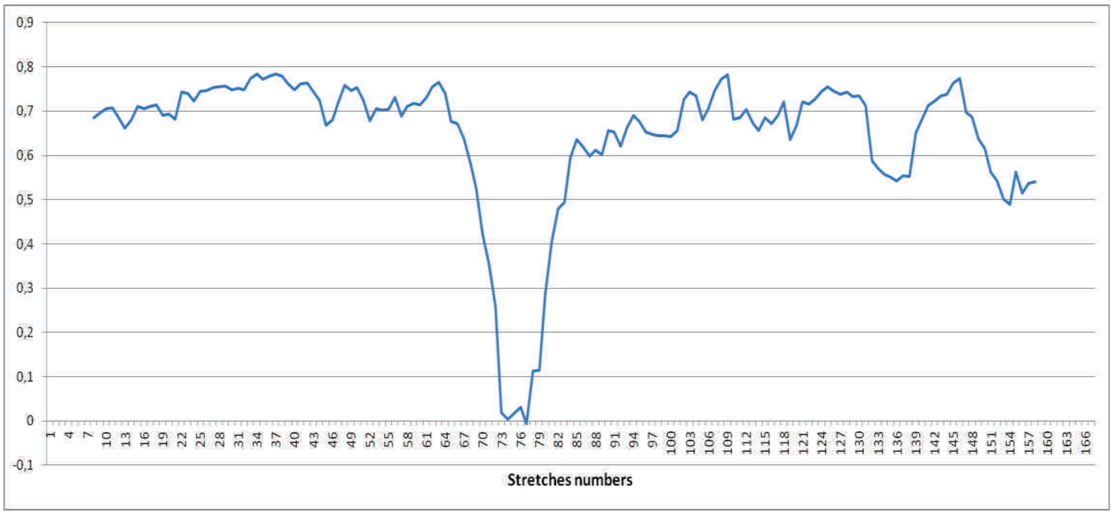

Chart 8 *The Pearson's correlation coefficient calculated between TH and IFF indexes, on groups of 31 stretches at the time.*

The count of stretches where the two indexes present the same class was performed on the whole Dora Baltea river. In total in 130 stretches over 180 (72%) the indexes classes were matching. Specifically the best performance was found in class IV stretches (82%), the worst performance was found in class V stretches (61%). Results are shown in table n.17

	Stretches matching	Stretches MISmatching	Total stretches	% Match
CLASS II	13	4	17	76%
CLASS III	46	26	72	64%
CLASS IV	60	13	73	82%
CLASS V	11	7	18	61%
Total	130	50	180	72%

Table 17 *Number of stretches matching and mismatching for IFF and TH indexes.*

The regression of IFF over TH index has been performed as shown in chart n.9. The best fitting regression line found is an order-two polynomial function, showing that TH index can explain up to 53% of the IFF variability. In general low TH values predict better IFF values than high TH values, as shown by the higher scatter around the tendency line in the right part of the chart.

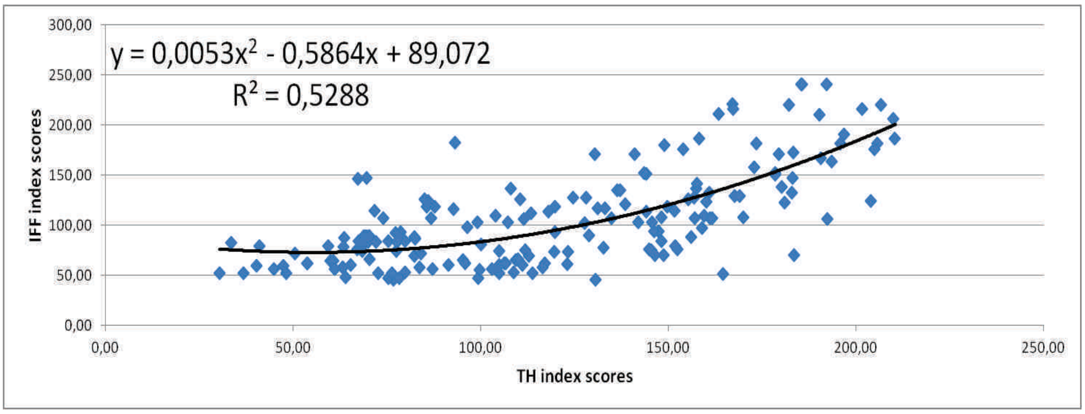

Chart 9 *Regression of IFF over TH index and tendency line.*

The model here proposed for estimating IFF from TH index is still rough and further elaboration on datasets should be performed.

7. DISCUSSION

This work was based on the application and comparison between field-based and aero photogrammetric based methods for the assessment of riparian vegetation status and river ecological functionality. The aim was to find less time and resources consuming methods, to support the Dora Baltea river management in Aosta Valley.

The selection of methods that could be applied in the Aosta Valley Region, followed a review of 11 methods (with an aero photogrammetric based approach) already used in the world and in Europe. Finally, for their characteristics and the availability of the required data sources, SREFF and RCEs-IAR resulted the best indexes specific for the Alpine context: they are based on photo interpretation and can be applied on embedded rivers and at any altitude. Other available indexes required additional data support such as infra-red aerial images and LIDAR and where therefore excluded (Abati and Leonelli, 2011).

IFF index is officially considered in the Regional set of law and it is the most linked to the ecological conditions *inside* the river. Being a field method, it includes several ecological indicators that of course cannot be considered from any aero photogrammetric based approach. For example, the IFF requires the evaluation of macrobenthonic communities, vegetation in the wet riverbed and fish suitability. This index is more focused on the wet channel ecosystem than on the surrounding areas. Therefore the riparian vegetation is well described but the human impacts on territory near the river are less considered (Siligardi *et al., 2007)*. An evident example of these characteristics is given by the stretches close to the urban area of Aosta (stretches from number73 to 96): here IFF values are still rather high if compared to the results obtained with the other indexes.

RCEs-IAR resulted to be easier to be implemented and less time consuming, however it was not perfectly fitting with the regional context, especially for what concerns the description of some potential human impacts and the agricultural land uses (Beltrame et al.,1993) . This index was applied in two days over the whole Dora Baltea and the resulting series of values showed an high synchronicity with SREFF and IFF (always highly significant values of Glk index in all the comparisons).

The application of SREFF index was performed in about two months, and required a rather high amount of calculations and computational efforts. It is based on well defined quantitative sub-indexes related to the characteristics both of the river and the surrounding areas (Ferrarato *et al,*.2003). Every sub index is calculated on the relative area covered by each characteristics, and therefore it gives a rather well defined knowledge of the stretches. Its synchronicity with the IFF resulted always lower than the one obtained between IFF and RCEs-IAR, but still statistically highly significant over the entire study area (Schweingruber, F.H., 1988).
This index is more focused on detailing the pressures and the impacts on the river, as resulted, e.g., in the urban stretches of Aosta.

Synchronicity between data series resulted rather high in all the comparisons (especially between IFF and RCEs-IAR, the latter being partially derived from IFF). This result indicates that the variations in the river ecosystem quality along the Dora Baltea are well intercepted by all indexes.

IFF	N. STRETCHES	% OF STRETCHES
II GOOD	12	7%
II-III GOOD-MODERATE	6	3%
III MODERATE	40	22%
III-IVMODERATE-SCARCE	27	15%
IV SCARCE	65	36%
IV-V SCARCE-BAD	24	13%
V BAD	6	3%

Table 18 *IFF index, number and % of stretches per class.*

RCES-IAR	N. STRETCHES	% OF STRETCHES
EXCELLENT	29	16%
GOOD	53	29%
DECENT	60	33%
SUFFICIENT	7	4%
POOR	30	17%
BAD	1	1%

Table 19 *RCEs-IAR index, number and % of stretches per class.*

SREFF	N. STRETCHES	% OF STRETCHES
NO DEGRADE	35	19%
INSIGNIFICANT DEGRADE	42	23%
LOW DEGRADE	21	12%
MEDIUM - LOW DEGRADE	29	16%
MEDIUM DEGRADE	13	7%
MEDIUM - HIGH DEGRADE	13	7%
HIGH DEGRADE	12	7%
VERY HIGH DEGRADE	5	3%
EXTREMELY HIGH DEGRADE	9	5%
MAXIMUM DEGRADE	1	1%

Table 20 *SREFF index, number and % of stretches per class.*

As shown in table n. 18, IFF assigns a low level of functionality (from moderate to scarce) to 3 over 4 stretches of the river while RCEs-IAR, as depicted in table 19, assigns the same percentage of stretches to higher classes (from excellent to decent). This simple consideration demonstrates the inner differences between the two indexes as reported in chart n. 1 of material and methods chapter. At the same time, table 20 displays the same RCEs-IAR trend for SREFF, grouping 71% of stretches in the first degradation classes.

This study indirectly shows also the different vocation of indexes considered and indicates when and why it's better to use an index or another. When the user needs a more selective and *protection* oriented assessment of river status, the more performing method seems to be IFF while RCEs-IAR and SREFF better detail impacts presence and perifluvial areas land uses modification.

These clear differences between indexes have been considered for the elaboration of the TH index as a selection of sub-indexes and hydrological parameters. TH index has been elaborated in order to predict with a good reliability the IFF scores.

The creation of the TH index has been performed as described in materials and methods chapter. The iterative process of tuning has been refined to obtain the best correspondence with IFF scores. The best sub indexes set has been found using two sub-indexes of the SREFF index (Iia and Ima see materials and methods chapter) and five sub-indexes of the RCEs-IAR index (questions 1,2,3,4,5), as shown in table n. 12. Moreover the natural flows discharges data have been included in the TH index calculation.

As shown in the results chapter the indexes (TH and IFF) showed highly significant synchronicity all over the whole length of the Dora Baltea river (Aosta area excluded). Higher synchronicity values were found in the higher part of the river (stretches 1-72), whereas in the lower part of the river the indexes synchronicity was lower but still highly significant. The TH index is less variable than the IFF index, and its mean values on the higher part of the river reach lower scores than IFF; in the Aosta area instead TH scores are mainly higher than IFF scores. In the lower part TH scores are mainly higher than IFF scores (see chart n.6 in the results chapter).

The different kind of perifluvial areas (more natural areas in the upper and lower sections, urbanized areas in the Aosta plain) evidences a different sensibility of the two indexes which in fact present a good correlation in the upper and lower stretches (more natural) than in the Aosta area stretches (more urbanized). This is also well evidenced by the abrupt drop in the correlation coefficient values calculated and showed in chart n.8.
The main result of this thesis is the very good matching between IFF and TH scores in the defined functionality classes. The TH classes predict 72% of IFF index classes: 130 stretches over 180 were matching the IFF classes. This fact means that TH index, mainly based on a photo interpretative approach can predict IFF functionality classes derived from a field based approach.
However it must be considered that the two indexes have a different sensitivity to changes that may occur in the fluvial and perifluvial ecosystems, because of their different structure. For example, IFF that is based also on ecological parameters (e.g. macrobenthonic communities, water plants and fish communities) fast responds to local point pollution and to local hydro-peaking effects. Instead TH index is less sensitive to these components unless a change on the perifluvial vegetation structure and extension is brought on a longer time scale.

IFF is sensitive to hydro-peaking effects, bed load size and related trophic retention compounds, local erosion and biotic communities status, however TH index presents several operative advantages such as regional scale assessment of fluvial functionality, relatively fast computational methods, quantitative calculation of structural parameters of the perifluvial areas in a 300 meters buffer from the river banks.
In only three cases over 50, of mismatch the error was of two classes of difference between IFF and TH indexes, in all the other mismatching stretches the error was of one class (above or below).

The regression of IFF over TH scores underlined that the 180 TH and IFF scores are fitted by a polynomial regression line of second order: the relationship however showed also that especially the high values of IFF are not well predicted by TH index (see the large scatter in the higher-right part of chart n.9). As a first approach, the model showed that TH values can explain up to 53% of IFF variability. More specific elaboration on the data series (e.g. data normalizations or transformations) should permit the optimization of the model performance.

Another enforceable approach could be related to the fine tuning of the TH sub-indexes weights or the introduction of further environmental parameters showing a gradient along the Dora Baltea river. In particular the TH index needs additional factors for fitting better the IFF in the urbanized areas. For example, the density of hydrological works per stretch in the river bed could be added as a new parameter to the TH index in order to better predict IFF scores in urbanized areas.
At this stage the TH index values already include an hydrological parameter (the average natural discharges) that showed a gradient along the river which allowed us to improve the predictive performance of the TH classes. The use of this feature in the TH index is considered very significant because in Dora Baltea river, a glacial regime river, the natural liquid and solid flows strongly influences the river ecology and functionality. Finally, the inclusion of the natural discharges has brought an ecological characteristic to the TH index.

8. CONCLUSIONS

The aims of this thesis consisted in reviewing the available approaches for assessing river status in Alpine water courses, determine which aero photogrammetric method or metric of index could fit better to the field based IFF index and possibly define a new index of fast application.
Since IFF series on the Dora Baltea river was incomplete (the north-western part, from Morgex up to the conjunction of Dora di Veny and Dora di Ferret in the Courmayeur municipality was missing) as a first step the IFF dataset was completed by field sampling the 44 remaining stretches. Overall the work was finished in three days and was performed with a team of 5 skilled observers walking along river banks.
The review of the eleven indexes revealed that only the RCEs-IAR index, and the SREFF index were enforceable in an Alpine context, with an aero photogrammetric approach.
I performed the application of RCEs-IAR and SREFF indexes working on GIS based programs: 180 stretches for each index were calculated as depicted in materials and methods. The GIS analysis was performed, for both indexes, in two days and two months, respectively. Both indexes showed different vocations. RCEs-IAR is of easy and fast implementation, however for the description of some potential human impacts and the agricultural land uses it was not perfectly fitting with the regional context. SREFF index is based on several quantitative sub-indexes related to the characteristics both of the river and the surrounding areas; this index is more focused on detailing the pressures and the impacts on the river, as resulted, e.g., in the urban stretches of Aosta.
As a first result RCEs-IAR and SREFF showed too marked differences with the IFF index. Therefore we performed the elaboration of the TH index as a selection of sub-indexes and hydrological parameters. The new index has been created in order to predict with good reliability the IFF index scores just by using GIS technologies. The new index, called *TeleHybrid* (TH), was applied on the Dora Baltea river in Aosta Valley.
Based on the results of the thesis the TH index showed a highly significant synchronicity with the IFF index, meaning that those indexes respond in a similar way to changes in the river ecosystem quality.
In particular, TH index was able to predict 72% of the IFF classes over the 180 studied river stretches, meaning that TH index can predict in a fairly good way the potential IFF class of a stretch.
The comparison between IFF and TH scores showed that in the higher part of the Dora Baltea river the correlation coefficient calculated over a window of 31 stretches shifted of one stretch at the time was high (values ranging from about 0,7 to 0,8). In the lower part of Dora Baltea the correlation coefficient was lower and more variable (values ranging from about 0,5 to 0,8) but still significant. In the central part of the river, corresponding to the town of Aosta, the correlation coefficient dropped down to zero showing no correlation between IFF and TH scores. These results indicates that in urbanized contexts the current version of the TH index do not well predict the IFF values.
The regression of IFF over TH index showed that TH index can explain up to 53% of the IFF variability. TH index predicts well IFF especially for low values, whereas high values of TH are less performing in predicting the IFF values.

The TH index at this level of implementation should be considered as a “beta version”: new data are required in order to have good results in different situations (e.g. the most urbanizes areas). For example the density of hydrological works per stretch or other river ecological parameters can be included in the TH index for better predicting the IFF values, especially in the urbanized areas.

The inclusion of these parameters should improve the performance of TH model in predicting IFF values.

Finally this work has shown that by means of a photogrammetric approach it is possible to predict the classes of a field based index such as IFF. With the TH index, for any stretch, it is possible to predict the expected IFF class and it can proposed as new tool for river management in the Alpine context, being less time and resources consuming than field based methods.

In particular, it has to be noticed that, at present, TH index can be implemented to obtain a first screening of river status to be eventually validated by direct IFF sampling: this opportunity suggests a potential use of TH index for river management and planning as a proxy of IFF. This opportunity could be strongly considered in case of river basins without related IFF datasets.

However the TH index, being based on a photogrammetric approach does not respond to fast changes potentially occurring in the river ecosystem such as point pollution, short terms hydro-peaking and short terms disturbances in general. On the other hand if the mentioned disturbances acts on a longer time scale they will change also the structure of the perifluvial buffer being therefore also evidenced, in lomger times, by aerial images approaches such as the TeleHybrid (TH) index.

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11. APPENDIX A

	SREFF	Ig	Iv	Ief	Iia	Ima	Indice di stato	Indice di Pressione
1	**7 DEGRADO ALTO**	0,1	0,6227	0,1518	0,3584	1,0	0,3063	0,5509
2	**4 DEGRADO MEDIO - BASSO**	0,1	0,9726	0,9059	0,0091	1,0	0,7681	0,3064
3	**10 DEGRADO MASSIMO**	0,1	0,1609	0,1033	0,7638	1,0	0,1228	0,8347
4	**5 DEGRADO MEDIO**	0,1	0,5111	0,5679	0,0511	1,0	0,4544	0,3357
5	**9 DEGRADO ESTREMAMENTE ALTO**	0,1	0,0746	0,2842	0,4915	1,0	0,1740	0,6440
6	**7 DEGRADO ALTO**	0,1	0,5845	0,4232	0,2646	1,0	0,4150	0,4852
7	**6 DEGRADO MEDIO - ALTO**	0,3	0,4126	1,0000	0,3725	1,0	0,6544	0,5607
8	**6 DEGRADO MEDIO - ALTO**	0,3	0,4993	1,0000	0,2332	1,0	0,6848	0,4633
9	**4 DEGRADO MEDIO - BASSO**	0,3	0,5461	1,0000	0,1305	0,7	0,7011	0,3014
10	**3 DEGRADO BASSO**	0,3	0,9879	1,0000	0,0579	0,7	0,8558	0,2506
11	**1 ASSENZA DI DEGRADO**	0,6	0,8044	1,0000	0,0682	0,1	0,8516	0,0777
12	**1 ASSENZA DI DEGRADO**	0,6	0,9870	1,0000	0,0000	0,1	0,9155	0,0300
13	**3 DEGRADO BASSO**	0,3	0,6320	0,3874	0,0533	0,5	0,4555	0,1873
14	**1 ASSENZA DI DEGRADO**	0,3	0,9858	1,0000	0,0000	0,5	0,8550	0,1500
15	**1 ASSENZA DI DEGRADO**	0,3	0,9859	1,0000	0,0020	0,5	0,8551	0,1514
16	**1 ASSENZA DI DEGRADO**	0,3	0,9859	1,0000	0,0020	0,5	0,8551	0,1514
17	**2 DEGRADO IRRILEVANTE**	0,3	0,5182	1,0000	0,0635	0,5	0,6914	0,1945
18	**1 ASSENZA DI DEGRADO**	0,3	0,9859	1,0000	0,0230	0,5	0,8551	0,1661
19	**2 DEGRADO IRRILEVANTE**	0,1	0,7175	1,0000	0,0214	0,5	0,7211	0,1650
20	**4 DEGRADO MEDIO - BASSO**	0,1	0,7221	0,1911	0,0570	0,5	0,3588	0,1899
21	**2 DEGRADO IRRILEVANTE**	0,1	0,6862	0,8658	0,0253	0,5	0,6498	0,1677
22	**6 DEGRADO MEDIO - ALTO**	0,1	0,3115	0,2530	0,1808	0,5	0,2429	0,2766
23	**1 ASSENZA DI DEGRADO**	0,3	0,9796	1,0000	0,0497	0,3	0,8529	0,1248
24	**1 ASSENZA DI DEGRADO**	0,3	0,9864	1,0000	0,0279	0,3	0,8553	0,1095
25	**1 ASSENZA DI DEGRADO**	0,1	0,9927	1,0000	0,0053	0,5	0,8174	0,1537
26	**1 ASSENZA DI DEGRADO**	0,1	0,9696	1,0000	0,0658	0,5	0,8094	0,1961
27	**1 ASSENZA DI DEGRADO**	1,0	1,0000	1,0000	0,0158	0,3	0,9935	0,1011
28	**1 ASSENZA DI DEGRADO**	1,0	1,0000	1,0000	0,0124	0,3	0,9935	0,0987
29	**3 DEGRADO BASSO**	0,5	0,6071	0,6238	0,1004	0,3	0,5932	0,1603
30	**1 ASSENZA DI DEGRADO**	0,5	0,9930	1,0000	0,0167	0,3	0,8975	0,1017
31	**1 ASSENZA DI DEGRADO**	0,5	0,9339	1,0000	0,0344	0,1	0,8769	0,0541
32	**1 ASSENZA DI DEGRADO**	0,5	0,9828	1,0000	0,0000	0,1	0,8940	0,0300
33	**3 DEGRADO BASSO**	0,5	0,3228	0,5829	0,0805	0,3	0,4753	0,1464
34	**1 ASSENZA DI DEGRADO**	0,5	1,0000	1,0000	0,0000	0,3	0,9000	0,0900
35	**7 DEGRADO ALTO**	0,3	0,0434	0,2149	0,2035	0,5	0,1719	0,2925
36	**5 DEGRADO MEDIO**	0,3	0,8969	0,3711	0,1064	0,5	0,5409	0,2245
37	**4 DEGRADO MEDIO - BASSO**	0,1	0,1255	0,4576	0,1543	0,1	0,2698	0,1380
38	**2 DEGRADO IRRILEVANTE**	0,1	0,5963	1,0000	0,0598	0,1	0,6787	0,0719
39	**3 DEGRADO BASSO**	0,5	0,3179	0,7269	0,1434	0,3	0,5384	0,1904
40	**1 ASSENZA DI DEGRADO**	0,5	0,9246	1,0000	0,0443	0,3	0,8736	0,1210
41	**7 DEGRADO ALTO**	0,3	0,1580	0,1023	0,2601	0,7	0,1614	0,3921
42	**6 DEGRADO MEDIO - ALTO**	0,3	0,7727	0,0819	0,1219	0,7	0,3673	0,2953
43	**1 ASSENZA DI DEGRADO**	0,5	0,7421	1,0000	0,0677	0,3	0,8097	0,1374
44	**2 DEGRADO IRRILEVANTE**	0,5	1,0000	0,6678	0,0579	0,3	0,7505	0,1306
45	**4 DEGRADO MEDIO - BASSO**	0,3	0,9876	0,6904	0,0402	0,7	0,7163	0,2382
46	**5 DEGRADO MEDIO**	0,3	0,4973	0,3924	0,0543	0,7	0,4106	0,2480
47	**4 DEGRADO MEDIO - BASSO**	0,6	0,4973	1,0000	0,0367	0,7	0,7440	0,2357
48	**4 DEGRADO MEDIO - BASSO**	0,6	0,4973	0,8356	0,0515	0,7	0,6701	0,2461
49	**1 ASSENZA DI DEGRADO**	0,6	1,0000	1,0000	0,0085	0,3	0,9200	0,0959
50	**2 DEGRADO IRRILEVANTE**	0,6	0,4973	0,9679	0,0635	0,3	0,7296	0,1345
51	**2 DEGRADO IRRILEVANTE**	0,3	0,9816	0,4849	0,0347	0,3	0,6218	0,1143
52	**2 DEGRADO IRRILEVANTE**	0,3	0,4973	0,9275	0,1024	0,3	0,6514	0,1617
53	**2 DEGRADO IRRILEVANTE**	0,6	0,6763	0,8668	0,0533	0,5	0,7468	0,1873
54	**3 DEGRADO BASSO**	0,5	0,3548	0,7485	0,0230	0,3	0,5610	0,1061
55	**1 ASSENZA DI DEGRADO**	0,6	0,7762	0,9540	0,0365	0,3	0,8210	0,1156
56	**1 ASSENZA DI DEGRADO**	0,6	0,8178	1,0000	0,0892	0,3	0,8562	0,1524
57	**1 ASSENZA DI DEGRADO**	0,5	1,0000	1,0000	0,0000	0,3	0,9000	0,0900
58	**1 ASSENZA DI DEGRADO**	0,5	0,8159	1,0000	0,0529	0,3	0,8356	0,1270
59	**1 ASSENZA DI DEGRADO**	0,5	0,9841	1,0000	0,0327	0,3	0,8944	0,1129
60	**1 ASSENZA DI DEGRADO**	0,5	0,9915	1,0000	0,0000	0,3	0,8970	0,0900
61	**2 DEGRADO IRRILEVANTE**	0,5	0,6620	1,0000	0,1174	0,3	0,7817	0,1721

62	**2 DEGRADO IRRILEVANTE**	0,5	0,6644	1,0000	0,0053	0,3	0,7825	0,0937
63	**3 DEGRADO BASSO**	0,5	0,3648	0,7485	0,0230	0,3	0,5645	0,1061
64	**2 DEGRADO IRRILEVANTE**	0,3	0,6098	0,9648	0,0552	0,5	0,7076	0,1886
65	**2 DEGRADO IRRILEVANTE**	0,3	0,6098	0,9648	0,0552	0,5	0,7076	0,1886
66	**2 DEGRADO IRRILEVANTE**	0,3	0,6098	0,9648	0,0552	0,5	0,7076	0,1886
67	**5 DEGRADO MEDIO**	0,3	0,4098	0,6527	0,2194	0,5	0,4971	0,3036
68	**2 DEGRADO IRRILEVANTE**	0,3	0,6098	0,9648	0,0552	0,5	0,7076	0,1886
69	**5 DEGRADO MEDIO**	0,3	0,4097	0,6495	0,2194	0,5	0,4957	0,3036
70	**4 DEGRADO MEDIO - BASSO**	0,3	0,4392	0,8155	0,1819	0,5	0,5807	0,2773
71	**5 DEGRADO MEDIO**	0,3	0,4392	0,8155	0,1819	0,5	0,5807	0,2773
72	**2 DEGRADO IRRILEVANTE**	0,3	0,6098	0,9648	0,0552	0,5	0,7076	0,1886
73	**5 DEGRADO MEDIO**	0,3	0,1779	0,5733	0,4464	0,5	0,3803	0,4625
74	**7 DEGRADO ALTO**	0,3	0,8227	0,5733	0,3011	0,5	0,6059	0,3608
75	**6 DEGRADO MEDIO - ALTO**	0,5	0,2808	0,6181	0,4305	0,5	0,4764	0,4514
76	**8 DEGRADO MOLTO ALTO**	0,5	0,2300	0,2579	0,7697	0,5	0,2965	0,6888
77	**9 DEGRADO ESTREMAMENTE ALTO**	0,3	0,2003	0,0311	0,8842	0,3	0,1441	0,7089
78	**4 DEGRADO MEDIO - BASSO**	0,3	0,5075	0,7255	0,2534	0,3	0,5641	0,2674
79	**8 DEGRADO MOLTO ALTO**	0,3	0,1623	0,0286	0,3965	0,5	0,1297	0,4275
80	**4 DEGRADO MEDIO - BASSO**	0,3	0,3648	0,4066	0,0701	0,5	0,3707	0,1991
81	**4 DEGRADO MEDIO - BASSO**	0,3	0,4392	0,8155	0,1819	0,5	0,5807	0,2773
82	**6 DEGRADO MEDIO - ALTO**	0,3	0,3177	0,4610	0,1275	0,5	0,3786	0,2392
83	**6 DEGRADO MEDIO - ALTO**	0,5	0,4359	0,3143	0,1728	0,7	0,3940	0,3310
84	**7 DEGRADO ALTO**	0,5	0,2704	0,3161	0,3178	0,7	0,3369	0,4324
85	**6 DEGRADO MEDIO - ALTO**	0,5	0,1895	0,0823	0,1617	0,3	0,2034	0,2032
86	**9 DEGRADO ESTREMAMENTE ALTO**	0,5	0,1691	0,2282	0,3760	0,3	0,2619	0,3532
87	**7 DEGRADO ALTO**	0,3	0,1759	0,1710	0,2478	0,5	0,1985	0,3234
88	**8 DEGRADO MOLTO ALTO**	0,3	0,0591	0,3002	0,7359	0,5	0,2157	0,6651
89	**9 DEGRADO ESTREMAMENTE ALTO**	0,3	0,0395	0,0311	0,9236	0,5	0,0878	0,7965
90	**8 DEGRADO MOLTO ALTO**	0,3	0,0376	0,0311	0,5963	0,5	0,0872	0,5674
91	**9 DEGRADO ESTREMAMENTE ALTO**	0,3	0,0395	0,0311	0,9236	0,5	0,0878	0,7965
92	**8 DEGRADO MOLTO ALTO**	0,3	0,0376	0,0311	0,5963	0,5	0,0872	0,5674
93	**4 DEGRADO MEDIO - BASSO**	0,6	0,4417	0,0271	0,0205	0,5	0,2868	0,1644
94	**9 DEGRADO ESTREMAMENTE ALTO**	0,6	0,0803	0,0236	0,7154	0,5	0,1587	0,6508
95	**6 DEGRADO MEDIO - ALTO**	0,5	0,3522	0,0311	0,1290	0,5	0,2373	0,2403
96	**7 DEGRADO ALTO**	0,5	0,1278	0,0311	0,2948	0,5	0,1587	0,3564
97	**4 DEGRADO MEDIO - BASSO**	0,5	0,6042	0,0311	0,0000	0,5	0,3255	0,1500
98	**5 DEGRADO MEDIO**	0,5	0,0505	0,7450	0,2013	0,5	0,4529	0,2909
99	**2 DEGRADO IRRILEVANTE**	0,3	0,5341	1,0000	0,0274	0,5	0,6969	0,1692
100	**9 DEGRADO ESTREMAMENTE ALTO**	0,0	0,0554	0,0203	0,0011	0,5	0,0315	0,1508
101	**2 DEGRADO IRRILEVANTE**	0,5	0,5123	1,0000	0,0384	0,5	0,7293	0,1769
102	**2 DEGRADO IRRILEVANTE**	0,5	0,6604	1,0000	0,0824	0,3	0,7811	0,1477
103	**3 DEGRADO BASSO**	0,5	0,4707	0,3671	0,0358	0,3	0,4299	0,1150
104	**4 DEGRADO MEDIO - BASSO**	0,5	0,5040	1,0000	0,1921	0,3	0,7264	0,2245
105	**1 ASSENZA DI DEGRADO**	0,5	0,9741	1,0000	0,0157	0,1	0,8909	0,0410
106	**2 DEGRADO IRRILEVANTE**	0,5	0,5045	0,8141	0,0715	0,1	0,6429	0,0800
107	**4 DEGRADO MEDIO - BASSO**	0,5	0,3715	1,0000	0,1234	0,5	0,6800	0,2364
108	**2 DEGRADO IRRILEVANTE**	0,5	0,6438	0,9059	0,0596	0,5	0,7330	0,1917
109	**4 DEGRADO MEDIO - BASSO**	0,6	0,4856	0,8168	0,1024	1,0	0,6575	0,3717
110	**4 DEGRADO MEDIO - BASSO**	0,6	0,5904	1,0000	0,1039	1,0	0,7767	0,3727
111	**1 ASSENZA DI DEGRADO**	0,3	0,9543	1,0000	0,0058	0,3	0,8440	0,0940
112	**2 DEGRADO IRRILEVANTE**	0,3	0,5064	1,0000	0,0309	0,3	0,6872	0,1116
113	**1 ASSENZA DI DEGRADO**	0,3	0,9902	1,0000	0,0000	0,1	0,8566	0,0300
114	**2 DEGRADO IRRILEVANTE**	0,3	0,3534	1,0000	0,1270	0,1	0,6337	0,1189
115	**3 DEGRADO BASSO**	0,6	0,5565	0,3378	0,0393	0,3	0,4668	0,1175
116	**5 DEGRADO MEDIO**	0,6	0,3073	0,5605	0,1765	0,3	0,4798	0,2136
117	**3 DEGRADO BASSO**	0,6	0,5565	0,3378	0,0393	0,1	0,4668	0,0575
118	**5 DEGRADO MEDIO**	0,6	0,3073	0,5605	0,1765	0,1	0,4798	0,1536
119	**2 DEGRADO IRRILEVANTE**	0,5	0,6672	1,0000	0,0279	0,5	0,7835	0,1695
120	**2 DEGRADO IRRILEVANTE**	0,5	0,5918	0,8660	0,0124	0,5	0,6968	0,1587
121	**2 DEGRADO IRRILEVANTE**	0,5	0,6672	1,0000	0,0279	0,1	0,7835	0,0495
122	**2 DEGRADO IRRILEVANTE**	0,5	0,5918	0,8660	0,0124	0,1	0,6968	0,0387
123	**2 DEGRADO IRRILEVANTE**	0,5	0,6672	1,0000	0,0279	0,1	0,7835	0,0495
124	**2 DEGRADO IRRILEVANTE**	0,5	0,5918	0,8660	0,0124	0,1	0,6968	0,0387
125	**3 DEGRADO BASSO**	0,6	0,5749	0,3258	0,0393	0,5	0,4678	0,1775
126	**4 DEGRADO MEDIO - BASSO**	0,5	0,4429	0,9874	0,2394	0,5	0,6993	0,3176
127	**2 DEGRADO IRRILEVANTE**	0,5	0,6830	0,6293	0,0283	0,5	0,6223	0,1698
128	**4 DEGRADO MEDIO - BASSO**	0,5	0,4429	0,9874	0,2394	0,5	0,6993	0,3176
129	**1 ASSENZA DI DEGRADO**	0,3	0,7851	1,0000	0,0584	0,5	0,7848	0,1909
130	**2 DEGRADO IRRILEVANTE**	0,5	0,4429	1,0000	0,1517	0,3	0,7050	0,1962

131	**1 ASSENZA DI DEGRADO**	0,3	0,7851	1,0000	0,0584	0,5	0,7848	0,1909
132	**2 DEGRADO IRRILEVANTE**	0,5	0,4429	0,9874	0,1517	0,3	0,6993	0,1962
133	**4 DEGRADO MEDIO - BASSO**	0,6	0,7408	0,5442	0,2366	0,5	0,6242	0,3156
134	**2 DEGRADO IRRILEVANTE**	0,6	0,6907	0,5820	0,0184	0,5	0,6236	0,1629
135	**3 DEGRADO BASSO**	0,3	0,2669	1,0000	0,0045	0,3	0,6034	0,0932
136	**4 DEGRADO MEDIO - BASSO**	0,5	0,4011	0,8924	0,0501	0,7	0,6420	0,2451
137	**3 DEGRADO BASSO**	0,3	0,2669	1,0000	0,0045	0,3	0,6034	0,0932
138	**4 DEGRADO MEDIO - BASSO**	0,5	0,4011	0,8924	0,0501	0,7	0,6420	0,2451
139	**3 DEGRADO BASSO**	1,0	1,0000	1,0000	0,0235	1,0	0,9935	0,3165
140	**5 DEGRADO MEDIO**	1,0	0,5759	0,2938	0,0331	1,0	0,5273	0,3232
141	**1 ASSENZA DI DEGRADO**	0,6	1,0000	1,0000	0,0000	0,5	0,9200	0,1500
142	**2 DEGRADO IRRILEVANTE**	0,6	0,7138	0,9059	0,0141	0,5	0,7775	0,1599
143	**5 DEGRADO MEDIO**	0,5	0,8192	0,1773	0,1219	1,0	0,4665	0,3853
144	**6 DEGRADO MEDIO - ALTO**	0,5	0,6916	0,0921	0,1275	1,0	0,3835	0,3892
145	**2 DEGRADO IRRILEVANTE**	0,5	0,7201	0,8142	0,0511	0,5	0,7184	0,1857
146	**6 DEGRADO MEDIO - ALTO**	0,5	0,5310	0,0712	0,1265	0,5	0,3179	0,2385
147	**1 ASSENZA DI DEGRADO**	0,5	0,9729	0,9878	0,0515	0,5	0,8850	0,1861
148	**3 DEGRADO BASSO**	0,5	0,5392	0,6862	0,0184	0,5	0,5975	0,1629
149	**4 DEGRADO MEDIO - BASSO**	0,5	0,5932	0,1497	0,0621	0,3	0,3750	0,1335
150	**4 DEGRADO MEDIO - BASSO**	0,5	0,5264	0,2470	0,0271	0,3	0,3954	0,1090
151	**4 DEGRADO MEDIO - BASSO**	0,5	0,5932	0,1497	0,0621	0,3	0,3750	0,1335
152	**4 DEGRADO MEDIO - BASSO**	0,5	0,5264	0,2470	0,0271	0,3	0,3954	0,1090
153	**6 DEGRADO MEDIO - ALTO**	0,3	0,2944	0,5291	0,1120	0,5	0,4011	0,2284
154	**2 DEGRADO IRRILEVANTE**	0,3	0,9385	0,9168	0,0000	0,5	0,8011	0,1500
155	**7 DEGRADO ALTO**	0,3	0,1841	0,0593	0,2937	0,5	0,1511	0,3556
156	**3 DEGRADO BASSO**	0,3	0,8153	0,5220	0,0649	0,5	0,5802	0,1954
157	**4 DEGRADO MEDIO - BASSO**	0,5	0,7138	0,0296	0,0552	0,5	0,3631	0,1886
158	**2 DEGRADO IRRILEVANTE**	0,5	0,5505	1,0000	0,0053	0,5	0,7427	0,1537
159	**3 DEGRADO BASSO**	0,3	0,8053	0,5220	0,0649	0,5	0,5767	0,1954
160	**2 DEGRADO IRRILEVANTE**	0,5	0,7201	0,8142	0,0511	0,5	0,7184	0,1857
161	**7 DEGRADO ALTO**	0,1	0,3560	0,0311	0,0777	0,7	0,1586	0,2644
162	**9 DEGRADO ESTREMAMENTE ALTO**	0,1	0,2564	0,0311	0,7045	0,7	0,1237	0,7031
163	**2 DEGRADO IRRILEVANTE**	0,5	0,7491	0,7847	0,0054	0,3	0,7153	0,0938
164	**4 DEGRADO MEDIO - BASSO**	0,5	0,5123	0,2725	0,0129	0,3	0,4019	0,0990
165	**2 DEGRADO IRRILEVANTE**	0,3	0,5680	1,0000	0,0029	0,3	0,7088	0,0920
166	**4 DEGRADO MEDIO - BASSO**	0,3	0,4122	0,1356	0,1209	0,3	0,2653	0,1746
167	**1 ASSENZA DI DEGRADO**	0,5	1,0000	1,0000	0,0000	0,3	0,9000	0,0900
168	**3 DEGRADO BASSO**	0,5	0,4538	0,6485	0,0367	0,3	0,5507	0,1157
169	**3 DEGRADO BASSO**	0,5	0,5645	0,3444	0,0443	0,5	0,4526	0,1810
170	**2 DEGRADO IRRILEVANTE**	0,5	1,0000	0,6146	0,0145	0,5	0,7266	0,1602
171	**9 DEGRADO ESTREMAMENTE ALTO**	0,3	0,2071	0,0000	0,8474	0,5	0,1325	0,7432
172	**3 DEGRADO BASSO**	0,3	0,9314	1,0000	0,0336	0,5	0,8360	0,1735
173	**1 ASSENZA DI DEGRADO**	0,5	0,7623	1,0000	0,0000	0,5	0,8168	0,1500
174	**2 DEGRADO IRRILEVANTE**	0,5	0,5507	1,0000	0,0240	0,5	0,7428	0,1668
175	**5 DEGRADO MEDIO**	0,3	0,6495	0,5106	0,1093	0,5	0,5171	0,2265
176	**6 DEGRADO MEDIO - ALTO**	0,3	0,3471	0,1720	0,0897	0,5	0,2589	0,2128
177	**3 DEGRADO BASSO**	0,3	0,5507	0,6821	0,0022	0,5	0,5597	0,1515
178	**7 DEGRADO ALTO**	0,3	0,2696	0,0209	0,2624	0,5	0,1638	0,3337
179	**1 ASSENZA DI DEGRADO**	0,5	0,7623	1,0000	0,0000	0,5	0,8168	0,1500
180	**7 DEGRADO ALTO**	0,3	0,2696	0,0209	0,2624	0,5	0,1638	0,3337

	IFF	Domanda 1	Domanda 2	Domanda 2bis	Domanda 3	Domanda 4	Domanda 5	Domanda 6	Domanda 7	Domanda 8	Domanda 9	Domanda 10	Domanda 11	Domanda 12	Domanda 13	Domanda 14
1	**IV**	1	1	0	1	1	1	1	25	1	1	1	5	15	15	10
2	**IV**	1	1	0	1	1	1	1	25	1	1	1	5	15	15	10
3	**IV**	1	1	0	1	1	10	1	25	1	1	1	1	15	15	10
4	**IV**	1	1	0	1	1	10	1	25	1	1	1	1	15	15	10
5	**IV**	1	1	0	1	1	10	1	25	1	1	1	5	15	15	10
6	**IV**	1	1	0	1	1	10	1	25	1	1	1	5	15	15	10
7	**III - IV**	25	1	0	1	1	5	1	25	1	1	1	5	15	15	10
8	**III - IV**	25	1	0	1	1	5	1	25	1	1	1	5	15	15	10
9	**III - IV**	20	1	0	1	1	10	1	25	1	1	1	5	15	15	10
10	**III - IV**	20	1	0	1	1	10	1	25	1	1	1	5	15	15	10
11	**II**	20	40	0	10	15	10	1	25	20	15	5	5	15	15	10
12	**II - III**	20	25	0	10	10	10	1	25	20	15	5	5	15	15	10
13	**IV**	1	1	0	1	1	10	1	1	1	1	1	1	15	15	10
14	**IV**	20	1	0	1	1	10	1	1	1	1	1	1	15	15	1
15	**II - III**	25	10	0	10	10	10	1	25	5	20	20	5	15	15	10
16	**II - III**	25	10	0	10	10	10	1	25	5	20	20	5	15	15	10
17	**III**	5	10	0	5	10	10	1	25	5	15	5	5	15	15	10
18	**III**	5	10	0	10	10	10	1	25	5	15	5	5	15	15	10
19	**IV**	5	10	0	5	10	0	1	1	1	1	1	1	15	15	10
20	**IV**	1	1	0	1	1	10	1	1	1	1	1	1	15	15	10
21	**IV**	5	10	0	5	5	10	1	5	5	5	1	5	15	15	10
22	**IV**	1	10	0	5	10	10	1	5	1	5	1	5	15	15	10
23	**II - III**	20	10	0	10	15	10	1	15	20	15	20	5	15	15	10
24	**II**	25	40	0	5	15	10	1	15	20	15	20	5	15	15	10
25	**III**	25	10	0	15	10	10	1	1	1	5	1	5	15	15	10
26	**IV**	1	1	0	1	10	10	1	1	1	5	1	5	15	15	10
27	**II**	25	40	0	15	15	10	15	15	20	20	20	5	15	15	10
28	**II**	25	40	0	15	15	10	15	15	20	20	20	5	15	15	10
29	**IV**	1	1	0	1	1	10	1	5	5	15	5	5	15	15	10
30	**III**	25	25	0	10	15	10	1	5	20	15	5	5	15	15	10
31	**II**	25	40	0	15	15	10	5	5	20	20	20	5	15	15	10
32	**II**	20	25	0	5	15	10	5	5	20	20	20	5	15	15	10
33	**III**	1	1	0	1	1	10	5	5	20	15	20	5	15	15	10
34	**III**	20	25	0	5	10	10	5	5	20	15	20	5	15	15	10
35	**IV**	1	1	0	1	1	10	1	5	1	1	1	1	15	15	10
36	**IV**	1	1	0	1	1	10	1	5	1	1	1	1	15	15	10
37	**III**	5	10	0	5	10	10	5	5	20	15	5	5	15	15	10
38	**III**	5	10	0	5	10	10	5	5	20	15	5	5	15	15	10
39	**III - IV**	5	10	0	5	15	10	1	5	1	5	5	5	15	15	10
40	**III**	20	25	0	10	5	10	1	5	1	5	5	5	15	15	10
41	**IV**	1	1	0	1	1	10	1	5	1	5	5	5	15	15	10
42	**IV**	5	1	0	1	1	10	1	5	1	5	5	5	15	15	10
43	**II**	20	40	0	15	15	5	15	15	20	20	20	5	15	15	20
44	**II**	20	25	0	10	15	5	15	15	20	20	20	5	15	15	20
45	**V**	1	0	1	1	1	1	1	1	5	1	1	1	10	10	10
46	**V**	1	0	1	1	1	1	1	5	1	1	1	1	10	10	10
47	**IV**	5	10	0	5	10	5	1	15	1	1	5	5	10	10	10
48	**IV**	1	10	0	1	1	5	1	15	1	1	5	5	10	10	10
49	**II**	25	40	0	10	15	5	1	15	15	15	20	20	10	15	10
50	**III**	20	10	0	5	10	5	1	15	15	15	20	20	10	15	10
51	**III**	20	10	0	5	5	5	1	15	5	1	5	15	10	15	10
52	**IV**	5	0	1	1	1	5	1	15	1	1	5	15	10	15	10
53	**III - IV**	1	10	0	5	5	5	1	15	1	5	20	15	10	15	10
54	**III - IV**	1	10	0	5	5	5	1	15	1	5	20	15	10	15	10
55	**III - IV**	1	10	0	5	5	5	1	15	1	5	20	15	10	15	10
56	**III - IV**	1	10	0	5	5	5	1	15	1	5	20	15	10	15	10
57	**II**	25	40	0	15	15	5	5	5	15	15	20	15	10	15	10
58	**III**	1	25	0	5	5	5	5	5	15	15	20	15	10	15	10
59	**II**	25	40	0	15	15	5	1	15	5	20	25	20	10	15	10
60	**II**	25	40	0	10	15	5	1	15	5	20	25	20	10	15	10
61	**III**	1	10	0	5	15	5	1	15	5	15	25	20	10	15	10
62	**III**	20	10	0	5	15	5	1	15	5	15	25	20	10	15	10
63	**III**	1	10	0	5	15	5	1	15	5	15	25	20	10	15	10

64	**III**	20	10	0	5	15	5	1	15	5	15	25	20	10	15	10
65	**II - III**	20	25	0	5	10	5	1	15	5	15	25	15	10	15	10
66	**III**	1	40	0	10	15	5	1	15	5	15	25	15	10	15	10
67	**IV**	1	10	0	5	15	5	1	5	1	1	5	5	10	15	10
68	**IV**	5	1	0	1	1	5	1	5	1	1	5	5	10	15	10
69	**IV**	1	0	1	1	1	5	1	5	1	1	5	5	10	15	10
70	**IV**	1	0	1	1	1	5	1	5	1	1	5	5	10	15	10
71	**IV**	1	0	1	1	1	5	1	5	1	1	5	5	10	15	10
72	**IV**	1	0	1	1	1	5	1	5	1	1	5	5	10	15	10
73	**IV**	1	10	0	5	10	5	1	1	1	1	5	5	5	15	10
74	**IV - V**	1	0	1	1	1	5	1	1	1	1	5	5	5	15	10
75	**IV - V**	1	1	0	1	1	5	1	1	1	1	5	5	5	15	10
76	**IV**	1	10	0	5	10	5	1	1	1	1	5	5	5	15	10
77	**IV**	1	10	0	5	10	5	1	5	1	1	5	5	5	10	10
78	**III - IV**	1	40	0	10	15	5	1	5	1	1	5	5	5	10	10
79	**IV - V**	1	0	1	1	1	5	1	5	1	1	5	5	5	10	10
80	**IV**	1	10	0	1	1	5	1	5	1	1	5	5	5	10	10
81	**IV - V**	1	0	1	1	1	5	1	5	1	1	5	5	5	10	5
82	**V**	1	0	5	1	5	5	1	5	1	1	5	5	5	10	5
83	**V**	1	0	5	1	1	5	1	5	1	1	5	5	1	10	5
84	**V**	1	0	5	1	1	5	1	5	1	1	5	5	1	10	5
85	**IV**	1	10	0	5	15	5	1	5	1	1	5	5	1	10	5
86	**IV**	1	10	0	5	15	5	1	5	1	1	5	5	1	10	5
87	**IV**	1	10	0	5	15	5	1	5	1	5	5	5	1	10	5
88	**IV**	1	10	0	5	15	5	1	5	1	5	5	5	1	10	5
89	**IV**	1	10	0	5	5	5	1	5	1	5	20	15	1	10	5
90	**IV**	1	10	0	5	5	5	1	5	1	5	20	15	1	10	5
91	**IV**	1	10	0	5	5	5	1	5	1	5	20	15	1	10	5
92	**IV**	1	10	0	5	5	5	1	5	1	5	20	15	1	10	5
93	**IV**	5	10	0	5	5	5	1	5	1	5	20	15	1	10	5
94	**III**	1	25	0	5	15	5	1	5	1	5	20	15	1	10	5
95	**IV**	5	10	0	5	10	5	1	5	5	5	20	5	1	10	5
96	**IV**	1	10	0	5	10	5	1	5	1	5	20	5	1	10	5
97	**IV - V**	5	1	0	1	1	5	1	5	1	1	5	5	1	10	5
98	**IV - V**	1	10	0	5	5	5	1	5	1	1	5	5	1	10	5
99	**III - IV**	5	25	0	10	10	5	1	5	1	5	20	5	1	10	5
100	**IV**	1	10	0	5	10	5	1	5	1	5	20	5	1	10	5
101	**III**	1	40	0	10	15	5	1	5	1	5	20	5	1	10	10
102	**III**	1	40	0	10	15	5	1	5	1	5	20	5	1	10	10
103	**III**	20	10	0	5	15	5	1	5	15	5	20	5	1	10	10
104	**III**	1	10	0	5	15	5	1	5	15	5	20	5	1	10	10
105	**III**	1	40	0	15	15	5	1	5	20	15	20	5	1	10	10
106	**III**	1	40	0	10	15	5	1	5	20	15	20	5	1	10	10
107	**IV**	1	0	1	1	1	5	1	5	1	1	20	15	1	10	10
108	**IV**	1	0	1	1	1	5	1	5	1	1	20	15	1	10	10
109	**III - IV**	5	40	0	10	10	5	1	5	5	5	5	1	1	10	10
110	**IV - V**	5	0	1	1	1	5	1	5	1	5	5	1	1	10	10
111	**III**	5	40	0	10	15	5	1	15	15	5	20	15	1	10	10
112	**III**	1	10	0	5	10	5	1	15	15	5	20	15	1	10	10
113	**III - IV**	20	0	1	1	1	5	1	15	1	5	20	15	1	10	10
114	**III**	5	10	0	5	15	5	1	15	15	5	20	15	1	10	10
115	**III**	5	10	0	5	10	5	1	15	15	5	20	15	1	10	10
116	**III**	5	10	0	5	10	5	1	15	15	5	20	15	1	10	10
117	**IV**	5	1	0	5	10	5	1	5	15	5	20	1	1	10	10
118	**III - IV**	5	10	0	5	10	5	1	5	15	5	20	1	1	10	10
119	**III - IV**	1	10	0	5	10	5	1	15	5	5	20	5	1	10	10
120	**IV**	1	10	0	5	5	5	1	15	5	5	20	5	1	10	10
121	**III - IV**	1	10	0	5	10	5	1	15	5	5	20	5	1	10	10
122	**IV**	1	1	0	1	1	5	1	15	5	5	20	5	1	10	10
123	**III**	1	25	0	10	15	5	1	5	1	15	20	15	5	10	10
124	**III**	5	10	0	5	15	5	1	5	5	15	20	15	5	10	10
125	**III - IV**	1	10	0	5	5	5	1	15	5	5	20	15	5	10	10
126	**III - IV**	1	10	0	5	10	5	1	15	5	5	20	15	5	10	10
127	**IV - V**	5	1	0	1	1	5	1	5	1	1	5	5	5	10	10
128	**IV - V**	1	0	1	1	1	5	1	5	1	1	5	5	5	10	10
129	**IV**	1	10	0	5	5	5	1	5	1	1	5	5	1	10	10
130	**IV**	1	10	0	5	5	5	1	5	1	1	5	5	1	10	10
131	**IV - V**	5	0	0	1	1	5	1	5	1	1	5	5	1	10	10
132	**IV**	1	10	1	5	5	5	1	5	1	1	5	5	1	10	10

133	**IV - V**	1	1	0	5	5	5	1	5	1	1	5	5	1	10	10
134	**IV - V**	5	1	0	5	5	5	1	5	1	1	5	5	1	10	10
135	**IV**	1	1	0	1	1	5	1	5	15	1	5	1	5	10	10
136	**V**	1	0	1	1	1	5	1	5	1	1	5	1	5	10	10
137	**IV**	20	10	0	5	5	5	1	5	1	1	5	5	5	10	10
138	**IV**	1	10	0	5	5	5	1	5	1	1	5	5	5	10	10
139	**III**	20	10	0	15	15	5	5	15	15	5	5	15	5	10	10
140	**III - IV**	1	10	0	5	10	5	5	15	15	5	5	15	5	10	10
141	**III**	25	10	0	15	15	5	1	15	1	15	25	20	5	10	10
142	**III**	5	10	0	10	15	5	1	15	1	15	25	20	5	10	10
143	**IV - V**	1	0	1	1	1	1	1	15	1	1	1	5	10	10	10
144	**IV - V**	1	0	1	1	1	1	1	15	1	1	1	5	10	10	10
145	**IV - V**	1	0	1	1	1	5	1	5	1	5	5	5	5	10	10
146	**IV - V**	1	0	1	1	1	5	1	5	1	5	5	5	5	10	10
147	**IV**	20	1	0	1	1	5	1	5	5	5	5	5	5	10	10
148	**III - IV**	20	10	0	5	5	5	1	5	15	5	5	5	5	10	10
149	**IV**	1	10	0	1	1	5	1	5	5	5	5	5	5	10	10
150	**IV**	20	0	1	5	5	5	1	5	1	5	5	5	5	10	10
151	**IV**	1	1	0	1	1	5	1	5	1	1	20	5	10	10	10
152	**III - IV**	20	10	0	5	10	5	1	5	5	1	20	5	10	10	10
153	**III**	1	40	0	5	15	5	1	5	15	5	20	5	10	10	10
154	**III**	20	10	0	5	15	5	1	5	15	5	20	5	10	10	10
155	**IV**	1	10	0	5	10	5	1	5	5	1	5	5	10	10	10
156	**IV**	1	10	0	5	10	5	1	5	5	1	5	5	10	10	10
157	**IV**	1	0	1	1	1	5	1	5	1	1	20	5	10	10	10
158	**III - IV**	5	10	0	5	10	5	1	5	5	1	20	5	10	10	10
159	**III - IV**	1	10	0	5	15	5	1	1	20	15	5	1	10	10	10
160	**III - IV**	1	10	0	5	15	5	1	1	20	15	5	1	10	10	10
161	**IV - V**	1	0	1	1	1	5	1	5	1	1	5	5	5	10	10
162	**IV - V**	1	0	1	1	1	5	1	5	1	1	5	5	5	10	10
163	**IV**	1	10	0	5	10	5	1	5	5	5	5	5	10	10	10
164	**IV**	1	10	0	5	5	5	1	5	1	5	5	5	10	10	10
165	**III**	5	10	0	10	10	5	1	5	15	5	20	5	10	10	10
166	**III - IV**	1	10	0	5	5	5	1	5	15	5	20	5	10	10	10
167	**II - III**	25	25	0	10	10	5	1	15	15	20	20	15	5	10	10
168	**III**	5	10	0	5	10	5	1	15	15	20	20	15	5	10	10
169	**III**	20	10	0	5	5	5	1	5	15	15	5	15	5	10	10
170	**III**	20	10	0	5	5	5	1	5	15	15	5	15	5	10	10
171	**IV - V**	1	0	1	1	1	5	1	5	1	1	5	5	5	10	10
172	**IV - V**	1	0	1	1	1	5	1	5	1	1	5	5	5	10	10
173	**III - IV**	25	10	0	5	5	5	1	5	1	1	5	5	10	15	10
174	**IV**	1	0	1	1	1	5	1	5	1	1	5	5	10	15	10
175	**IV - V**	1	0	1	1	1	5	1	1	1	1	5	5	10	15	10
176	**IV - V**	1	0	1	1	1	5	1	1	1	1	5	5	10	15	10
177	**IV - V**	1	0	1	1	1	5	1	1	1	1	5	5	10	15	10
178	**IV - V**	1	0	1	1	1	5	1	1	1	1	5	5	10	15	10
179	**III - IV**	1	10	0	5	5	5	1	5	15	1	20	15	10	10	10
180	**IV**	1	0	1	1	1	5	1	5	1	1	20	15	10	10	10

	RCEsIAR	RCE Domada 1	RCE Domada 2	RCE Domada 3	RCE Domada 4	RCE Domada 5	RCE Domada 6	IAR Domanda 1 abc	IAR Domanda 2abc	IAR Domanda 3abc	IAR Domanda 4 ab	IAR Domanda 5	IAR Domanda 6	RCEsIAR
1	**SCARSA**	10	1	1	1	5	1	1	13	25	13	1	1	-35
2	**SCARSA**	10	1	1	1	5	15	1	18	5	15	1	1	-8
3	**SCARSA**	10	10	5	10	5	1	5	23	18	13	1	1	-20
4	**SCARSA**	10	1	1	10	5	1	5	10	15	20	5	1	-28
5	**SCARSA**	10	10	5	10	5	1	5	23	18	15	1	1	-22
6	**SCARSA**	10	1	5	10	5	1	5	10	18	20	1	1	-23
7	**SUFFICIENTE**	10	10	5	1	5	5	1	5	15	10	5	1	-1
8	**DISCRETA**	10	25	20	5	20	5	25	5	25	10	5	1	14
9	**BUONA**	15	25	20	10	30	15	1	10	5	15	1	1	82
10	**BUONA**	15	25	20	10	30	15	1	20	1	15	1	1	76
11	**OTTIMA**	30	25	30	20	30	15	5	10	6	15	1	1	112
12	**OTTIMA**	30	25	30	20	30	15	1	1	1	1	1	1	144
13	**SCARSA**	15	1	1	1	1	10	1	15	1	15	1	1	-5
14	**OTTIMA**	15	25	30	20	30	15	1	1	1	10	1	1	120
15	**OTTIMA**	30	25	30	10	30	15	5	1	1	1	1	1	130
16	**OTTIMA**	30	25	30	20	30	15	1	1	1	1	1	1	144
17	**BUONA**	15	25	20	5	30	10	1	1	5	5	1	1	91
18	**BUONA**	15	25	20	5	30	10	1	1	1	5	1	1	95
19	**BUONA**	15	25	20	10	20	10	13	1	5	15	1	1	64
20	**DISCRETA**	15	10	5	5	5	1	1	1	10	15	1	1	12
21	**BUONA**	30	10	20	20	20	10	6	1	1	15	1	1	85
22	**BUONA**	30	10	20	10	20	1	1	1	15	15	1	1	57
23	**BUONA**	15	25	30	20	20	10	10	1	10	10	1	1	87
24	**BUONA**	15	25	20	20	20	15	1	1	10	10	1	1	91
25	**OTTIMA**	30	25	30	20	30	15	1	1	1	10	1	1	135
26	**BUONA**	30	10	5	10	20	15	1	1	1	10	1	1	75
27	**OTTIMA**	30	25	30	10	20	15	1	13	1	5	1	1	108
28	**OTTIMA**	30	25	30	10	20	15	1	1	1	8	1	1	117
29	**DISCRETA**	30	10	5	5	20	1	1	25	1	10	1	1	32
30	**OTTIMA**	30	25	30	20	30	15	1	1	1	5	1	1	140
31	**OTTIMA**	30	25	30	20	30	15	1	1	1	10	1	1	135
32	**OTTIMA**	30	25	20	20	30	10	10	1	1	1	1	1	120
33	**DISCRETA**	30	1	1	1	1	1	10	1	10	5	1	1	7
34	**OTTIMA**	30	10	20	10	20	15	1	1	1	1	1	1	99
35	**SCARSA**	15	1	1	1	1	1	1	1	15	15	1	1	-14
36	**DISCRETA**	15	1	1	1	1	1	1	1	10	1	1	1	5
37	**DISCRETA**	15	10	20	20	20	10	10	10	20	20	1	1	33
38	**BUONA**	15	10	20	20	20	10	10	1	10	5	1	1	67
39	**BUONA**	30	25	5	10	20	1	1	1	15	10	1	1	62
40	**BUONA**	30	25	20	20	20	10	10	1	1	20	1	1	91
41	**SCARSA**	15	5	1	1	5	1	1	25	5	10	1	2	-16
42	**SCARSA**	15	5	1	1	5	10	1	1	10	20	10	1	-6
43	**OTTIMA**	30	25	20	20	30	15	1	16	1	5	5	10	102
44	**BUONA**	30	25	20	20	20	15	1	1	1	20	5	10	92
45	**DISCRETA**	15	25	5	10	20	1	1	1	1	20	1	1	51
46	**SCARSA**	15	10	1	1	5	1	5	1	15	20	1	1	-10
47	**BUONA**	15	10	20	10	20	10	8	1	10	8	1	1	56
48	**DISCRETA**	15	25	20	10	20	15	10	20	10	15	1	1	48
49	**OTTIMA**	30	25	30	20	30	15	1	1	1	1	1	1	144
50	**BUONA**	30	10	5	10	20	10	10	1	1	10	1	1	61
51	**OTTIMA**	30	25	20	20	20	15	1	1	10	15	1	1	101
52	**SCARSA**	30	1	1	1	1	5	10	1	15	20	1	1	-9
53	**SCARSA**	15	10	5	5	5	10	15	15	10	20	1	1	-12
54	**SCARSA**	15	10	5	5	5	1	15	10	20	10	1	1	-16
55	**DISCRETA**	30	10	5	10	10	10	20	1	15	5	1	1	32
56	**DISCRETA**	30	25	5	5	20	10	20	1	10	15	1	1	47
57	**OTTIMA**	30	25	30	20	20	15	1	1	1	1	1	1	134
58	**BUONA**	30	10	20	10	20	15	1	25	1	10	1	1	66
59	**OTTIMA**	15	25	20	20	30	15	1	1	1	15	1	1	105
60	**OTTIMA**	15	25	30	20	20	15	1	1	1	1	1	1	119
61	**BUONA**	30	25	20	20	20	5	15	1	15	20	1	1	67
62	**OTTIMA**	30	25	20	20	20	15	1	1	1	1	1	1	124
63	**BUONA**	30	10	20	10	20	15	1	1	5	15	1	1	81

64	**BUONA**	30	10	20	10	20	15	20	1	5	1	1	1	76
65	**BUONA**	15	25	20	20	20	10	15	1	15	10	1	1	67
66	**DISCRETA**	15	10	10	10	5	10	10	1	1	1	1	1	45
67	**SUFFICIENTE**	15	5	5	1	5	1	1	1	20	5	1	1	3
68	**SUFFICIENTE**	15	5	5	1	5	5	25	1	5	1	1	1	2
69	**SCARSA**	15	1	1	1	1	1	25	1	15	20	1	1	-43
70	**DISCRETA**	15	10	10	10	20	1	15	1	15	5	1	1	28
71	**SCADENTE**	15	1	1	1	1	1	15	15	20	15	15	1	-61
72	**DISCRETA**	15	10	20	10	20	1	10	1	15	15	1	1	33
73	**BUONA**	30	10	20	10	30	10	15	1	10	10	1	1	72
74	**DISCRETA**	30	10	1	1	20	1	15	20	10	10	1	1	6
75	**SCARSA**	30	5	1	1	1	10	10	25	10	5	1	1	-4
76	**DISCRETA**	30	10	20	5	5	10	15	1	10	10	1	1	42
77	**DISCRETA**	15	10	5	20	20	10	20	1	15	20	1	1	22
78	**BUONA**	15	25	20	10	30	10	10	1	5	1	1	1	91
79	**SCARSA**	30	1	1	1	1	10	12	1	13	20	1	1	-4
80	**DISCRETA**	30	10	5	10	20	10	20	1	20	13	1	1	29
81	**DISCRETA**	15	10	5	10	20	10	10	1	20	15	1	1	22
82	**DISCRETA**	15	10	5	10	20	1	10	1	10	15	1	1	23
83	**DISCRETA**	15	10	5	5	5	10	10	1	15	10	1	1	12
84	**SUFFICIENTE**	15	10	5	5	5	10	1	20	8	20	1	1	-1
85	**DISCRETA**	30	25	5	10	20	1	10	5	30	20	1	1	24
86	**DISCRETA**	30	25	5	10	20	1	15	20	20	10	1	1	24
87	**DISCRETA**	15	10	5	5	5	10	1	1	15	10	1	1	21
88	**SCARSA**	15	10	5	5	1	1	13	1	30	20	1	1	-29
89	**DISCRETA**	15	10	5	5	5	10	1	1	15	10	1	1	21
90	**SCARSA**	15	10	5	5	1	1	13	1	30	20	1	1	-29
91	**DISCRETA**	15	10	5	5	5	10	1	1	15	10	1	1	21
92	**SCARSA**	15	10	5	5	1	1	13	1	30	20	1	1	-29
93	**DISCRETA**	15	10	5	5	5	10	15	1	1	10	10	1	12
94	**SCARSA**	15	10	5	5	5	1	1	1	30	20	10	1	-22
95	**DISCRETA**	15	10	5	5	5	10	10	1	1	20	1	1	16
96	**DISCRETA**	15	10	5	5	5	1	1	15	10	5	1	1	8
97	**DISCRETA**	15	10	5	5	5	10	10	1	5	5	1	1	27
98	**DISCRETA**	15	10	20	10	20	1	1	1	30	20	1	1	22
99	**BUONA**	15	25	20	20	20	10	10	20	1	5	1	1	72
100	**SUFFICIENTE**	15	25	20	20	20	1	1	25	30	20	1	25	-1
101	**BUONA**	15	25	30	20	30	1	1	15	10	20	1	1	73
102	**BUONA**	15	25	30	20	30	1	1	15	10	10	1	1	83
103	**BUONA**	30	25	20	5	20	10	10	1	10	10	1	1	77
104	**BUONA**	30	25	20	20	20	1	1	1	10	10	1	1	92
105	**OTTIMA**	30	25	30	20	30	10	1	20	1	10	1	1	111
106	**BUONA**	30	25	20	20	20	10	1	20	10	10	1	1	82
107	**BUONA**	30	25	5	5	5	1	1	1	5	10	1	1	52
108	**BUONA**	30	25	5	1	5	10	1	1	10	10	1	1	52
109	**BUONA**	30	25	5	5	5	1	1	1	5	10	1	1	52
110	**BUONA**	30	25	5	1	5	10	1	1	10	10	1	1	52
111	**OTTIMA**	30	25	30	20	30	15	1	1	5	1	1	1	140
112	**BUONA**	30	25	20	10	20	1	15	1	15	20	1	1	53
113	**OTTIMA**	30	25	30	20	30	15	1	1	5	1	1	1	140
114	**BUONA**	30	25	20	10	20	1	15	1	15	20	1	1	53
115	**DISCRETA**	30	25	5	5	5	10	10	1	10	10	1	1	47
116	**DISCRETA**	30	25	5	10	5	1	1	1	10	20	1	1	42
117	**BUONA**	30	25	5	10	20	10	10	1	1	20	1	1	66
118	**DISCRETA**	30	10	5	5	5	10	10	1	1	20	1	1	31
119	**BUONA**	30	25	5	10	20	10	10	1	1	20	1	1	66
120	**DISCRETA**	30	10	5	5	5	10	10	1	1	20	1	1	31
121	**BUONA**	30	25	5	10	20	10	10	1	1	20	1	1	66
122	**DISCRETA**	30	10	5	5	5	10	10	1	1	20	1	1	31
123	**OTTIMA**	30	25	20	20	30	10	10	1	1	10	1	1	111
124	**BUONA**	30	25	5	10	30	10	10	1	1	20	1	1	76
125	**DISCRETA**	15	25	5	5	20	10	10	1	10	20	1	1	37
126	**DISCRETA**	15	25	20	10	20	1	10	1	15	20	1	1	43
127	**DISCRETA**	30	10	1	1	5	10	10	1	1	10	1	1	33
128	**SCARSA**	30	5	1	1	5	1	10	1	10	20	10	1	-9
129	**BUONA**	30	10	20	5	5	15	1	1	1	20	1	1	60
130	**DISCRETA**	30	10	5	5	5	5	1	1	15	15	1	1	26
131	**OTTIMA**	30	25	30	10	20	10	1	1	1	1	1	1	119
132	**BUONA**	30	10	20	5	5	10	1	1	1	20	1	1	55

133	**DISCRETA**	30	10	5	1	20	10	10	20	10	20	1	1	14
134	**DISCRETA**	30	10	5	1	20	10	10	1	10	10	1	25	19
135	**DISCRETA**	30	10	5	5	5	10	10	1	10	10	1	1	32
136	**DISCRETA**	30	1	1	1	1	10	10	1	10	1	1	1	20
137	**BUONA**	30	25	20	10	20	15	1	1	10	10	1	1	96
138	**SCARSA**	30	5	5	5	5	1	10	15	10	20	1	1	-6
139	**OTTIMA**	30	25	30	20	30	15	1	1	1	20	1	1	125
140	**DISCRETA**	30	10	5	10	5	10	10	1	1	20	1	1	36
141	**OTTIMA**	30	25	30	20	30	15	1	1	1	20	1	1	125
142	**OTTIMA**	30	25	30	20	30	15	1	1	10	20	1	1	116
143	**DISCRETA**	15	5	1	1	5	15	1	1	10	20	1	1	8
144	**SUFFICIENTE**	15	1	1	1	5	15	1	1	10	10	1	15	0
145	**SUFFICIENTE**	15	10	1	1	5	10	10	1	10	20	1	1	-1
146	**SCARSA**	15	1	1	1	5	10	10	1	15	20	1	1	-15
147	**BUONA**	30	25	20	10	20	15	1	1	1	20	1	1	95
148	**BUONA**	30	10	5	10	20	10	10	1	1	20	1	1	51
149	**DISCRETA**	30	10	5	10	20	10	10	1	10	20	1	1	42
150	**DISCRETA**	30	1	5	5	5	15	10	1	10	20	1	1	18
151	**DISCRETA**	30	5	5	5	5	10	10	1	10	20	1	1	17
152	**BUONA**	30	25	5	5	20	10	10	1	10	10	1	1	62
153	**DISCRETA**	15	5	1	5	20	10	1	1	10	20	1	1	22
154	**BUONA**	15	10	5	20	30	15	1	1	1	10	1	1	80
155	**SCARSA**	15	10	5	10	5	1	10	25	25	20	1	1	-36
156	**DISCRETA**	15	10	5	10	5	10	10	1	10	20	1	1	12
157	**DISCRETA**	15	5	1	1	5	10	10	1	10	5	1	1	9
158	**BUONA**	15	25	20	10	20	10	10	1	10	20	1	1	57
159	**DISCRETA**	30	10	5	5	20	10	10	10	10	10	1	1	38
160	**BUONA**	30	25	30	10	20	10	10	1	10	20	1	1	82
161	**SCARSA**	15	1	1	1	1	10	10	1	20	10	1	1	-14
162	**SCARSA**	15	1	1	1	1	1	1	1	20	20	1	1	-24
163	**DISCRETA**	30	1	1	1	1	10	10	1	1	10	1	1	20
164	**DISCRETA**	30	1	1	1	1	10	10	1	1	10	1	1	20
165	**BUONA**	15	25	20	10	30	10	10	1	1	10	1	1	86
166	**DISCRETA**	15	10	5	10	20	10	10	20	10	20	1	1	8
167	**OTTIMA**	15	25	30	20	30	15	1	1	1	5	1	1	125
168	**SCARSA**	15	10	5	5	5	10	10	20	5	20	1	1	-7
169	**DISCRETA**	15	10	5	10	20	10	10	20	1	20	1	1	17
170	**DISCRETA**	15	25	5	10	20	15	10	1	10	20	1	1	47
171	**SCARSA**	15	5	5	5	5	1	1	1	20	20	1	1	-8
172	**BUONA**	15	25	5	5	20	1	1	1	1	10	1	1	56
173	**BUONA**	30	10	5	10	20	15	1	1	1	1	1	1	84
174	**BUONA**	30	10	5	10	20	15	1	1	1	10	1	1	75
175	**DISCRETA**	15	10	5	5	5	10	10	1	10	20	1	1	7
176	**DISCRETA**	15	10	5	5	5	10	1	1	10	20	1	1	16
177	**BUONA**	30	10	20	5	20	10	10	1	5	1	1	1	76
178	**DISCRETA**	30	10	5	5	5	1	1	1	10	20	1	1	22
179	**OTTIMA**	15	25	20	20	30	15	1	1	5	1	1	1	115
180	**SCARSA**	15	1	1	1	1	1	1	1	15	20	1	10	-28