Corine Mauch
Emmanuel Reynard
Adèle Thorens

Historical Profile of Water Regime in Switzerland (1870-2000)

Working paper de l'IDHEAP 10/2000
UER: Politiques publiques et environnement

idheap
Swiss Graduate School of
Public Administration

ETH
Swiss FederalInstitute of
Technology Zürich

Comparative analysis of the formation and the outcomes of the institutional resource regimes in Switzerland

---

Vergleichende Analyse der Genese und Auswirkungen institutioneller Ressourcenregime in der Schweiz

---

Analyse comparée de la genèse et des effets des régimes institutionnels de ressources naturelles en Suisse

Project financed by the Swiss national science foundation

Peter Knoepfel, Ingrid Kissling-Näf, Frédéric Varone
Kurt Bisang, Corine Mauch, Stéphane Nahrath, Emmanuel Reynard,
Adèle Thorens

Analyse comparée de la formation et des effets des régimes institutionnels de ressources naturelles en Suisse

Partant du constat de l'accroissement significatif et généralisé de la consommation des ressources naturelles, le projet a pour ambition d'examiner, dans le cas de la Suisse, quels sont les types de régimes institutionnels -régimes composés de l'ensemble des droits de propriété de disposition et d'usages s'appliquant aux différentes ressources naturelles, de même que des politiques publiques d'exploitation et de protection les régulant- susceptibles de prévenir des processus de surexploitation et de dégradation de ces ressources.

Dans le cadre de ce projet de recherche financé par le Fonds national suisse de la recherche scientifique (FNRS), il s'agit, dans un premier temps, d'analyser les trajectoires historiques d'adaptation et de changements des régimes institutionnels des différentes ressources sur une durée d'environ un siècle (1900-2000). C'est l'objet des différents screenings.

Dans un second temps et à l'aide d'études de cas, ces transformations de (ou au sein des) régimes institutionnels sont analysées sous l'angle de leurs effets sur l'état de la ressource.

L'ambition finale de cette recherche est de comprendre les conditions d'émergence de "régimes intégrés" capables de prendre en compte un nombre croissant de groupes d'usagers agissant à différents niveaux (géographiques et institutionnels) et ayant des usages de plus en plus hétérogènes et concurrents de ces différentes ressources.

Le champ empirique de la recherche porte plus particulièrement sur cinq ressources que sont: l'eau, l'air, le sol, le paysage et la forêt.

Vergleichende Analyse der Genese und Auswirkungen institutioneller Ressourcenregime in der Schweiz

Ausgehend von der Feststellung, dass die Konsumraten natürlicher Ressourcen weltweit stetig steigen, untersucht das Projekt, ob und welche institutionellen Regime in der Schweiz einer Übernutzung und Degradation von solchen Ressourcen entgegenwirken. Solche Regime bestehen aus der eigentumsrechtlichen Grundordnung (Eigentumstitel, Verfügungs- und Nutzungsrechte) und der Gesamtheit der ressourcenspezifischen öffentlichen Nutzungs- und Schutzpolitiken.

In einem ersten Schritt zeichnen wir nach, wie sich die institutionellen Regime verschiedener Ressourcen über eine Dauer von ungefähr hundert Jahren (1900-2000) angepasst und entwickelt haben. Diese überblicksartigen historischen Analysen bilden den Inhalt der verschiedenen Screenings.

In einem zweiten Schritt werden mittels Fallstudien die Wirkungen von Veränderungen eines institutionellen Regimes auf den Zustand der Ressource evaluiert.

Mit dem Projekt soll das Verständnis dafür erhöht werden, unter welchen Bedingungen „integrierte Regime“ entstehen können: Wie kann es zu institutionellen Regimen kommen, welche die zunehmend heterogenen und konkurrenzierenden Nutzungen einer steigenden Anzahl von Nutzergruppen aus verschiedenen geographischen und institutionellen Ebenen berücksichtigen?

Als empirische Beispiele stehen in diesem vom Schweizerischen Nationalfonds zur Förderung der wissenschaftlichen Forschung (SNF) finanzierten Projekt die fünf natürlichen Ressourcen Wasser, Luft, Boden, Landschaft und Wald im Zentrum.

Comparative analysis of the formation and outcomes of resource regimes in Switzerland

In the context of a significant and widespread increase in the consumption of natural resources, the aim of this project is to determine, in the case of Switzerland, which type of institutional regime (the property and uses rights pertaining to the different natural resources as well as the public policies regulating their exploitation and protection) would most effectively prevent the overexploitation and degradation of these resources.
In the first stage of this project, financed by the Swiss National Science Foundation, we will analyse how previous institutional regimes evolved over a period of one hundred years (1900-2000). Several screenings will be devoted to this issue.
The next stage of our research will be devoted to the analysis, based on several case studies, of these modifications from the point of view of their impact on the state of a given natural resource.
The final aim of this research project is to understand the conditions necessary for the elaboration of an "integrated regime" which would take into account the growing number of users at various levels (both geographical and institutional), as well as the increasingly varied and competing forms of consumption of these resources.
This study will focus on five main resources: water, air, soil, landscape and forests.

INSTITUT DE HAUTES ETUDES EN ADMINISTRATION PUBLIQUE
Fondation autonome associée à l'Université de Lausanne et à l'Ecole polytechnique fédérale de Lausanne

Historical Profile of Water Regime in Switzerland (1870-2000)

Corinne Mauch
Emmanuel Reynard
Adèle Thorens
UER: Politiques publiques et environnement

Working paper de l'IDHEAP 10/2000
novembre 2000

Résumé

Après avoir présenté les conditions politiques et naturelles de la gestion de l'eau en Suisse, cette étude reconstitue l'évolution historique des droits de propriété, des politiques publiques et des régimes institutionnels de la ressource en eau en Suisse entre 1870 et 2000. Ces trois analyses sont structurées autour de la définition de dix catégories de biens et services fournis à la société par la ressource en eau. L'étude analyse et qualifie tout d'abord l'évolution du système régulatif (droits de propriété), puis des politiques publiques. Cette double analyse débouche sur une proposition de développement du régime de l'eau en Suisse en cinq phases majeures, pour deux types de régimes principaux : un régime complexe entre 1874 et 1991 et une tendance à un régime intégré durant les années 90.

Abstract

After presenting the political and natural conditions of water management in Switzerland, the study aims to reconstruct the historical development of property rights, public policies and institutional regimes of the water resource in Switzerland between 1870 and 2000. The three analyses are organised in relation with ten categories of goods and services provided to the society by the water resource. First, the study analyses and qualifies the regulatory system (property rights) and the public policies. This double analysis allows to propose a periodisation of the water regime in five main phases, for two principal types of regimes: a complex regime between 1874 and 1991 and a tendency to the integration during the 1990's.

Contents

1. The evolution of water policies in Switzerland

1.1 Introduction: the «water tower» of Europe

Due to its position in the central European Alps, Switzerland is described as the «water tower» of Europe. Precipitation in Switzerland is approximately twice the average European value and some six percent of Europe's total freshwater stock is stored in Swiss glaciers, streams, rivers, lakes and groundwater. Seven percent of Switzerland is covered by surface water bodies, most of which take the form of glaciers and lakes. Two major European rivers, the Rhine and the Rhone, rise in the Swiss Alps and Switzerland is also linked to other major rivers, e.g. the Po, Danube, Etsch, by the rivers Ticino, Inn and Rombach.

Abundant quantities of drinking water and service water have traditionally been taken for granted by the people of Switzerland. Droughts and water shortages are limited to the summer season in specific regions and are a rare occurrence. Rivers rarely dry up as a result of natural causes.

1.2 The political system and organisation of water management

The Swiss political system is characterised by direct democracy and by its distinctive federalist structure. The Confederation was established with the Federal Constitution of 1848 and the transmutation of the previous loose federation of cantons. Due to the nature of the Confederation's historical origins, state affairs mostly remained in the hands of the cantons, all of which have their own constitution and political institutions comprising a legislature (generally parliament), government and courts[1]. Even the new Federal Constitution, which came into force on 1 January 2000, states that «Cantons are sovereign insofar as their sovereignty is not limited by the Federal Constitution; they shall exert all rights that are not assigned to the Confederation » (article 3 Cst).

Over the past century, tasks have been increasingly assigned to the Confederation as a result of the revision of certain articles of the Federal Constitution; almost half of these concerned the sharing of tasks between the cantons and the Confederation. Despite this, the Swiss cantons still exercise a great deal of influence and power in the political arena as a result of the «federalism of implementation» («*Vollzugsföderalismus*»), whereby the implementation of most of the public policies regulated by the Confederation is assigned to the cantons, often with considerable room for manoeuvre.

Thus, the administrative structures in the area of water policy reflect the federalist structures of the Swiss political system. The main actors in Swiss water policy are the Confederation, the cantons and the municipalities/local authorities.

At the level of the *Confederation*, there are three administrative «branches» involved in water policy, which correspond to the three main issues in Swiss water policy («protection against water» (i.e. flood protection), use of water for energy production (hydroelectricity), and water protection). These are located in the Federal Departement for Environment, Transport, Energy and Communication (*UVEK)*. The Federal Office for Water and Geology (*BWG*, located in Biel) was

[1] Germann 1999, p. 388

established at the beginning of this year following the amalgamation of the former Federal Office for Water Management (*BWW*) and the National Hydrological and Geological Survey. The new *BWG* is responsible for matters concerning flood protection, statistics on water use infrastructure (e.g. dams) as well as hydrological and geological surveys and statistics. The Federal Office for Energy (*BFE*) assumes the Confederation's tasks in the area of hydroelectric production (e.g. energy policies, energy programmes, international energy-related affairs, control of nuclear power plants). Water protection issues are dealt with at state level by the Water Protection and Fisheries Division of the Swiss Agency for the Environment, Forests and Landscape (*BUWAL*, formerly the Federal Office for Environmental Protection). *BUWAL*'s International Affairs Division is involved in the work for the European Convention on the Protection and Use of Transboundary Watercourses and International Lakes and in the work of the United Nations Commission on Sustainable Development (CSD) and the United Nations Environment Programme (UNEP) on water. Further international activities in the field of water (e.g. Convention for the Protection of the Rhine) as well as the corresponding national policy are dealt with by the Water Protection and Fisheries Division. Crisis planning and provisions are the task of the Federal Office for National Economic Supply[2]; this also includes measures to ensure adequate water resources.

In addition, the Confederation runs three *research stations* which are involved in water research: the Swiss Federal Institute for Environmental Science and Technology (*EAWAG*, e.g. monitoring studies and surveys on the qualitative aspects of Swiss water bodies), the Swiss Federal Institute for Forest, Snow and Landscape Research (*WSL*, e.g. development of a systematic network to monitor groundwater reserves, the *NAQUA* project[3]), and the Swiss Federal Institute for Snow and Avalanche Research (Davos) which was affiliated to WSL in 1989.

Sovereignty over (public) waters is assigned to the *cantons*. Hence, they are responsible for the allocation of permits, licences, and concessions relating to different water uses such as navigation, fishing and the production of hydroelectric power. While their activities must respect the framework of the federal legislation, they still have considerable room for manoeuvre. This gives rise to far greater diversity in the administrative structures at cantonal level as compared with the federal administration. The implementation of the above-mentioned tasks, in addition to the implementation of water protection legislation and the management of watercourses by means of hydrological engineering infrastructure, often gives rise to «an office for each service» at cantonal level and significant differences can always be observed between the different cantons (e.g. the way in which different administrative services are combined within specific offices).

The *municiplities'* responsibilities in the area of water policy mainly involve the operation of sewage systems and wastewater treatment plants as well as the production and distribution of drinking water. Over the past few years, a growing number of small hydroelectric production installations combined with drinking-water production systems have been built. These projects were actively subsidised by the «Energy 2000» federal program which was launched as a voluntary program to promote efficient use of enery and energy savings. In general, Swiss drinking-water production and distribution companies are run by the municipalities or by amalgamations of several municipalities (particularly in the case of the smaller municipalities). As yet, there have been no significant privatisation projects in the areas of water supply and wastewater treatment although they are an increasing topic of

2 Located in the Federal Department of Economic Affairs.

3 Groundwater data is mostly collected on a cantonal and municipal as opposed to national basis. Nationwide evaluation is not yet possible, since – with a few exceptions – routine measurements are not available (BUWAL/BFS 1997).

discussion. Similarly, administrative structures that map the borders of the water catchment areas do not yet exist in Switzerland. In general, the cantons or municipalities are responsible for water management and very few of them reflect the boundaries of regional or local water catchment areas. This clearly indicates that political-administrative structures as opposed to natural boundaries form the criteria for the definition of management units.

Decision-making processes with respect to water policy issues take place at state level, to which specific tasks are assigned within the framework of the direct democratic system. A very large number of legislative acts in most policy fields, therefore, are subject to (mandatory or optional) referendum and must be ratified by a majority of the voting population and the cantons. This also applies to water policy issues. As a result of these uniquely Swiss political structures, in general, the non-governmental organisations (NGOs, e.g. environmental protection organisations) and syndicates (e.g. hydroelectric power companies, Association of the Swiss Gas and Water Industry - *SVGW*) exert a considerable influence on political decision-making processes.

1.3 The evolution of water policies

This section describes the evolution of Swiss water-related policies in the terms of the three main topics in Swiss water policy: «protection against water», water use (for hydroelectric power production), and protection of water.

1.3.1 The «protection against water»

Deforestation in mountain areas (especially the Alps) was considered the main culprit behind the damage caused by a series of catastrophic floods in the 19th century. As a result, article 24 of the Constitution, which was adopted in 1874, and the corresponding Federal Law on the Policing of Waters of 1877 and the Federal Law on the Policing of Forests of 1876 assigned sovereignty over water and the superintendence of forests in mountain regions to the Confederation. The federal jurisdiction over mountain forests was subsequently extended to all of the country's forests in a federal decision in 1898.

Measures were also increasingly implemented on the plains during the first half of the 20th century. The «Wahlen Plan», which was implemented during the Second World War, strongly promoted drainage measures, as a result of which substantial areas were made available for agricultural use. This trend continued later with the extensive land improvement measures promoted under the Federal Law on Agriculture of 1951. The main objective here was to increase agricultural productivity.

A new approach emerged in the field of water policy in the early 1990s. Within the framework of a generally more integrated approach to water policy, renaturation work was carried out along many watercourses which had been «tamed» decades - or even a century - earlier. In many of these cases, serious conflicts with nature protection organisations (e.g. concerning the river Thur and Sihl creek as well as a large number of small watercourses) lead to bargaining processes and solutions which integrated the different uses («goods and services») of water.

1.3.2 The use of water

With the spread of industrialisation and urbanisation, demand for energy, i.e. mainly electricity, increased from the mid-19th century. Since this represented a new use of water (« goods and services »), the need for regulation arose. In 1908, the Swiss people voted on and accepted article 24bis of the Federal Constitution which regulated the assignment of concessions for the production of hydroelectric power, the transport of electricity, the charges to be raised by the Cantons, and limited the use of water bodies. Eight years later, in 1916, article 24bis was followed by the new Federal Law on the Use of Hydroelectric Power (WRG) which remains in force to the present day[4]. This law grants the Confederation the right of «superintendence over the use of private and public water bodies for hydroelectric power» (article 1), which was formerly regulated by the cantons. Nevertheless, the cantons were still responsible for the allocation of concessions to producers of hydroelectric power and owners of watercourses (cantons, regions, corporations and municipalities) and – within the framework of the federal legislation – profit from the charges paid by the users.

In 1945, the Federal Council proposed the revision of the law on the use of hydroelectric power which would have granted the Confederation the right to overrule opposition from cantons or municipalities in the event of a prevailing «general interest» . This proposition was rejected by the parliamentary chambers in 1947.

The attempt to establish a more comprehensive approach to an integrated water policy, which arose in the context of the discussions surrounding the revision of the law on water protection in the late 1980s, directly concerned interest groups in the area of hydroelectric production. This concern centred on the introduction of the quantitative protection of water, as a restriction on the quantities of water available for use appeared to represent a threat to their economic survival. Their opposition to the new law was not, however, accepted by the people, who rejected a referendum opposing it in 1992.

1.3.3 The protection of water

The introduction of central water distribution infrastructure in the 19th century brought about a significant improvement to sanitary conditions in Switzerland, mainly in densely populated urban areas. However, it also led to new problems arising from the increasing quantities of wastewater from households and industry which overstretched the existing drainage infrastructure. As a result, sewage systems were built. However, due to the absence of wastewater treatment before dumping into rivers and lakes, this gave rise to the new problem of a significant deterioration in water quality. The damage to the aquatic system was first observed by the fishermen, whose economic survival was threatened by fish death and the decrease in the fish population.

Hence, in 1888, the Confederation amended the existing Law on Fishing with a paragraph prohibiting the dumping of wastewater and other substances by industry into water bodies if this represented a threat to fish and shellfish stocks. In 1925, this provision was extended to household wastewater. Due to implementation deficits, these provisions had little significant effect in most cantons. In view of the increasing levels of water pollution and the inaction of the cantons, the demand for a new article in the Federal Constitution arose in the 1930s. This objective was finally realised in 1953 with the ratification and adoption of article 24quater of the constitution. The 81%

---

[4] RS 721.80

«yes» vote in the referendum reflected a high level of awareness with respect to water pollution among the population and the perceived need for effective measures.

The corresponding legal basis was developed around the same time and in 1955, the Swiss parliament ratified the first Federal Law on the Protection of Water against Pollution (GSchG / LPEP). The corresponding implementation order was enacted by the Federal Council in early 1957. Nevertheless, implementation of the new legislation largely failed from the outset. This was mainly due to the vague formulation of the law and the assignment of detailed implementation instructions to the cantons, as well as the significant costs involved. It was not until 1962, when the Confederation began subsidising sewage systems and wastewater treatment plants, that progress was eventually made.

Despite a degree of success, the first law on water protection soon needed to be revised. This was due, on the one hand, to the sluggish implementation of its provisions by the cantons and to the emergence of new problems arising from pollution by synthetic detergents and heavy metals, on the other. In 1971, parliament adopted a strongly amended version of the water protection law whose main objective remained the widespread implementation of wastewater treatment and the reclamation of polluted water bodies (lakes, rivers). The law also included provisions governing other areas such as the transport and storage of polluting substances, the removal of waste containing oil, industrial measures and the creation of groundwater protection zones. Last but not least, sanctions were severely tightened. As a result, appropriate regulations were implemented, many of which focused on the elimination of pollutants at source as opposed to the «end-of-pipe» solution of cleaning up contaminated water bodies. Despite this, however, the phosphorus content of water bodies continued to increase.

Under the terms of the revision of the law in 1971, the Confederation was assigned the competency to legislate on substances and products which have a negative impact on water systems. The increased presence of foam on water bodies was to be limited, in particular. As a result of this, provisions governing detergents were intensified several times and a complete ban on phosphates in detergents came into force in 1986. The Federal Law on Environmental Protection (USG / LPE[5]), which came into force in 1985, represented another important milestone. This formed the basis of other important instruments, for example the Substances Decree[6], which was enacted with the aim of gaining control of environmentally hazardous substances.

The water protection law of 1971 focused mainly on the qualitative protection of water. As the result of the drying up of an increasing number of mountain creeks and small watercourses being forced underground, the quantitative aspect of water protection, which was understood as part of a more comprehensive protection of «aquatic environments» and biotopes, gained in significance. Also, there was greater awareness of the fact that as an increasingly important source of water pollution, agriculture had hitherto been more or less excluded from the water protection legislation. Long and hard conflicts accompanied the next revision of the water protection law. The most controversial aspects were water protection in agriculture and hydroelectric power. In 1991, after extensive debate, parliament accepted a revised law which protected water cycles and groundwater more efficiently, protected flowing waters from artificial interference and from being forced underground, promoted the renaturation of watercourses, emphasised the importance of water protection in agriculture and defined suitable volumes of residual water for watercourses. The owners of small

---

5 RS 814.01

6 Decree on Substances of 9 June 1986 (RS 814.013)

hydroelectric power plants launched a referendum against this law, yet the law was ratified by 66% of the voting population in 1992. At the same time, a popular initiative demanding even more severe water protection measures was rejected by 63% of voters. The key element introduced by the new law was the *quantitative protection* of watercourses.

1.4 The main issues in Swiss water policy

Water management in Switzerland currently faces five main challenges:

1. the problem of increasing competition or rival uses of water (the spectrum of water use has become more heterogeneous in recent decades in most regions);
2. the problem of phreatic and lacustrine water quality (related to diffuse pollution);
3. the question of minimum residual flows;
4. the problem of increasing imperviousness of soils (waterproofing) in settlement areas (general water planning on a communal scale);
5. the question of natural hazards relating to water (floods, permafrost and glacier degradation, debris flows).

These five problems do not affect the entire country to the same extent (e.g. problems with water quality in lakes are typical in the rural areas of the Central Plateau, the question of minimum flows and certain climatic hazards are more common in the Alpine belt and increasing competition between uses is typical of urban and tourism centres etc.). The scale of the analysis must, therefore, be adapted to the problem being studied (e.g. general water plans concern a local area whereas flood management concerns large areas (river basins, such as the Rhine Basin)).

2. The resource water and the goods and services derived from it in Switzerland

2.1 Definition of the resource water

2.1.1 General definition of water

The resource water can be defined as the part of the hydrological cycle which forms the basis of all uses derived from it by humans in order to satisfy their needs.

The resource water has the following *physical characteristics* :

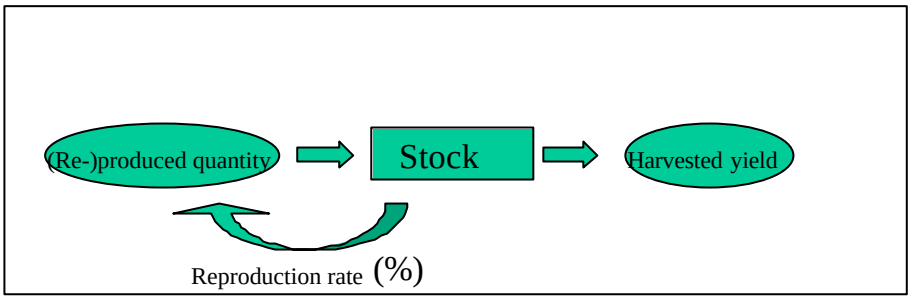
- Water (H2O) forms the earth's global hydrosphere. It is found on earth in three states : solid («ice»), liquid («water»), and gaseous (mist, haze, steam ...). In its natural form, water has a large variety of qualitative properties based on its biological, physical and chemical aspects.
- Water is continuously renewed on earth in form of a *cycle*, which is known as the hydrological or water cycle. The most important elements of the water cycle are precipitation, storage in form of snow, ice, and underground water, drains (overground or underground) and evaporation. Water systems are *open systems*; water catchment basins must also be considered as open systems.

Two fundamentally different aspects of water are crucial to its use by humans, i.e. quantity and quality. In terms of *quantity*, water is referred to in terms of litres, cubic metres (m^3) or in relation to units of time (e.g. litres/m^3 per second). In terms of *quality*, the focus lies on the chemical and biological properties of water (e.g. mineral, nitrogen or bacterial content).

2.1.2 Stock and yield

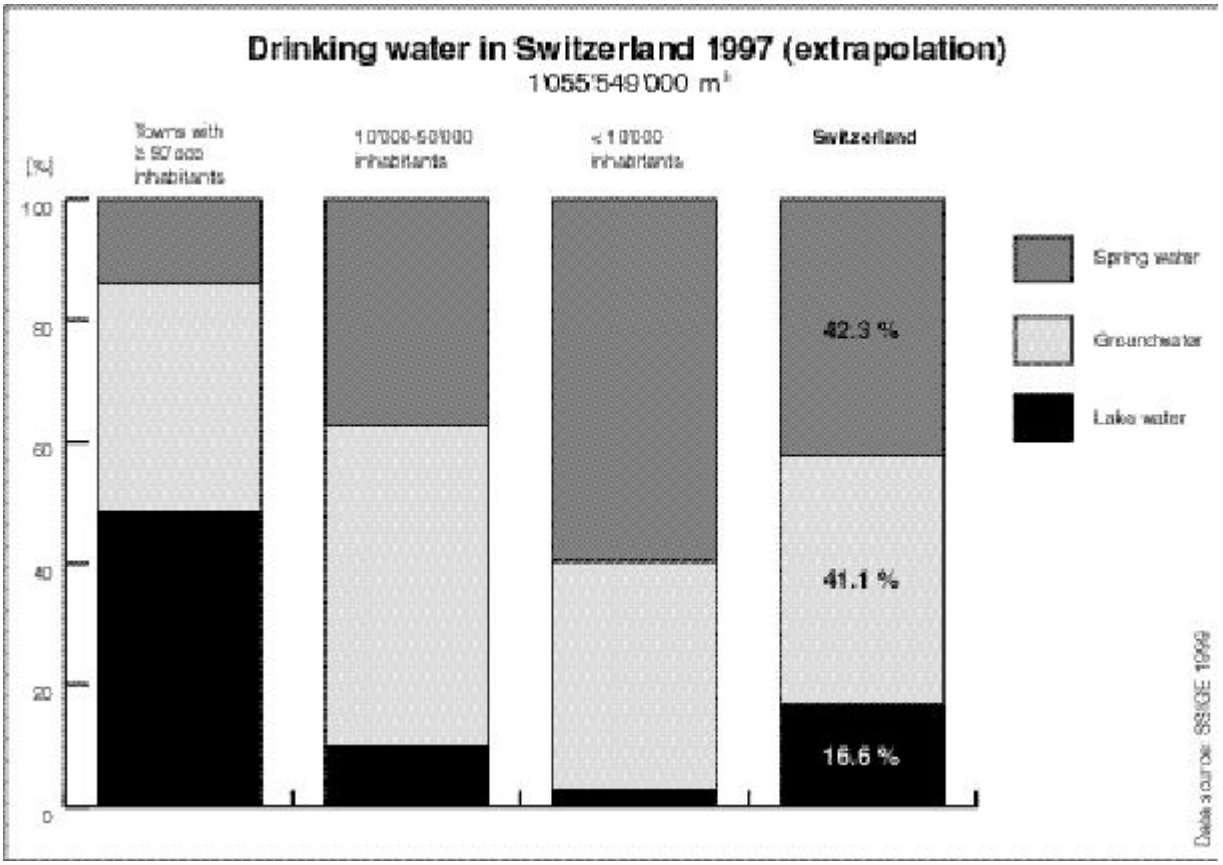
The hydrological cycle or hydrosystem («stock») allows human societies to make use of a considerable variety of goods and services («yield») derived from the resource stock (cf. Figure 1). Hence, we define the resource water as the self-regenerating stock which produces a certain volume or yield (within a certain period of time).

Figure 1: The dynamics of stock and yield of a natural renewable resource. «Underuse» occurs when the harvested yield is less the (re-)produced quantity, whereas «overuse» means that larger quantities are taken from the stock than the stock is able to (re-)produce within a given time period.



Since different forms of use (i.e. different goods and services derived from the resource) demand different properties of water in terms of quantity and quality, the renewability of the stock and the yield have to be seen in relation to these specific requirements, and they need to be differentiated according to these uses or requirements (cf. «demand (quality)» and «demand (quantity)» columns in Table 3). Different units of the resource must, therefore, be applied.

Figure 2: Impounding of water in Switzerland 1997



2.1.3 Renewability

In global terms, water is a renewable resource whereby qualitative and quantitative demands play a key role in the specific definition of renewability. The renewability of the resource is, therefore, closely linked to the hydrological cycle. This cycle can be natural or influenced by humans. Time and space-related aspects are of importance.

In global terms, the renewability of water can be deemed stable in the medium-term (time period of one hundred years). On a regional level, however, (e.g. Europe, the Alps) renewability may be seriously disrupted (time period of around ten years), in terms of quantity as well as in terms of quality. The hydrological cycle (and thus the renewability of the resource) may suffer serious interference at regional level as a result of the current climate change processes (e.g. regional decline in precipitation, regional changes in evaporation due to temperature rise, regional alteration of the solid stock (ice, snow) similarly caused by rises in temperature etc.). The temporal perspective is also important with respect to sustainability issues (from an anthropocentric point of view, for example, a period of one generation could be considered relevant in terms of the renewability of a resource).

2.1.4 Perimeter

The basic spatial unit for the study of the resource water is the ***water basin*** (catchment area); this is defined as the surface receiving the waters that flow into a specific watercourse. In general, a distinction is made between two forms of water basin: the «topographical water basin» and the «real water basin» (or «hydrological water basin»). The latter can differ from the former in terms of whether the water supply to the watercourse in question comes from groundwater streams which are independent of the surface structure. This is particularly the case in limestone regions (e.g. the Jura mountains) where the real water basin of a source largely exceeds the topographical water basin. Water basins are separated from each other by water catchment divides. This project will be based on the regional water basins defined in the *Hydrological Atlas of Switzerland*[7].

[7] Hydrological data has been processed in cartographical form in the national hydrological atlas since 1992. This hydrological atlas is still being compiled. It divides Switzerland into 1050 small basins with an average size of 37 km2 (sizes from 7 to 195 km2).

2.2 The hydrography and water balance of Switzerland

2.2.1 Hydrography

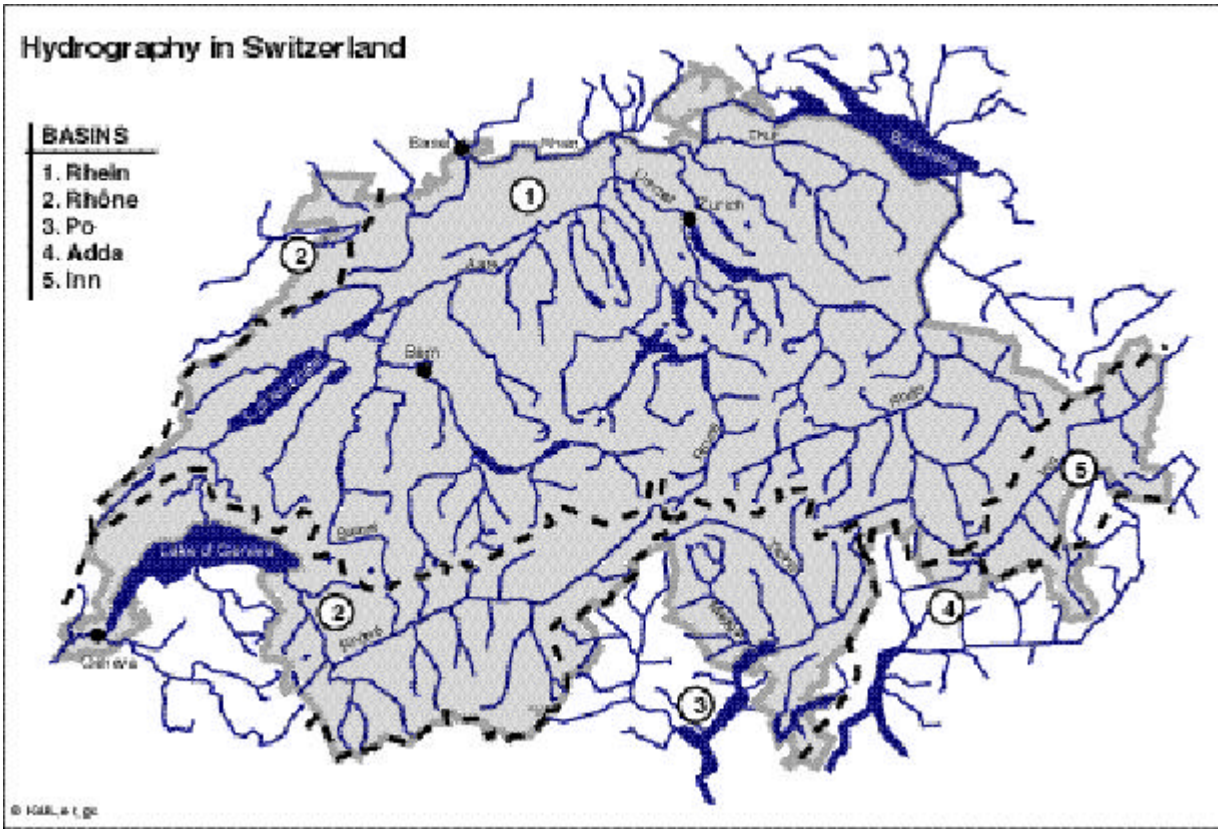
Switzerland is drained by 5 major river basins.

Table 1: Overview over Switzerland's major river basins

River basins	Sub-basins	Area (km^2)	Mean elev. (m)	River basins	Area (km^2)	Mean elev. (m)
Rhine	Rhein	3249	2001	**Rhône**	5220	2096
	Thur	1696	782	**Inn** (Donau)	1945	2351
	Töss	342	656	**Ticino** (Po)	1515	1694
	Ergolz	261	578	**Poschiavino** (Adige)	169	2149
	Birs	911	727			
	Aare	11750	1000			
	Reuss	3382	1262			
	Limmat	2176	1200			

Source: *Hydrological Atlas of Switzerland*, 1992.

Figure 3: Hydrography in Switzerland. The location of possible case studies for the projects Euwareness (EU) and IRM (SNF, Switzerland) are indicated by the characters a – f.



2.2.2 Climate

The climate of Switzerland is extremely diverse. The northern and western slopes of the Alps have an oceanic climate, i.e. relatively humid with precipitation distributed throughout the year. The southern slopes (Ticino) experience Mediterranean-type precipitation, i.e. less frequent and more intense. The Alpine interior (especially the canton of Valais) has a relatively dry continental climate (less than 600 mm of water per year on the plain).

2.2.3 Water balance

2.2.3.1 General water balance

The water balance of a country depends, for the most part, on climatic parameters. It can be determined using the following equation :

$R = P - E \pm ?S$ where R = Run-off

P = Precipitation

E = Evaporation

?S= Storage changes (ground water, ice and snow, natural and artificial lakes)

Table 2: The water balance in Switzerland for the period 1961-1980 (Schädler & Bigler 1992)

Elements of the water balance	Positive Volume (mm/y)[8]	Negative Volume (mm/y)
Precipitation	1481	
Evaporation		513
Runoff coming from abroad	318	
Runoff to other countries		1279
Storage changes	7.5*	

* The average storage change for the period 1961-1980 (+7.5 mm/y) is not representative for the 80-year period of 1901-80 (-6 mm/y) (Schädler & Bigler 1992).

2.2.3.2 Variation in water balance over time

The average water balance shows significant variations over time, as demonstrated by Schädler & Bigler (1992) :

«In the course of time, large differences are revealed in the precipitation series and, parallel to these, in the discharge series. Extremely wet years can be immediately followed by extremely dry ones (1920/1921). […] In addition to periodic fluctuations, the dry period of the 1940s stands out: due to a shortage of precipitation, the discharge values were very low all over Switzerland. In mountain basins (Rhône, Inn), however, the precipitation deficit in the discharge was compensated by increased melt water. Precipitation volumes have barely changed, on the whole. *A tendency towards lower discharge values is, however, apparent*. The general decrease in discharge is

[8] One mm of water per year over the area of Switzerland is equivalent to 41.3 million m^3 per year, or 1.31 m^3/s (*Hydrological Atlas of Switzerland*, 1992).

caused by an increase in evaporation […] which in turn can be explained by the general increase in temperature».

Storage changes over time are also significant. The *glaciers* lost ca. 25 % of their initial volume between 1901 and 1980 for the whole of Switzerland. Artificial storage increased considerably during the same period (artificial lakes).

2.3 Goods and services currently derived from the natural resource water

Water uses can be classified in ten main groups of goods and services. The following list, which is considered to be representative for Switzerland, is not exhaustive. Certain groups of goods and services are clearly localised in space (e.g. thermal springs, certain geomorphological functions). Others did not exist at the beginning of our period of reference and emerged only later (e.g. cooling water for nuclear power plants), others disappeared during the reference period (e.g. timber transportation in mountain rivers). There have also been significant changes with respect to importance of the different goods and services in relation to each other.

The ten groups of goods and services are[9]:

1. Living environment for plants and animals
2. Consumption: drinking water
3. Production: water used directly or indirectly for the production of economic goods and services
4. Energy (specific form of water use for economic production)
5. Transport and absorption of waste waters
6. Support for economic production and recreation
7. Recreation: leisure and tourism
8. Medical uses
9. Geomorphological changes
10. Strategic reserve

[9] The goods and services could also have been classified in nine groups as the production of hydroelectric power represents a special case of water use for economic production. However, due to the importance of the hydroelectric sector for the evolution of water management regimes in Switzerland, we preferred to define hydroelectric power as an individual group.

Table 3: The goods and services derived from the resource water

N°	Goods and services	Types of uses	Types of users	Internal or external use	Demand (quality)	Demand (quantity)	Complementary relationships with :	Potential conflictual relationships with :
1	Living environment	Nutrition, reproduction	Plants and animals	In situ	High (depending on the species)	Depends on the species, usually regular demand	?nature conservation	?hydroelectric power ?transport and absorption of wastewaters ?all polluting activities
2	Consumption	Drinking water	?households (indirect users); ?public administrations (direct users)	Ex situ, restitution in a lower quality	High	In CH, 414 l/d/inhab. in 1995 High variability in tourist areas		?all uses with a high demand in quality ? irrigation (quantity and quality) ?other uses for consumption (quantity)
3	Production	Industrial water	Private companies (direct withdrawal or supply by public networks)	Ex situ, restitution in a lower quality	Low	Usually high		?all uses with a high demand in quality ?other uses for consumption (quantity) ? agriculture (soil subsidence, salinisation)
3	Production	Irrigation	Private farms (direct withdrawal or supply by public or collective networks (e.g. auto-organised corporations)	Ex situ, a small part is returned, usually with a lower quality (fertilization)	Low	Depends on the climate and seasons. In dry areas, high quantities.	?recreation, cultural uses (e.g. traditional irrigation channels) ?drainage	?all uses with a high demand in quality ?drinking water (quantity and quality - diffuse pollution) ?Hydroelectric power ?other uses for consumption (quantity) ? agriculture (soil subsi-dence, salinisation)
3	Production	Drainage	Private farms and public administrations	In situ	-	-	?farm production ? irrigation	? living organisms ?nature conservation
3	Production	Production of mineral water	Private companies	Ex situ	High and specific (mi-	Variable	?water cures	?all polluting activities

					neralisation)		?tourism ?drinking water	

3	Production	? infrastructures for tourism and leisure ?swimming pools ?skating rinks ?production of artificial snow ?"aquaparks"	Private or public companies	Ex situ, partial restitution with a lower quality	Depending on the uses	Depends on uses and season	?recreation	?nature conservation ?other uses for consumption (quantity)
4	Energy	Hydropower production (dam and with high head)	Private companies with usually a monopoly on a watershed (concessions)	Ex situ, complete restitution with the same quality (except the sediment charge)	Low	High	?recreation, tourist uses ?fishing ?storing for drinking, industrial and irrigation water (dams) ?protection against floods	?nature conservation (residual flows, spatial impacts, purges) ?organisms (residual flows, purification)
4	Energy	Hydropower production (dam with low head)	Private companies with usually a monopoly on a river portion (concessions)	In situ	Low	High	?protection against floods and flow control ? navigation (locks) ? irrigation	? organisms (obstacles) ?nature protection (spatial impacts)
5	Transport and absorption	Absorption of wastewater (households, industry and agriculture)	Companies, households and public administrations	In situ	Depending on the quantity	Relatively high (dilution)	? living organisms ?fishing	?hydroelectric power (residual flows) ? living organisms ?human health ?recreation, tourism ?nature conservation
6	Support	Gravel extraction	Private companies and public administrations	In situ	Low	Low High quantities of sediments	?hydroelectric power	?tourism, recreation ?nature conservation ? living organisms
6	Support	Fishing	Private companies and individuals	In situ	Medium	Relatively high	? living organisms ?recreation ?absorption of wastewater	?hydroelectric power ?nature conservation ? industry ?all polluting activities
6	Support	Navigation	Private companies	In situ	Low	High	?tourism, recreation	?hydroelectric power (residual

			and individuals (leisure navigation)					flows, obstacles)

7	Recreation	Landscape	Individuals (inhabitants and tourists)	In situ "cultural use"	Low	High and need of natural landscape	?navigation ?fishing ?sport ?nature and landscape conservation	?all activities with spatial impact ? gravel extraction
7	Recreation	Sports	Individuals (inhabitants and tourists)	In situ "cultural use"	Medium to high	Medium to high	?navigation ?fishing ? landscape	?all activities with spatial impact ? gravel extraction
7	Recreation	Thermal springs / water cures	Individuals (inhabitants and tourists)	Ex situ or in situ	Particular (warm water)	Variable	? mineral water production ?other tourist and leisure activities ? medical water cures	
8	Medical uses	Water cures	Individuals	Ex situ or in situ	Particular (warm water)	Variable	? mineral water production ?other tourist and leisure activities ? leisure water cures	
9	Geomorpholo-gical changes	Landscape evolution	Indirect impacts on human activities	-	-	-	? living organisms ?nature conservation ?recreation : tourism, "geotopes"	?all human activities
9	Geomorpholo-gical changes	Natural hazards (floods, debris flows)	Direct impact on human activities	-	-	-		?all human activities
9	Protection	Protection against natural hazards (floods, debris flows)	Public administrations	In situ	-	-	?drainage, irrigation	?organisms ?nature protection hydroelectric power
10	Strategic reserve	Reserves in case of war	State	Ex situ	-	-	?drinking water supply	? irrigation ? ?hydroelectric power?
10	Strategic reserve	Reserves in case of fire	Public administrations	Ex situ	-	-	?drinking water supply	? irrigation ? ?hydroelectric power?

2.4 Historical evolution of the stock status and the importance of different goods and services

2.4.1 A living environment for plants and animals

Water as a living environment consists of wetlands and aquatic biotopes. **Aquatic biotopes** exist in lakes and rivers. They are affected by qualitative (chemical, temperature) and quantitative changes in the water.

Certain lakes and rivers showed signs of **pollution** and **eutrophication**, especially Lake Zurich and certain stretches of rivers downstream of large cities (e.g. Zurich, Basle, Geneva), as early as the beginning of the 20th century. This phenomenon gained in significance from the 1940s, mainly as a result of the increasing number of sewage systems (at the time the sewage was discharged untreated into surface waters) as well as the more widespread use of chemical fertilisers in agriculture. Wastewater from chemical industries also played an important role in certain areas (e.g. Basle). The eutrophication problem mainly arose in the Central Plateau where population density is far higher than in Alpine regions and where some small lakes were particularly heavily affected (e.g. Lake Sempach, Lake Baldegg, Lake Hallwyl). Eutrophication reached its maximum level in the 1970s before declining again due to the implementation of selected measures. Today, the situation has improved significantly and good water quality values can now be observed in the lakes and, to a lessor extent, rivers (Jakob 1998). However, regional differences still exist and problems mainly occur in regions with intensive agriculture (e.g. pig breeding and maize cultivation in certain water basins in the Central Plateau).

Table 4: Average concentration of oxygen, phosphorus, nitrates, and chloride in the Lake of Geneva.

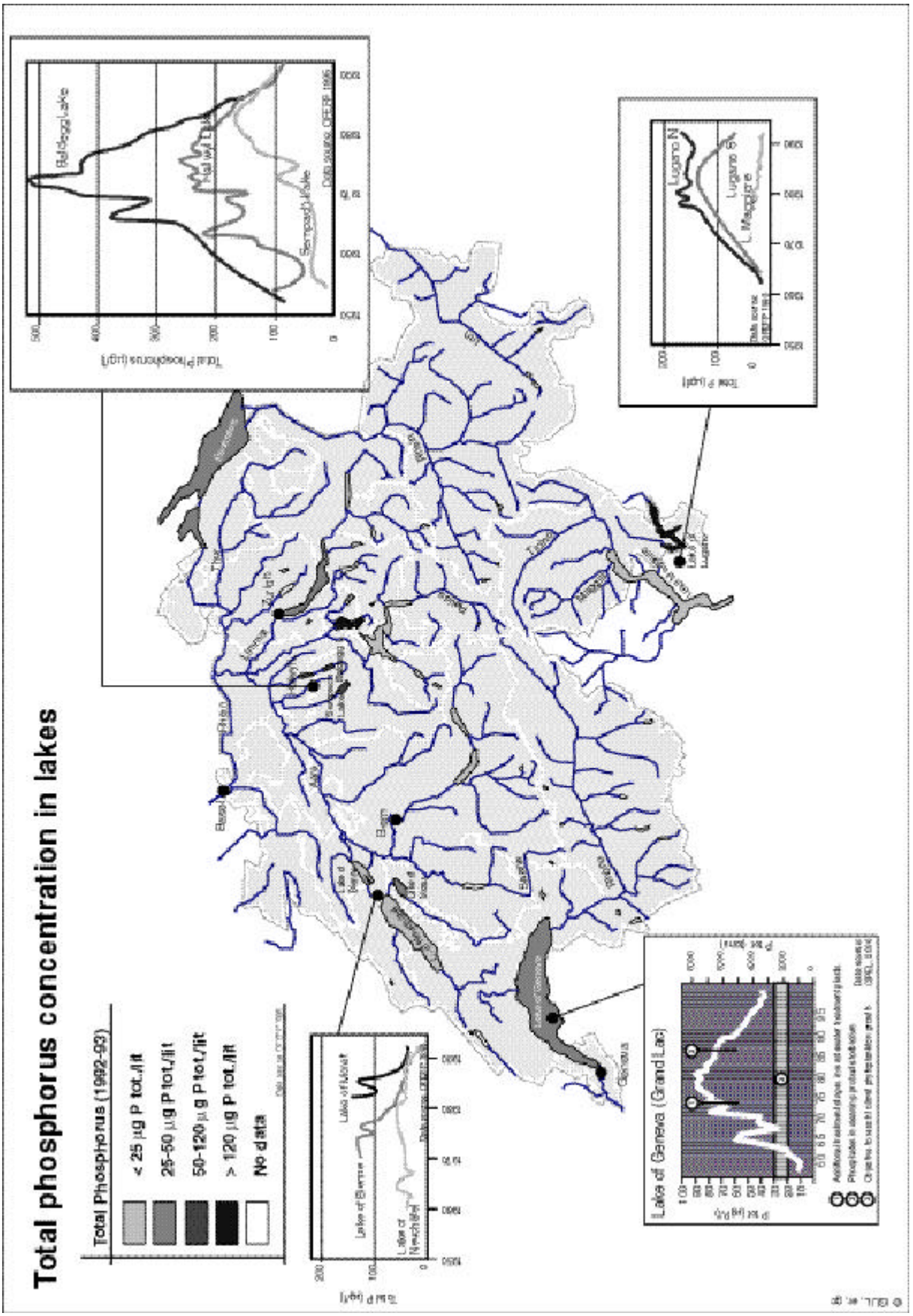
	1960	**1970-71**	**1979-80**	**1990**	**1998**
Oxygen (mg/l)	9.57	9.69	9.06	8.33	8.26
Disolved phosphorus (µgP/l)	-	50.5	71.5	48.3	35.2
Total phosphorus (µgP/l)	15.4	80.5	82.5	55.3	39.6
Nitrates (mgN/l)	0.35	0.38	0.48	0.58	0.55
Chloride (mg/l)	-	2.70	4.39	5.79	7.06

In *quantitative* terms, hydroelectric power plants pose the main threat to aquatic biotopes. The increase in the number of hydroelectric power stations from the 1940s and 50s created significant obstacles for the natural migration of fishes. In addition, a considerable number of small watercourses ran completely dry over several kilometres and consequently inhibited the survival of any form of aquatic life in these locations. The complete drying up of watercourses was prohibited in the new water protection legislation which came into force in 1991 (cf. also chap. 2.4.4).

With respect to the *wetland biotopes*, the situation was already rather unfavourable at the beginning of the reference period, mainly as a result of the exploitation of peat bogs and the drainage of certain zones for agriculture. Moreover, the situation deteriorated significantly during the Second World

War («Wahlen Plan») and in its aftermath with the development of intensive agricultural practices and widespread urbanisation from the 1950s to the 1990s.

Figure 4: Total phosphorus concentration in Swiss lakes.


Total phosphorus concentration in lakes
Total Phosphorus (1982-92)
< 25 µg P tot./l
25-50 µg P tot./l
50-120 µg P tot./l
> 120 µg P tot./l
No data
Lake of Geneva (Grand Lac)
Lugano N
Lugano SE
L. Maggiore
Rotsee
Sempachersee
Baldeggersee
Lake of Biel
Lake of Murten
Lake of Neuchâtel
Rhein
Aare
Reuss
Limmat
Thur
Basel
Bern
Zürich
Genève

Over the past century, *biodiversity* diminished significantly in all three types of aquatic environment (lakes, rivers and wetlands). The conflict surrounding the Rothenturm army training ground (1987) marked a turning point in the enforcement of the protection of wetlands and the 1990s also saw a new trend for change in this area with the advent of renaturation projects.

Table 5: Changes in the lenght of waterways in Switzerland per year, 1984-1995.

Stream courses covered in	Stream courses blocked or straightened	New stream courses (included re-opened)
74 kilometers	29 kilometers	47 kilometers

Source : Swiss Agency for the Environment, Forest and Landscape (95 out of a total of 152 random samples from landscapes in the Alps, mountains, Central Plateau and agglomerations were evaluated).

Table 6: Changes to standing water and wetlands in Switzerland, 1984 – 1995. Within this time period, the area accounted for by lakes and ponds increased by 68 hectares annually, while the area accounted for by marshes increased by 49 hectares annually.

Lakes, ponds (new)	Lakes, ponds (silted up)	New marshes (without silting)	Drained marshes
76 hectares	8 hectares	57 hectares	8 hectares

Source : Swiss Agency for the Environment, Forest and Landscape (95 out of a total of 152 random samples from landscapes in the Alps, mountains, Central Plateau and agglomerations were evaluated.

Table 7: Number of endangered animal species in Switzerland (ca. year 2000).

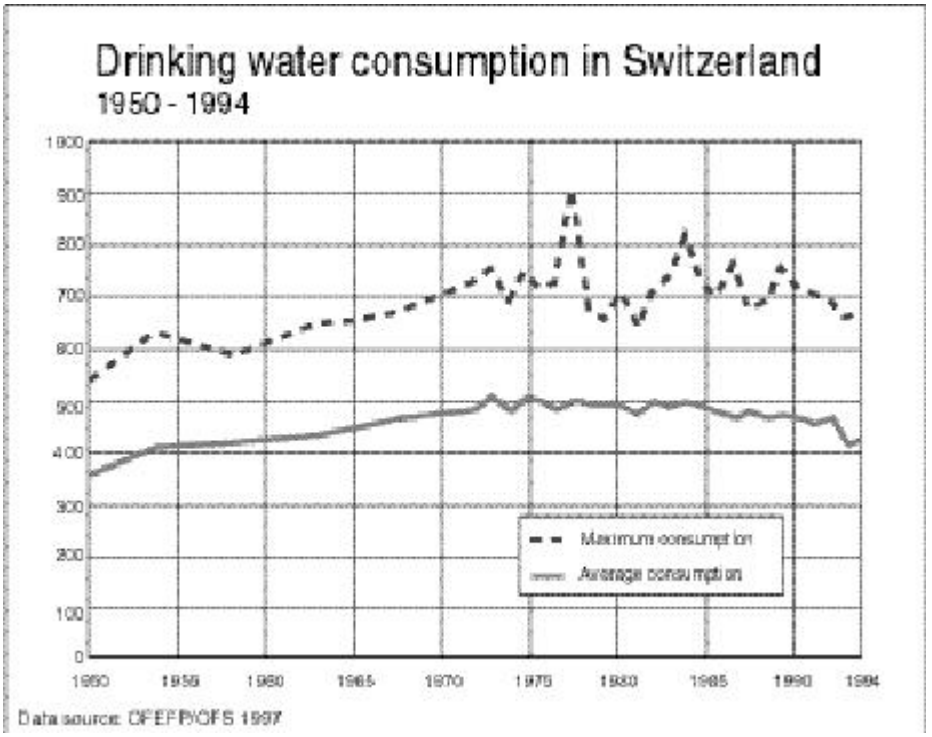
Animal group	Total species	Species on the Red Lists	Species on the Red Lists (in percent)	Extinct	Threatened with extinction	Seriously endan-gered	Endan-gered	Rare
Amphibians	20	19	**95**	3	1	3	12	-
Fishes and cyclostomes	54	42	**78**	7	5	8	8	14
Vertebrates total	376	234	**62**	22	30	27	102	53
Invertebrates total (recorded species)	2369	1215	**51**	118	176	254	409	258
Total species (vertebrates/ recorded invertebrates)	2745	1449	**53**	140	206	281	511	311

Source: SFSO / SAEFL, 1997.

2.4.2 Drinking-water consumption

In 1910, approximately 280 million m^3 of drinking water was produced to satisfy the needs of the population of 3,753 million. This gives a specific drinking-water consumption of ca. 205 l/inhab/y[10]. Today, the total production volume of ca. 1090 m^3 of drinking water originates from spring water (ca. 40%), ground water (ca. 40%), and lake water (ca. 20%).

Figure 5: Drinking water consumption in Switzerland 1950 – 1994 (source: BUWAL / BFS 1997, p. 48).

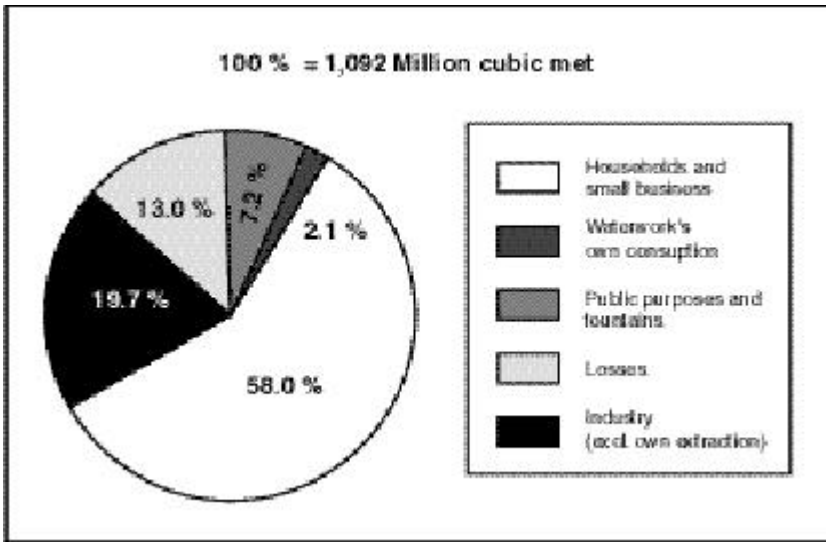


Total consumption of drinking water has quadrupled over the last century. The biggest increase in consumption was recorded in the period between 1945 and 1970. Since 1970, consumption has remained stable thanks to progress in the industrial sector and improvements in the productivity of the water networks. Consumption levels were ca. 420 litres per inhabitant per year during the mid-1990s. Peak demand may increase in the future as a result of climate change.

Figure 6: Breakdown of dringking water consumption in Switzerland 1995 (source: SFSO / SAEFL 1997, p. 47).

---

[10] Calculation based on the graph published by the OFEFP 1995, p. 10. The population taken into account is that specified in the *annuaire statistique*, OFS 1997, p. 67. The data concerning the distribution of drinking water in Switzerland was collected by the Swiss gas and water company, *Société suisse de l'industrie du gaz et des eaux (SVGW)*, for approximately 60 % of the population (OFEFP 1994). The data is extrapolated from this by the Swiss federal statistics services (SFSO/SAEFL 1997).



Generally speaking, sanitary risks in relation to the consumption of drinking water are lower today than in the early 20th century (and particularly as compared to the 19th century) (BUWAL 1993). Nevertheless, *toxication accidents* can always occur, as it was the case in Zermatt (typhus epidemic in 1961), toxication in La Neuveville (1999). Agriculture is a major contributor to the impairment of ground and surface water quality. In addition to plant treatment products, the plant nutrients nitrogen (mostly ammonium and nitrate) and phosphorus are the main culprits here.

2.4.3 Production

2.4.3.1 Industrial water

It is difficult to estimate the evolution of trade and industry's quantitative water requirements during the last century. Nevertheless, it can be surmised that industrial requirements more or less echoed the general trends in water consumption. Consumption definitely increased more rapidly in the decades after the Second World War. Since 1980, consumption has remained largely constant at a level of 250 million m^3 per year which amounts to ca. 20% of the drinking water distributed by public services (OFEFP 1994, p. 197, SFSO/SAEFL 1997, p. 47). In addition to consuming public drinking water, some industries also extract their own supplies.

Industry also makes use of the hydrosystem in an indirect way as a means of absorption of polluted water. A third type of industrial use of water - this time direct - involves *cooling water for nuclear power plants.* This kind of use arose for the first time in the late 1960s when Switzerland's first nuclear power plant came into operation in 1969. The requirement in this area stopped increasing from 1990 with the coming into force of the «nuclear moratorium». To limit the impacts from this type of use on the hydrosystem (heating), cooling systems were prohibited by the Federal Council in the rivers Rhine and Aare from 1971.

In *qualitative* terms, the 20th century can be divided into two phases. Up to 1950, very few restrictions were imposed on industry with respect to the discharge of pollutants. From 1955, industry's rights to pollute were diminished. This did not prevent accidental pollution, however, which occurs throughout the reference period. Diffuse pollution from contaminated sites also occurred throughout the century but was definitely more common from 1950 to 1960.

2.4.3.2 Water for agriculture: irrigation and drainage

Drainage, which was already extensively used in the early part of the century, particularly in the alluvial plains, endured throughout the period with peaks during the Second World War (Wahlen Plan) and during the 1960s and 70s (intensification of agriculture and urbanisation). Since the mid-80s, there has been a decline in drainage. The *irrigation of the plains* followed more or less the same pattern: strong increases in the 1960s and 70s followed by stagnation. *Mountain irrigation* was extremely well developed and a high consumer of water in the early part of the century. From the 1950s, it diminished significantly in the mountain meadows and pastures, mainly as a result of the demise in livestock rearing in mountain regions. The irrigation of the vineyards followed an inverse trend: relatively underdeveloped up to the Second World War, it increased significantly during the 1960s and 70s before diminishing again from 1985.

2.4.3.3 The production of mineral water

Several sources of mineral water exist in Switzerland, mainly in the Alps. Production of certain well known Swiss brands started at the beginning of our reference period (Passugger 1897, Henniez 1905). Others emerged after the Second World War (Aproz 1947, Valser 1960). Problems with respect to quality have also emerged within certain mineral water sources (particularly in relation to nitrogen from agriculture).

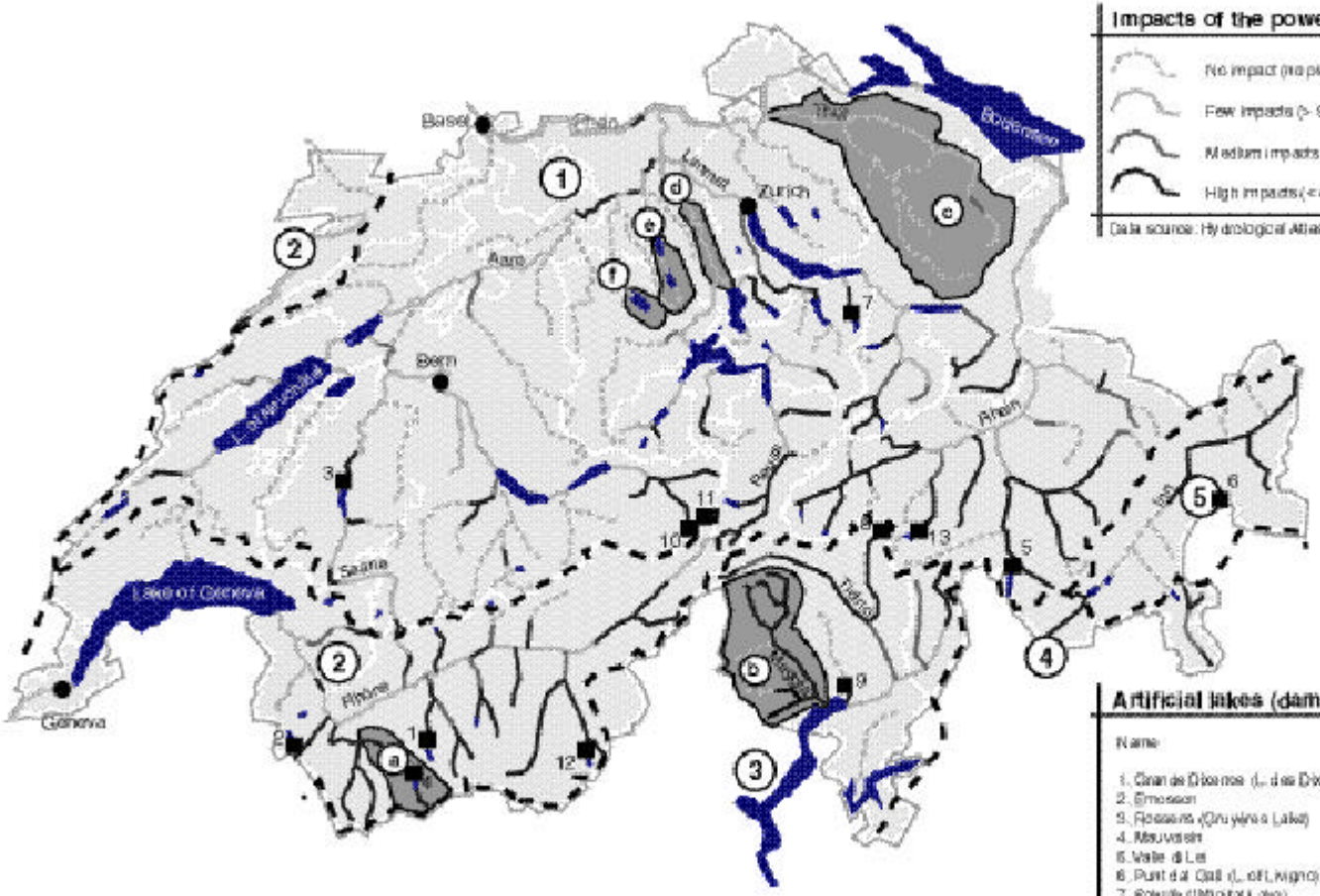
2.4.4 Hydroelectric power

The production of hydroelectric power in Switzerland was originally based on river stations and storage stations. The first *river stations* were built in the late 19th century. Of the eleven stations recorded by the *Société Suisse des Entreprises Hydroélectriques* (Swiss Association of Hydroelectric Companies), nine were built between 1896 and 1920, one in 1935 and one in 1975 (Bremgarten). In the period from 1950 to 1970, there was extensive construction of *storage structures*. Since then, there has been little increase in the production of hydroelectric power (in contrast to the production of electrical energy from thermal sources) and the projects that have been realised are smaller in scale.

Electricity consumption in Switzerland increased steadily over the course of the century. It rose from 10 thousand million kWh in 1950 to 49.3 thousand million kWh in 1998 (OFE 1999, p. 10). Electricity production followed a similar trend, increasing from 12 to 60 thousand million kWh over the same period. Electricity originating from hydroelectric production represented 20.5 thousand million kWh in 1960 (or 99% of total electricity production) and increased quite steadily up to the mid-1970s (34 thousand million kWh in 1975 or 79 % of total production), after which it remained at a level between 30 and 35 thousand million kWh per year. In 1998, of the *61 thousand million kWh* of electricity produced in Switzerland, 56.3 % was based on hydroelectric power (24.6 % from river stations and 31.7 % from storage stations) (OFE 1999, p. 13). Several stations are now in the course of being refurbished or constructed. This should increase production in Switzerland by 235 million kWh (OFE 1999, p. 39).

Figure 7: Hydroelectric power production and impact on rivers in Switzerland.

Hydropower production and impacts on rivers



Impacts of the power plants on the river discharge

- No impact (no plants on the river)
- Few impacts (> 80% of the natural discharge is conserved)
- Medium impacts (40-80 % of the natural discharge is conserved)
- High impacts (< 40% of the natural discharge is conserved)

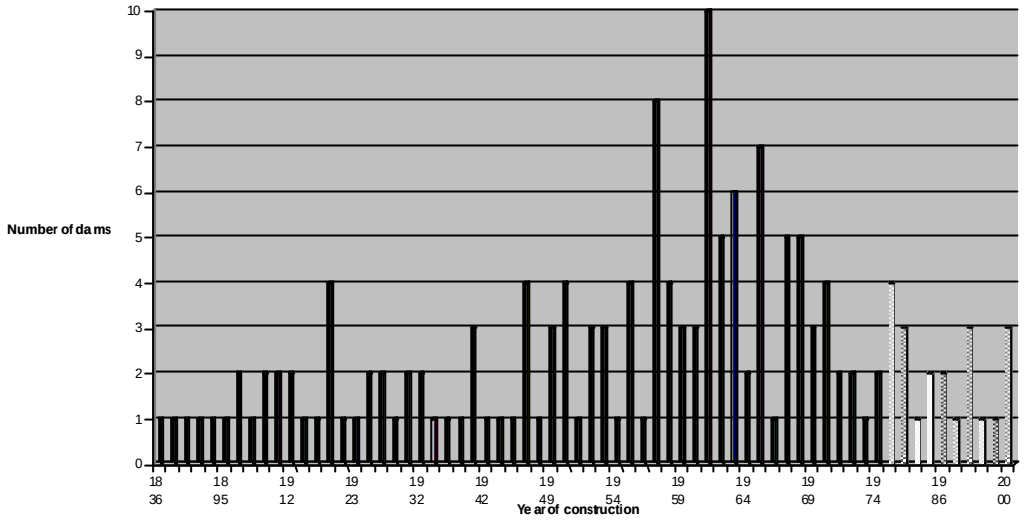
Data source: Hydrological Atlas of Switzerland, chap. 5.2, simplified

Artificial lakes (dams) with more than 100 Mio m³

Name	Volume [Mio m³]	Year of construction
1. Grande Dixence (L. des Dix)	400	1961
2. Emosson	227	1974
3. Mauvoisin (Driance Lake)	220	1947
4. Mauvoisin	211.5	1957
5. Valle di Lei	200	1961
6. Punt dal Gall (L. di Livigno)	164.6	1968
7. Schräh (Wägital Lake)	150	1924
8. Luzzone	108	1963
9. Contra (Lake of Vogorno)	105	1965
10. Spitallamm (Grimsel Lake)	101	1932
11. Seeuferegg (Grimsel Lake)	101	1932
12. Mattmark	101	1957
13. Zervreila	100.6	1957

Data source: Swiss Committee on Dams, 2000 (Web site: www.swissdams.ch)

Figure 8: Number of dams constructed in Switzerland for hydroelectric power production purposes since 1836.

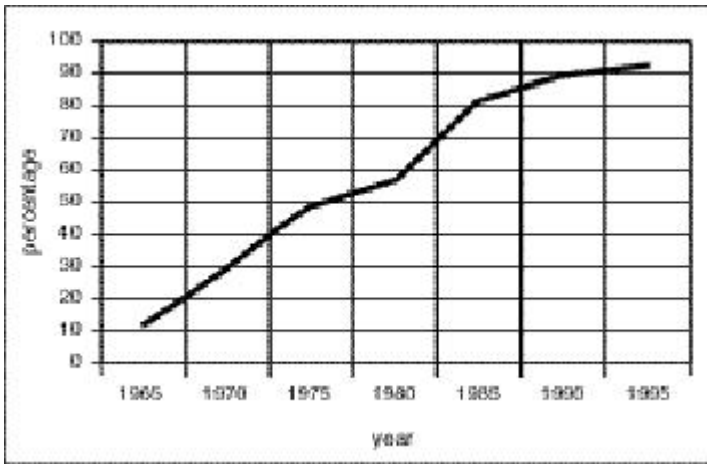


Throughout the century, the construction of hydroelectric power plants faced the *opposition of nature conservation and heritage organisations* (LSPN and Heimatschutz since the beginning of the century, WWF since the 1970s). These frequently serious conflicts involved both the river stations (e.g. Reinhau from 1944 and Hydro-Rhône from 1984) and storage stations (e.g. Urseren (UR) from 1920, Lake of Sils from 1927, Torrent Spöll (National Park) from 1926, Grimsel-West from 1987, Cleuson-Dixence from 1988). Some resulted in victory for the nature conservation movement (Urseren, Sils, Hydro-Rhône, Grimsel-Ouest) and others for the electricity producers (Reinhau), and there were some compromises (Spöll, Cleuson-Dixence). Most of these conflicts lasted between one and several decades.

2.4.5 Transport and absorption of wastewater

At the beginning of the 20th century, pollution was sporadic (downstream of towns and chemical industrial plants) but certainly more intensive in the black spots than it is now. The situation remained largely unchanged up to and during the 1940s which were characterised by a major increase in the eutrophication of lakes in central Switzerland. The 1950s saw a reversal of this trend with the introduction of legal restrictions on pollution by industry and the - albeit rather gradual - introduction of household wastewater treatment.

Figure 9: Connection to wastewater treatment plants, 1965-1995 (percentage of the population conntected)



Source: Swiss Agency for the Environment, Forests and Landscape (SFSO/SAEFL 1997, p. 57)

The 1970s saw the spread of the centralised treatment of household and industrial wastewater. This resulted in an improvement in the quality of surface waters (mainly with respect to phosphorous content which gives rise to eutrophication) from the mid-1970s. However, nitrate concentrations continued to rise, mainly as a result of agricultural pollution. This phenomenon, which can also be observed in underground waters, has continued to the present day.

2.4.6 Support for economic production and recreation

2.4.6.1 Extraction of materials

There is no data available on the quantities and importance of materials extracted from water. However, it is worth mentioning in this context that gravel extraction, for example, often clashes with the aims of nature and landscape conservation (e.g. Bois de Finges).

2.4.6.2 Fishing

The different qualitative and quantitative changes to the hydrosystem caused major impacts on fish habitats. In general, there has been a clear demise in biodiversity in the three types of aquatic environment (lakes, rivers and wetlands) over the past century. For example, by the early 1980s, the fish stocks in Lake Geneva were fifteen times lower than in the 1960s (de Miller 1999, p. 282). The total fish yield from the Rhine, at Basle, has also decreased significantly since the Second World War (4000 kg in 1944, 1867 kg in 1967, Walter 1990, p. 224). Moreover, salmon has completely disappeared downstream of Basle since the 1950s. The same applies to otters which have not been found in Swiss rivers since the 1940s. The beaver disappeared in the early 19th century[11]. Fishes and cyclostomes comprise 78 % of the species on the «red» list of extinct, rare or threatened species (SFSO/SAEFL 1997, p. 106).

[11] It was reintroduced from the late 1950s. At present there are approximately 350 beavers in Swiss rivers, but their survival is not guaranteed and numbers are now static (OFS 1997, p. 125).

It should, however, be noted that this decrease in fish stocks is not only caused by changes to the aquatic environment: over-fishing and deliberate eradication (beaver, otter) should also be mentioned in this context.

2.4.6.3 Navigation (lakes and rivers)

Rivers in Switzerland are relatively underexploited when it comes to navigation, except, for example, in Basle. Nevertheless, some instances of river pollution from cargo ships have been reported to add to the level of pollution caused by industry. *Navigation on lakes* mainly serves tourism and leisure purposes. In the 1970s, conflicts arose in this regard when nature protection organisations tried to ban the use of motor boats on certain lakes in the Central Plateau.

2.4.7 Recreation

2.4.7.1 Interaction water – landscape

Water, in both liquid and solid forms, is an essential feature of the Swiss landscape (glaciers, rivers, lakes, wetlands etc.). Up to the 19th century, the natural landscape of Switzerland included numerous wetlands and areas prone to flooding (alluvial plains, lakeshores, central Switzerland). Many of these areas were drained from the early 19th century.

The main conflicts which occurred throughout the 20th century centred on the relationship between hydroelectric power companies and landscape and nature conservation organisations. Despite the fact that the impacts arising from the development of infrastructure and the correction of watercourses were as significant as those on the landscape, such projects generally aroused less opposition until recently.

2.4.7.2 Recreational infrastructure that uses water

There is no information available on the banning of *swimming* due to water pollution before 1960. There can be no doubt, however, that the sight of algae-covered eutrophicated lakes did not exactly encourage bathing in earlier years. The situation deteriorated in the 1970s, before improving again. There is now a strong decline in the number of shores where bathing is not advised.

The production of *artificial snow* represents a new use of water which was introduced in Switzerland in the late 1970s (Mosimann 1987, 1998, Keller & Fischer 1991). Artificial snow production consumes water in two ways: directly (transformation of water into snow) and indirectly (use of energy for this process) (Mosimann 1987, 1998, Broggi & Willi 1990, Keller & Fischer 1991). After the winters of 1988, 1989 et 1990, which were low in snowfall, there was a significant increase in artificially snowed areas. In 1997, there was a total of 1000 ha of artificially snowed land and this increased to 1300 ha in 1999. A total of ca. 1700 ha is predicted for 2003. The cantons with the largest artificially snowed areas in 1999 were Valais (559 ha) and Grisons (234 ha). In contrast, from now to the year 2003, the strongest increase in this area is expected in the Pre-Alps (Fribourg, Vaud, Berne, central Switzerland) (Mosimann 1998). At present, artificial snow is not guaranteed at several stations in the Jura and Pre-Alps (OFS 1997, p. 113). Given the temperature rise of 2°C, this trend can be expected to accelerate and there will be a rise in the need for artificial snow.

The direct environmental impacts of artificial snow are still relatively unknown and it is already a subject of significant conflict with nature conservation organisations (direct impacts on the environment, use of bacteria, question of minimum residual flows, geomorphological impacts etc.). (For case studies, cf. Reynard 2000a)

2.4.8 Thermal springs

The use of thermal springs for health and leisure purposes exploits a specific characteristic of water: its heat. Switzerland's main thermal centres are located in the Alps and at the foot of the Jura mountains. *Medical water cures* were practised in Switzerland before the beginning of the 20th century (Baden, Bad Ragaz, Yverdon-les-Bains, Leukerbad etc.) and in the early 20th century they were used solely for medical purposes. Some tourist centres developed around thermal sources (Leukerbad). Since the 1970s, some of the centres have developed the more recreational aspects of the springs and in some cases this has overtaken the medical aspects (e.g. Ovronnaz). In some places, the water is also sold as mineral water (e.g. Arkina at Yverdon-les-Bains).

2.4.9 Geomorphological changes, transport of sediment, natural risks and the correction of watercourses

The regime of most of the country's major watercourses tends to be *nival***,** with maximum monthly flows in June (OFS 1997, p. 105). However, catastrophic floods can take place at any time in the year (e.g. the Rhine floods, Bader & Kunz 1998, p. 161). In the 19th century, the period from 1827 to 1875 was characterised by a strong increase in flooding and this gave rise to the implementation of a large number of river correction projects. The situation was then stabilised and the instances of extreme flooding decreased significantly from 1927 to 1975. Since 1975, it would appear that flooding is once again on the increase, especially in the central and southern Alps[12] (Bader & Kunz 1998, p. 160 ss)[13]. It should also be noted that the country's vulnerability to the risks of flooding significantly increased in the course of the 20th century (urbanisation, anthropic pressure on the banks of watercourses etc.).

Most of the major correction projects in central Switzerland (lake stabilisation) were already completed in the 19th century. The torrential catastrophes of 1868, 1944, 1953 (Reuss), 1978 (Tessin), 1987 (mainly in central Switzerland) and 1993 (Oberwallis) each spurred renewed motivation for the implementation of dyking and correction projects. The following general schedule emerges: correction of rivers in central Switzerland (e.g. Linth from 1807, first correction of the Rhône 1863-1884, first correction of the Jura waters 1869-1886), *correction of Alpine watercourses* **(**from the beginning of the century and mainly in the 1940s and 50s when numerous structures were realised as part of the use of watercourses for hydroelectricity production (dams, harnassing etc.)). As a result of the obstruction of watercourses (flood barriers, use of hydroelectric power and housing development), today some 90% of Switzerland's ca. 65,000-kilometre-long network of rivers and streams have been straightened, dammed, canalised or channelled underground. After half a century of correction, the *1990s* saw the emergence of initiatives for the renaturation of watercourses which aim to restore the natural course of some rivers and streams.

---

[12] The authors explain this trend *inter alia* in terms of the reduction of infiltration capacity since the 1960s.

[13] The authors note that this increase cannot be solely explained in terms of climate change.

It should be noted that these correction projects were not solely aimed at providing protection against flooding etc. but also served agricultural (drainage, increasing supply of arable land) and health (battle against malaria) purposes. In some cases, the purpose was also to facilitate the construction of communication channels (railway). Throughout the century, the few conflicts that arose with the nature and landscape protection organisations concerned work intended to improve the safety of inhabitants. It was only in the last decade of the century that a shift in attitude emerged with opposition to certain correction projects and support for the the renaturation of watercourses (e.g. Finges following the floods of 1993, Reuss River in the 70s, Thur River in the 90s).

2.4.10 Strategic reserve

We were unable to find any information with respect to the situation at the beginning of the century and particularly during the world wars. At present, the use of water for the constitution of strategic reserves is regulated by the Decree on the Guaranteeing of Drinking-Water Supply during Emergencies (*Verordnung über die Sicherstellung der Trinkwasserversorgung in Notlagen, VTN)* of 20 November 1991 (RS 531.32) which defines the minimum quantities to be made available by suppliers of drinking water (article 4): as much as possible up to the third day, 4 l/inhab/day from the 4th day, 15 l/inhab/day from the 6th day etc.). Emergencies in this context are defined as natural disasters, major accidents and acts of sabotage or war (article 3).

3. Property rights to the resource water

3.1 «Private» and «public» rights to water in Switzerland

3.1.1 Private property and state sovereignty

The Swiss regulative system (= property and use rights) is mainly defined at three levels : the Swiss *Civil Code* (enacted in 1912), the *Federal Constitution*, and *federal laws*[14]. Rights to the ownership and use of water are regulated by the two general principles of «private property» and «state sovereignty». The principle of *private property* is defined in article 667 of the Swiss Civil Code which extends the possession of land to the spaces below above it: «This includes, subject to legal restrictions, buildings, plants, and sources». The principle of *state sovereignty with respect to water* («*Gewässerhoheit*») restricts private property by reason of the prevailing public interest.

As Leimbacher & Perler (2000, p. 261) pointed out, this restriction does not involve a formal transfer of the property title, but it complies with the assignment of a matter to the public domain and, therefore, withdraws such objects from private influence without changing any existing property title. However, state sovereignty involves important limitations with respect to the rights of disposal and use relating to private property. Where state sovereignty exists with respect to water, it is the state which decides on rights of use and disposal.

In general, use rights to a resource under state sovereignty are assigned by means of permits (e.g. for sailing events on lakes), licences (e.g. for fishing) or concessions (e.g. for hydroelectric power production), which offer an exclusive use right to a specific resource for payment of a fee[15]. In all of these cases, the state retains sovereignty with respect to the resource while according use rights to (e.g. private) users. Generally, concessions and permits are assigned by the cantons, municipalities and, in some cases, public bodies (Leimbacher & Perler 2000, p. 263).

3.1.2 Private and public water bodies

The Swiss Civil Code, which dates from 1912, makes a distinction between *public water bodies* (article 664 Civil Code) and *private water bodies* (article 704 Civil Code), on the basis of specific characteristics.

3.1.2.1 Public water bodies

The first category - public water bodies - includes *surface waters* (rivers, streams and lakes) as well as glaciers and névés (article 664 CC, paragraph 1 and 2):

> *1 Abandoned sites and the property of the public domain are subject to state policing on the territory on which they are located.*

---

[14] Amended by federal decrees and cantonal implementation laws derived from the federal law.

[15] Concessions differ from licences in that with licences, users obtain the right to use the resource in competition with users of the same type (e.g. other fishermen or sailors) whereas in the case of concessions, the user receives an exclusive right to the use of the resource.

2 In the absence of evidence to the contrary, public water bodies, as well as regions unsuitable for cultivation, boulders, masses of fallen rocks, névés, glaciers and rising sources shall not enter into the private domain.

Flowing waters should be considered as *common property* or *res communes omnium* (Leimbacher & Perler 2000, p. 257)[16]. As such, they are subject to state sovereignty and the state can dispose of them as it wishes. The cantons are responsible for the regulation of use rights to surface waters (article 664, al. 3 CC and article 24 bis, al. 3 Cst). A landowner does not, therefore, own the surface waters that flow along his/her property.[17] Thus, the surface waters in all cantons are considered public property with the sole exception of the canton of Glarus where surface waters are considered private property (Leimbacher & Perler 2000, p. 262).[18]

Finally, some cases of *free use* of public water should be mentioned. These include uses such as bathing and removal of small quantities, mainly for animals.

3.1.2.2 Private water bodies

Underground water sources are considered *private waters* (article 704 CC). According to article 667 of the Civil Code, they represent an integral part of the ground on or under which they are located. The landowner, can, therefore, dispose freely of source and underground water. However, the Swiss Civil Code does impose limitations on the right of disposal, particularly with respect to the *supply of water to neighbours* (articles 709 and 710, al. 1 CC) and in the general public interest (article 705, al. 1 CC and article 711, al. 1 CC).

All source waters are not, however considered as private property. Sources rising from a glacier or terrain unsuited to cultivation *(rocks, boulders etc.)* (article 664, al. 2 CC), some major sources of general interest (e.g. Leukerbad, decree TF 97 II 333, quoted by Leimbacher & Perler (2000, p. 257)) and sources at the *head of a river or stream* (decree TF 122 III, 49 quoted by Leimbacher & Perler (2000, p. 258)) are all considered public property. Similarly, even if they are formally comparable to source waters, expanses of underground water of a certain size have gradually come to be defined[19] as public waters (Liver 1952, quoted by Leimbacher & Perler 2000, p. 259). *Underground waters are now generally considered as public property* (Leimbacher & Perler 2000, p. 260).

---

[16] Exceptions : e.g. bottled water (attains the status of a «thing» which can be private property). In the case of water diversions, (for payment of a charge or purchase price) the water becomes the property of the owner of the structure for the duration of its passage through it (Leimbacher & Perler 2000, p. 257) on the basis of the principle of accession. The same applies for the storage of water in artificial reservoirs (Leimbacher & Perler 2000, p. 260).

[17] He/she does, however, have the right of disposal (for example for irrigation) as long as the use for which he/she intends the water does not withdraw it from third parties situated downstream (Leimbacher & Perler 2000, p. 257)

[18] Leimbacher & Perler (2000, p. 263-264) also report of the existence of old private rights *(die sogenannten ehehaften Rechte)* which consitute exceptions to the sovereignity of the state over water bodies, particularly in the areas of fishing and the use of hydroelectric power. These are old privileges which can be associated with private owners, local authorities and corporations. Such rights are, however, quite rare nowadays.

[19] The canton of Zurich deemed certain underground expanses of water as public property as early as 1919 (Leimbacher & Perler 2000, p. 265).

Table 8 : Summary of the current distinctions with respect to public and private ownership of water bodies in Switzerland

	Surface water	**Springs**	**Underground water bodies**
Type of rights	Public law	Private law	Private law
Property rights (Civil code, CC)	State sovereignty (art. 664, al. 1 CC) Exception: The canton of Glarus defines all water bodies as private water.	Related to ground property (art. 667 CC, art. 704 al. 1 CC). Glacier springs and springs on uncultivable land = public water (art. 664, al. 2). Jurisprudence defines certain large springs and springs building the source of a watercourse as public water.	Formally related to ground property (art. 667 CC, art. 704 al. 3 CC). At present, underground water bodies are accounted as public waters.
Rights of disposal	Regulated by the State (cantons) (art. 664, al. 3 CC) which may assign permits, licenses, and concessions.	Regulated by the owner (art. 704, al. 2, CC) who can assign use rights (« Servitude ») to others. Limitation on the rights of disposal in favour of neighbours (art. 709 and 710 CC) or on behalf of public interest (art. 705 et 711 CC) by means of expropriation.	Idem Springs. At present, generally regulated by the State (c.f. surface water).
Use rights	Regulated by rights of disposal of the State. Certain free uses: swimming, drinking water for animals. Increasing limitations on use rights due to growing number of public policies based on art. 24 bis Cst (new : art. 76 Cst).	Increasing limitations on use rights due to growing number of public policies based on art. 24 bis Cst (new : art. 76 Cst).	Increasing limitations on use rights due to growing number of public policies based on art. 24 bis Cst (new : art. 76 Cst).

3.2 The historical evolution of the constitutional and legal basis

Since the adoption of the Swiss Civil Code (CC) in 1912, there have been no major formal changes in the system regulating water. However, we must examine the relationship between the three levels of intervention (the Civil Code, the Constitution and federal laws) and the balancing of the two principles of private property and state sovereignty (public interest) to identify the factors which will enable us to demonstrate the stages in the formation of the law and the changes in the regulatory system.

Based on considerations outlined above, we would now like to propose a schedule of four phases which are summarised in the following table.

Table 9: *Synthesis of the evolution of the regulative system related to water in three resp. four phases from 1874 to 2000 (x - xxx indicates on the relative importance of the respective dimension in a certain period).*

Phases	Regulative system			Field of application	Range of goods and services implicated	Main actors
	Property rights	***Rights of disposal***	***Use rights***			
First phase **1874-1912** Before 1874, no specific law on water existed. The rights on water were regulated by the different Civil codes of the cantons (Leimbacher & Perler 2000, p. 264). After 1874, a growing institutionalization of **state sovereignty** on certain public water bodies takes place.	**XX** **1874** : art. 24 Cst., Superintendence of the Confederation over the policing of dams in mountain regions. **1877**: Federal law on the policing of water in elevated regions of 22 June 1877 (art. 8 – expropriations). **1897** : Modification of art. 24 Cst. ; Superintendence of the Confederation over all policing and all watercourses in Switzerland. **1908** : art. 24 bis Cst. Superintendence of the Confederation over the utilization of water for hydroelectrical production.	**1877**: Federal law on the policing of water in elevated regions of 22 June 1877 (art. 5 – rights over municipalities, syndicates or individual persons)	**1877**: Federal law on the policing of water in elevated regions of 22 June 1877 (art. 8 – revocation of previous rights ; art. 3 – determinations related to the floating of timber)	The regulations of art. 24 Cst and the the federal law on the policing of waters in elevated regions solely apply to surface water bodies (i.e. mainly to public watercourses). Before 1897, the law only applies to watercourses in mountainous regions. After the modification of art. 24 Cst in 1897 it applies to all watercourses.	9. Geomorphological changes 4. Hydroelectrical power 3. Production (floating, irrigation)	**State** • Federal State • Cantons **Owners** • Municiplaities and cantons • Private owners **Appropriators** • Traditional appropriators (irrigation unions, floating companies, traditional industry (e.g. mills)). • Spatial planners (administrations of the Confederation and the cantons) • Hydroelectricity companies **Endusers** • Riparian residents (mainly in the lower valleys and in the Central Plateau) • Industry (metal) • Industrial services of certain cities in the Central Plateau

Phases	Regulative system			Field of application	Range of goods and services implicated	Main actors
	Property rights	*Rights of disposal*	*Use rights*			
Second phase **1912-1953** Civil code : distinction of **public and private water** bodies Increasing transfer of **rights of disposal** into the public domain	**XXX** **1912** : CC Distinction of public and private water bodies (art. 664, 667, 704)	**XX** **1912** : CC art. 664, al. 3 surface water art. 704, al. 2 et 3 springs and underground water art. 708 common springs **1916** : Federal law on the utilization of water for hydroelecric production (LFH). General introduction of the concession system (rights of disposal). **1916**: art. 17, LFH - right of disposal over private watercourses needs permit by the canton. **1919** : Canton of Zurich - certain underground water bodies are defined as public water. **1939** : Decision of the Federal Court - certain underground water bodies are defined as public water.	**X** **1912** : CC art. 706 - reparations resp. interest payments (for detached springs)	The Civil code regulates the property on water within the whole country, i.e. surface water and underground water bodies as well as private and public waters.	2. Consumption 3. Production 4. Energy 6. Support 7. Recreation 8. Medical uses 9. Geomorphological changes 10. Strategic reserve	**State** • Federal State • Cantons • Federal Court **Owners** • Municiplaities and cantons • Private owners **Appropriators** • Traditional appropriators (irrigation unions, floating companies, traditional industry (e.g. mills)). • Spatial planners (administrations of the Confederation and the cantons) • Hydroelectricity companies • Other companies making use of concessions (e.g. for gravel extraction) • Industrial / distribution services of cities in the Central Plateau **Endusers** • Riparian residents • Industry • Electricity distribution services of cities • Consumers (drinking water and electrical power)

Phases	Regulative system			Field of application	Range of goods and services implicated	Main actors
	Property rights	*Rights of disposal*	*Use rights*			
Third phase (a) **1953-1975** Limitation of **use rights** in order to maintain water **quality**			**XX** **1953** : art. 24 quater Cst. on the protection of water against pollution. **1955** : First federal law on the protection of water against pollution (LPEP). **1971** : Second federal law on the protection of water against pollution (LPEP).	The two first laws on the protection of water apply to private and public actors and to surface and underground water. Also, they are valid for the whole country.	1. Living environment 2. Consumption 3. Production (industry) 5. Absorption	**State** • Federal State • Cantons • Federal Court **Owners** • Municipalities & cantons **Appropriators** • Mainly public corporations (water distribution and wastewater removal services) **Endusers** • Households • Industry • Fishers • Aquatic fauna and flora
Third phase (b) **1975-2000** Further limitation of **use rights** in order to protect water in terms of its **quantity**			**XX** **1975** : Revision of art. 24bis Cst; introduction of the principle of quantitative water protection **1991**: Third Fed. Law on the Protection of Water (LEaux) **1991**: Federal Law on the Management of Water-courses (RS 721.100)	The third law on the protection of water applies to private and public actors and to surface and underground water. Also, they are valid for the whole country.	1. Living environment 2. Consumption 3. Production (industry and agriculture) 4. Energy 5. Absorption 6. Support (gravel) 9. Geomorphological changes (dams) 10. Strategic reserve	**State** • Federal State • Cantons • Federal Court **Owners** • Municipalities & cantons • Private owners **Appropriators** • All pot. appropriators, esp. hydroel. comp. and terr. planners (restrictions regar-ding to the management of watercourses) **Endusers** • Households • Industry • Riparian residents • Fishers • Aquatic fauna and flora • Tourists

The following chapters provide a brief account of the developments surrounding the most important elements during each of the four phases (property and use rights, main actors, owners of the property title, decision-making process, classification).

3.3 Period 1874 - 1912

3.3.1 Property and use rights

Up to the adoption of the Swiss Civil Code in 1912, water property rights were regulated under the terms of the various cantonal civil codes (Leimbacher & Perler 2000, p. 264). This first phase in our schedule witnessed the progressive application of the principle of state sovereignty (in this case the sovereignty of the Swiss Confederation) to certain uses of water. The sovereignty of the state over dams on mountain watercourses was enshrined in the constitution with the adoption in 1874 of *article 24* which instituted the «high superintendence» (*haute surveillance*) of the Confederation over the policing of dams in the mountain regions.

The federal law on the policing of waters in elevated regions (*Loi fédérale sur la police des eaux dans les régions élevées*), of 22 June 1877 was adopted three years later. On the basis of this law, the Confederation was to exercise *«high superintendence over the policing of waters in elevated regions of Switzerland»* (article 1). Article 8 makes provision for the *expropriation* which may be necessary to implement this law and which would result in the modification of property rights to water, both private and public (common), in the public interest. The Confederation also has the option of limiting and prohibiting all «uses that are harmful to public interest» (article 3). Similarly, the cantons, which have the job of implementing damming projects, «may assert their rights over those of local authorities, corporations or individual interests» (article 5). The process initiated here clearly involved the reduction of private, local authority and public use and disposal rights to enable the implementation of correction policy.

In 1908, the Confederation was also granted *high superintendence over the use of water power* (article 24 bis Cst). This article of the constitution translated into effects on the regulatory system introduced with the adoption of the Federal Law on the Use of Hydroelectric Power of 1916 (*loi fédérale sur l'utilisation des forces hydrauliques, WRG*) (see next phase).

3.3.2 Main actors

This period saw the clear emergence of a new state actor: the Confederation. Prior to this, and particularly up to 1848[20], rights relating to water were mainly regulated at local level. Up to 1874, the central state had no right of inspection with respect to cantonal matters concerning water rights. Article 24 of the Swiss Constitution thus represented a turning point. This transfer of jurisdiction from the cantons to the Confederation did not run completely smoothly, as confirmed by reading the «message» (draft legislation) compiled by the Federal Council on the occasion of the adoption of this new article.

---

[20] Both the ownership and use of water (irrigation, small-scale hydraulic structures) were regulated by the land owners, mainly for economic purposes.

3.3.3 The owners of the property title

Property rights to water were defined in the civil codes of the various cantons. Hence, the situation could vary from one canton to another. At the current stage of investigation, which concentrates on national level, we do not know if common property regimes formally existed in certain cantons.

3.3.4 The decision-making process

The partial institution of state sovereignty over certain uses of water resulted in the introduction of a new decision-making instance to add to the other two decision-making actors[21], which had existed since 1848: i.e. the Confederation, which was awarded the right of superintendence over the policing of dams.

3.3.5 Classification

Table 10 : Classification of property and use rights from 1874-1912

	Private property		**Public property**		**No property**
Types of water (or uses)	Springs Underground water	Certain surface water bodies	Surface water	Springs on uncultivable land	Surface water bodies (free uses such as swimming or drinking water for livestock)
Property right title	Ground owners (cf. Civil Codes of the cantons)	Owners of water-sides (proportio-nally) Partial limitation on mountain watercourses (superintendence of the Confe-deration)	Public corporations (cantons, municipalities, communities of burghers) Residents along watersides Partial limitation on mountain watercourses (superintendence of the Confederation)	Public corporations on whose territory the springs are situated (?)	Nobody
Access control	Ground owners	State (?)	State (mainly cantons)	State (mainly cantons)	No control
Decision process	Ground owners	State (?)	State (mainly cantons)	State (mainly cantons)	State (?)

[21] Land owners (for decisions relating to private water bodies), the local authorities, bourgeoisies and cantons (for decisions relating to public water bodies, particularly surface waters).

3.4. Period 1912 - 1953

3.4.1 Property and use rights

The distinction between private and public waters was not formally questioned after the adoption of the Swiss Civil Code. Nevertheless, in practice, it is possible to observe the phenomenon of a *transfer from private to public property* (mainly within the jurisdiction of the federal court) in the case of groundwater and certain types of springs (e.g. river heads).

With respect to *rights of disposal*, the Swiss Civil Code makes a clear distinction between *public* and private water bodies. In the case of public water bodies, the right of disposal is regulated by the cantons (article 664, al. 3 CC), particularly with respect to the granting of licences, permits and concessions. In accordance with the principle of the transfer of competencies, the cantons were able to grant the local authorities or other public law bodies competencies with respect to rights of disposal. With the coming into force of the Federal Law on Water Power of 1916 (*Loi féderale sur les forces hydrauliques - LFH*) (RS 721.80), these rights of disposal were subject to a clearer formal regulation[22]. Article 17 introduced into law the principle of the subordination of the use of private watercourses to the cantons (limitation of the right of disposal over private watercourses). According to the Swiss Civil Code, the right of disposal over *private water bodies* is, in principle, unlimited. Limitations exist, however, in favour of neighbours (articles 709 and 710 CC) and in the case of the prevailing public interest (articles 705 and 711 CC). This right of disposal was also diminished with the coming into force of the Civil Code which instigated the actual transfer of certain private water bodies to the public sphere. With respect to *use rights*, the only rights strongly affected during this period were use rights for hydroelectric production.

3.4.2 Main actors

The Confederation was, once again, the main actor behind the changes that took place during this second phase. Within the group of owners, the *public bodies* started to exert their influence over private owners in the area of underground water bodies. This development would continue to gather pace during the second half of the century. The new group of owners, the *hydroelectric power companies*, assumed increasing influence with respect to the traditional owners, thanks mainly to the fact that concessions became more widespread. In fact, the irrigation consortia were the only group which succeeded in resisting takeover by the hydroelectric group. With irrigation being crucial to the survival of agro-pastoral society in the Alpine regions, most of the local authorities and irrigation consortia struggled fiercely to hold on to their property rights and resist their appropriation by the newcomer, i.e. the hydroelectric companies.

---

[22] Chap. 3 of the law (*Des concessions de droits d'eau* RO 33, 1917, pp. 201 ss.), particularly, articles 38-43, 45, 46, 48 and 58.

3.4.3 The owners of the property title

According to the Swiss Civil Code there is no *common property for water*[23]. The property title to *public water bodies (surface)* is divided between the cantons and the local authorities**.** During this period, the Confederation acquired the option of exercising high superintendence over the use of hydroelectric power. Property title to *sources* was in private ownership, based on geographical location. During this period, the property title to large expanses of underground water actually passed into the public sphere, despite the fact that the formal ownership of underground expanses remained associated with the land under which they were situated.

3.4.4 The decision-making process

The landowners were responsible for decisions concerning the use of *private sources*. The landowner's free choice was, however, limited by the terms of the Civil Code (articles concerning neighbours and the prevailing public interest). The decision-making processes concerning *public waters* generally fell within the competency of the cantons which were entitled to delegate certain tasks to the local authorities. The Confederation exercised high superintendence over dams and hydroelectric power structures.

3.4.5 Classification

Table 11 : Classification of property and use rights from 1912-1953

	Private property		**Public property**		**No property**
Types of water (or uses)	Springs Underground water (formally)	Surface water (special cases, e.g. canton of Glaurs, Raspille)	Surface water bodies	Springs on uncultivable land Underground water (in reality)	Surface water (free usses, such as swimming or drinking water for livestock)
Property right title	Ground owners CC art. 664 et 667	Owners of watersides (proportionally)	Public corporations (cantons, municipalities) Residents along watersides	Public corporations on whos territory the springs or underground water bodies are situated (?)	Nobody
Access control	Ground owners, partially limitated by the State	State (?)	State (mainly cantons)	State (mainly cantons)	No control
Decision process	Ground owners	State (?)	State (mainly cantons)	State (mainly cantons)	State (?)

[23] As opposed to this, **common uses** do exist for certain public water bodies: the territorial collective conceeds one part of the public water bodies to a group of users (e.g. irrigation consortia). Similarly, the concept of «common property » of an object is recognised by articles 651 to 653 of the Civil Code (see also Leimbacher & Perler 2000, Annex p. 3).

3.5 Periods 1953 – 1975 and 1975 - 2000

3.5.1 Property and use rights

Ownership rights as defined in articles 664, 667 and 704 of the Civil Code did not evolve formally over this period. The only change in the regulatory system during this phase was on the level of the organisation of use rights. The main changes were brought about by the adoption of *article 24 quater of the Constitution (1953)* on the protection of water bodies against pollution. This article introduced a major new restriction on users of the resource water: all uses, irrespective of their nature, must preserve the quality of water bodies. This «restriction» was further accentuated by the coming into force of the Federal Law on the Protection of Water Bodies against Pollution (*Loi fédérale sur la protection des eaux contre la pollution, LPEP*) of 16 March 1955[24]. The protection of water bodies applied, therefore to all kinds of water, *irrespective of their property status, private or public*. Moreover (article 13),

> *If justified by the public interest, the cantonal government may grant to the local authorities and private companies the* right of expropriation *for the purpose of acquiring the rights necessary for the construction of installations required for the protection of water bodies.*

The revision of article 24 bis of the Constitution in 1975 added new restrictions to the use of water, particularly with respect to hydroelectric power by instituting the principle of the quantitative protection of the hydrological system. Based on this important turning point, the phase from 1953 – 2000 can be divided into two subphases, even if this principle did not really come into its own until fifteen years later with the coming into force of the Federal Law on the Protection of Waters of 24 January 1991 (*Loi fédérale sur la protection des eaux* - LEaux) (RS 814.20). This law introduced a major new factor: the necessity to maintain *suitable residual flows* for water bodies, whether underground or surface (Chapter 2 of the law, articles 29 to 36). All uses requiring large quantities of water were now made subject to authorisation (article 29). The 1997 revision of the law saw the formal introduction of the «polluter-pays» principle into Swiss water protection policy (article 3a[25]).

3.5.2 Main actors

So far, we have omitted all mention of one important owner: the local bodies responsible for the distribution of drinking water and the disposal of waste water. From the end of the 19th century, these bodies set up a vast network for water distribution and drainage in the country's main towns and cities and then gradually in the rural areas. The adoption of article 24quater of the Constitution in 1953 placed strong restrictions on their rights. This was reflected in the restriction of the use rights of end users, i.e. industries and households, and at the same time a renewal of the «use rights » of the aquatic flora and fauna and of fishermen. The other actors were not significantly affected by the changes introduced to the regulatory systems in 1953. In contrast, the adoption of article 24bis of the Constitution in 1975 imposed strong limitations on the use rights of owners whose use of the resource was significant in quantitative terms, i.e. mainly the hydroelectric companies.

---

[24] Bundesblatt (BBl) 1954, I, 305

[25] Introduced by Chapter I of the Federal Law of 20 June 1997, in force since 1 November 1997 (RO 1997 2243 2248; FF 1996 IV 1213).

3.5.3 The owners of the property title

This phase did not bring about any formal changes to the allocation of property title as defined in the Swiss Civil Code.

3.5.4 The decision-making process

This phase witnessed a transfer of decision-making processes concerning *private water bodies* from the private to the *public sphere*. The adoption of the three principles for the qualitative protection of waters, the quantitative protection of waters and causality all resulted, firstly, in the restriction of the right of disposal over private waters and, secondly, in a reduction in the decision-making capacity of landowners.

With respect to the *public water bodies*, the adoption of article 24 quater of the Constitution *reduced the canton's decision-making scope to the advantage of the Confederation* which was granted power of superintendence over water quality (article 6, *LPEP* 1955). This trend would be enforced with the adoption of the two revisions of the law on the protection of waters in 1971 and 1991 as well as the revision of article 24bis of the Constitution in 1975.

3.5.5 Classification

There were no formal changes in the regulatory system as compared with the preceding phase, however use rights became more restricted and complex. These changes led to transfers of competencies in terms of decision-making, from private landowners to the state, on the one hand, and within the state itself, from cantonal to federal level (process of centralisation), on the other. The changes relating to the preceding phase are indicated in italics/bold in the following table.

Table 12 : Classification of property and use rights from 1953-2000

	Private property		**Public property**		**No property**
Types of water (or uses)	Springs Underground water (formally)	Surface water (special cases, e.g. canton of Glarus, Raspille)	Surface water bodies	Springs on uncultivable land Underground water (in reality)	Surface water (free uses such as swimming or drinking water for livestock)
Property right title	Ground owners CC art. 664 et 667	Owners of watersides (proportionally)	Public corporations (cantons, municipalities) Residents along rivers	Public corporations on which ground the springs and underground water bodies are situated	Nobody
Access control	Ground owners, *strongly* limitated by the State	State (?)	State (cantons under surveillance of the Confederation)	State (cantons under surveillance of the Confederation)	No control
Decision process	Ground owners, *strongly* limitated by the State	State (?)	State (cantons under surveillance of the Confederation)	State (cantons under surveillance of the Confederation)	State (?)

4. Public policies that regulate the use of the natural resource water

4.1 Introduction

In Switzerland, the public policies relating to the resource water have developed along three main topics:

- protection against flooding («hydraulic engineering»)
- the use of the resource («water use »)
- protection against abuse by society («water protection»)

These three lines were not integrated at federal level until the implementation of the Federal Law on the Protection of Waters of 1991 (*Loi fédérale sur la protection des eaux*), and even then the integration remained partial.

We propose to classify our description of water policy in four phases as shown in the following table. The following chapters provide a brief account of the development surrounding the most important elements during each phase (collective problem to be solved, causal hypothesis and choice of instruments, institutional arrangements and procedural rights, qualification of the policy design). Phases 2 and 3 are described in the same chapter (chap. 4.3).

Table 13 : Classification of water policies in five phases.

Phases	Constitutional bases	Legal bases	Collective problems to be solved	Important events
1871 - 1908 « Protection against water » and first contours of water protection in terms of quality	**1874** art. 24 Cst : Super-intendence by the Confederation over the policing of dams	**1871** Federal decree on federal subsidies for the construction of dams on torrents and reforestation in mountainous regions **1875** Federal law on fishing **1877** Federal law on the policing of waters in elevated regions **1886** Decree implementing the law on fishing **1888** Federal law on fishing	***Collective problems*** : Two main collective problems are to be solved during this period: on the one hand, an increase in **flood events** which marked the whole 19th century and the cause of which was assigned to deforestation in mountain areas; on the other hand, **pollution** of certain stretches of rivers beneath cities and industrial plants (mainly Basle) which threatened fishing activities. Needs in **electircity** resulting from urbanisation and industrialisation are equally beginning to be a concern , namely by the launch of a popular intitiative in 1906. Nevertheless, this problem will reach its peak only in the the second phase. ***Goods and services concerned*** : 9, 1, 6, 5 ***Actors concerned*** : Confederation, federal administration (forest), municipalities in mountainous regions, owners of forests, industry, federal experts (relating to forests).	Serious damages by **floods** in 1868. First signes of **eutrophication** of lakes in the Central Plateau (e.g. lake of Zurich) and polluted rivers below large urban areas (e.g. Zurich, Basle (chemical industry), Geneva). Construction of several **hydropower plants** along rivers (e.g.Rhine and Aare) and first hydropower stations in the Alps (dams). Several **large river corrections** in the Central Plateau (e.g. Rhone, Thur).
1908-1953 Development of the utilization of water for hydroelectrical production	**1908** art. 24bis Cst : Superintendence by the Confederation over the utilization of water for hydroelectrical production	**1916** Federal law on the utilization of hydropower **1925** Decree implementing the federal law on fishing **1939** " Wahlen Plan " (drainages) **1951** Federal law on agriculture (federal subsidies and drainage	***Collective problems*** : Allready since the first decades of the century but especially after world war II, a growing variety of different goods and services is taken from the resource water which, furthermore, get into competition with each other more and more. Mainly **hydropower production**, the use of the hydrosystem for **absorption of wastewaters**, and the artificial **corrections of river dynamics** (corrections of water courses and of mountain rivers) and of wetlands (**drainage**) have a strong impact on the functioning of the natural hydrosystem. This results in a qualitative as well as a quantitative degradation of the hydrosystem The introduction of several sectoral or partially integrated public policies aims at reducing the negative impacts on the natural environment. ***Goods and services concerned*** : 1, 4, 8, 5, 6, 11 ***Actors concerned*** : Confederation, federal and cantonal administrations (forest), municipalities in mountainous regions (VS, GR), hydroelectricity companies, industry,	Strong increase in dringking water consumption after the second world war (due to installation of bathrooms). Worsening of the **eutrophication** problem in lakes and rivers due to the expansion of sewerage systems in urban areas without adjacent water purification, and to growing use of chemical fertilizer in agriculture (mainly lakes). Main period of construction of **hydroelectric power plants**; complete drying out of certain mountain creeks over several kilometers. First heavy conflicts with nature protection organizations (e.g. Urseren lake after 1920, Spöll river (national park) after 1926, lake of Sils after 1927, Rheinau (Rhine River) after 1944). Strong **diminution of humid zones** due to drainage for agriculture (« Plan Wahlen » during the second world war), and to growing urban areas

Phases	Constitutional bases	Legal bases	Collective problems to be solved	Important events
			industry, federal experts (relatiing to forests), environmental activists (SBN, Heimatschutz).	
1953-1991 Protection of water in terms of quality	**1953** art. 24 quater Cst **1975** art. 24 bis Cst Protection of water in terms of quantity	**1955** First Federal Law on Water Protection against Pollution (LPEP) **1956** Decree implementing the LPEP **1962 :** Revison of the Decree implementing the LPEP (increase in subsidies for wastewater treatment plants) **1971 :** Second LPEP **1972 :** General decree on the protection of water **1975** Decree on the dumping of wastewater (VLE/VLI) **1981** Revision of the LPEP (subsidies for decentralized wastewater treatment plants) **1983** Federal law on the protection of the environment (LPE) ("principle of causality") **1986** Decree on substances from 9.6.1986 (StoV) Prohibition of phosphates in detergents **1987** "Rothenthurm" initiative (protection of moors and swamps)	***Collective problems*** : idem 1908-1953. Generally speaking, the problems are becoming more severe and the competition between goods and services stronger. ***Goods and services implicated*** : 1, 2, 7, 4, 3, 5, 9, 6 ***Actors implicated*** : Confederation, international comissions, federal and cantonal administrations, municipalities (allover the country), hydroelectric power companies, polluting industry, civil engineers, experts (mainly in the field of water protection), environmental activists (SBN, Heimatschutz, WWF), other pressure groups (USCI, Swiss league for water protection, municipalities in mountainous regions).	Maximum situation of **eutrophication** in the lakes of the Central Plateau and in ceratin rivers in the 50ies (regionally very different situations) ; improvement after beginning of the 80ies (strong increase in number of wastewater treatment plants). Lower level of improvement in areas with intensive agriculture (livestock). After 1950ies degradation in **groundwater quality** due to increasing use of chemical fertilizer in agriculture. Strong increase in **drinking water consumption** after world war II (installation of bathrooms). Main period of construction of hydropower plants (mainly in the Alps). Creation of the **Federal service for water** protection in 1957. After 1960 use of river water for **cooling** in **nuclear** power plants. After 1970 water saving measures in industry. Tendency for lowering groundwater levels (due to soil compression and sealing). **Decrease in drainage works** since middle of the 80ies. Heavy **conflicts** with nature protection organizations for large hydroelectrical power plant projects (e.g. Hydro-Rhone after 1984, Grimsel west after 1987, Cleuson-Dixense (VS) after 1988). **Prohibition of phosphates** in detergents from 1986 on. Persisting bad situation in lakes of the Plateau with intense husbandry (e.g. Zug Lake, Sempach Lake, Glatt River). Production of **artificial snow** in tourist regions after the 70ties. More **leisure oriented** use of mineral water and hot springs after the 70ties (e.g. Ovronnaz).

1991 - 2000 Tendency towards integration of sectoral policies and "ecologisation" of water policies		**1991** Federal law on water protection (Leaux ; protection of water n terms of quality and quantity) Federal law on the manage-ment of watercourses (RS 721.100) and related decree. **Beginning of the 90ties** Several decrees related to the LPN (decree on the protection of nature 1991, on upland marshes, on alluvial plains 1992, on lowland marshes 1994, on marshes) **1993** New agricultural policy (especially landscape protection) **1995 :** Decree on the hydroelectric production **1996** Modification of the LFH **1997** Revision of the LEaux **1998** Decree on the protection of water (GSchV, RS 814.201) **1998 :** Decree on the hydroelectric production (OFH)	***Collective problems*** : The increase in competion between different uses and the growing complexity of the legal and regulatory bases brings up a need on the one hand for coordination efforts related to the expectations of the different user groups and endusers and, on the other hand, for an integration effort towards a comprehensive and **integrated water policy**. Also within the different fields of water management a growing consciousness for the need of protecting the environment while still adhering to a sufficient economical growth can be observed. ***Goods and services concerned*** : 1, 2, 7, 4, 3, 5, 9, 6 ***Actors implicated*** : Confederation, international comissions, federal (mainly Buwal) and cantonal administrations, municipalities (allover the country), hydroelectric power companies, polluting industry, agriculture, experts (mainly in the field of water protection), environmental activists (Pro Natura, WWF), other pressure groups (esp. « anti-ecologist » groups such as Aqua Nostra)	Relatively **good eutrophication situation** in lakes; lower level of improvement in areas with intensive agriculture (livestock). **Decrease** in industraial water **pollution**. Persisting problem of **nitrogen** pollution (especially groundwater) due to disperse pollution by agriculture. Problem of increasee in **water temperature** in certain areas (nuclear power plants). Risk of aggravation of the problem due to climate change. Increasing number of „**renaturation“ works** on rivers (correction of previous river „corrections“).

4.2 1871 – 1908: The emergence of three sectorial policies in the area of water

4.2.1 Collective problem to be solved

As mentioned above, three collective problems emerged which needed to be resolved: the protection of the population against flooding, the emergence of centres of pollution and the country's increasing energy requirements and the possible use of hydroelectric power to satisfy them.

4.2.1.1 Protection against water

The implementation of a specific public policy in this area was motivated by a series of flooding catastrophes between 1827 and 1875 and confirmation of extensive forest clearing in the Alps. These events prompted the Confederation to implement the first federal public policy which was marked by the adoption of four major legislative texts: *article 24 of the Constitution* (1874), the *Federal Forest Law of 1876* (*Loi fédérale sur les forêts), the Federal Law on the Policing of Waters of 22 June 1877* (*Loi fédérale sur la police des eaux*) (RS 721.10) and the *Federal Forest Law of 1897*. The aim was to protect the country's low-lying areas and populated urban centres through the correction of mountain torrents (Reynard, Mauch & Thorens 2000, p. 63).

Article 24 of the Constitution grants the Confederation «the right of *high superintendence over the policing of dams* and forests» and states in article 24, al. 2: «It [i.e. the Confederation] shall implement the correction and damming of torrents as well as the reforestation of the regions in which they rise. It shall decree the measures necessary to ensure the maintenance of these structures and the conservation of existing forests».

The forest law of 1876 placed the Alpine forests under the high superintendence of the Confederation and the revised version of 1897 extended federal superintendence to all of the country's forests and established the principle of the maintenance of forest areas.

4.2.1.2 Protection of water

The aim of the *Federal Law on Fishing (Loi fédérale sur la pêche)* **(**RO, XI, 1889-1890, p. 59) adopted in 1888 (in force up to 1973) was to limit pollution in *waters that are well stocked with fish*. The protection of waters was not its main prerogative and this objective was subordinate to the main aim of protecting fish stocks and maintaining productivity levels in the fishing industry. The legislators had yet to develop an interest in maintaining the quality of water for its own sake.

4.2.1.3 The use of hydroelectric power

The third problem to be resolved concerned Switzerland's *electricity supply*. The policy implemented by the Confederation was aimed at the *maximum use of the hydroelectric power generated from watercourses*.

A popular initiative in support of the use of hydroelectric power was launched in Zurich in 1906. Following submission the same year, it was subsequently dropped when the Federal Council drew up its own plan which was ratified by the people on 25 October 1908 (Article 24bis of the

Constitution). This decree, which regulates the allocation of concessions, the transport of electricity, the charges collected by the cantons and use restrictions was followed by the adoption of *the Federal Law on the Use of Hydroelectric Power of 22 December 1916* (*Loi fédérale sur l'utilisation des forces hydrauliques*) (RS 721.80) which remains in force to the present day.

4.2.2 Causal hypothesis and target groups

With respect to *protection against floods*, it is believed that the main cause of this problem was the over-use of the Alpine forests and the progressive deforestation that took place over the course of the 19th century. The target groups of the federal measures were, therefore, the owners and users of forests. In the area of *water protection*, *industrial enterprises* were believed to be the main culprits when it came to the pollution of surface waters.

With respect to the development of *hydroelectric power*, it was a question of making rational use of the country's surface waters. Both the resource (the surface waters) and the resulting use of the resource (electricity produced, transmitted through the high-voltage lines and networks) have the characteristics of «material-flux» which do not easily conform to cantonal borders. For this reason, it was a question of creating an energy policy at national level with the aim of establishing a comprehensive and consistent electricity network[26].

4.2.3 Intervention hypothesis and choice of instruments

Protection against floods: besides the restrictions and bans on forest clearing, the main measures included the provision of funding by the Confederation for the damming of watercourses and correction of torrents.

Protection against pollution: this took the form of police law based on a regime of *permits.* Although the target group of the protection policy at the time mainly comprised industrial companies, the *rule of 1888* was not very restrictive as discharges were still authorised if the current was sufficiently strong to dilute and drain them.

4.2.4 Institutional arrangements and procedural rights

Protection against floods: the Confederation was granted the right of high superintendence of the forests and damming projects. The co-ordinating body in this instance was the Federal Inspectorate of Forests (*Inspectorat fédéral des forêts*).

Protection against pollution: the enforcement of the law and regulations (granting of permits) fell within the competency of the cantons. The Confederation could merely exercise a right of approbation over permits granted by the canton and was not entitled to impose sanctions against the cantons for failure to implement the law.

---

[26] The electrification of the railways, in particular of the Swiss Federal Railways (SBB), was also part of this process of centralisation of the energy policy in Switzerland.

4.2.5 Qualification of the policy design

The «water policy» which emerged at the turn of the century can be qualified as a policy with a *weak design*, as, firstly, the degree of implementation was weak and, secondly, the effects were not very tangible for the following four reasons:

- Strictly speaking, it could not yet be defined as a water policy: the different objectives were uncoordinated and pursued independent of each other.
- The best developed sectorial policy was based in part on a partly erroneous causal hypothesis: Alpine deforestation are not the only factor that caused flooding (climatic factors should also be mentioned). Because of this, despite the widespread (and costly) implementation of the Confederation's aims, the measures are not adequate.
- The other policies are very inadequate, particularly the water protection policy which only protected waters with fish stocks. The target groups were also incomplete (there were no restrictions on the pollution of waters by households, agriculture etc.) and the instruments employed (police administration) left too much scope for exceptions. This policy has, therefore, a weak design (partial implementation and weak effects).
- With respect to the last sectorial policy, it was still at a very embryonic stage.

4.3 1908 – 1991: Development of several independent sectorial policies conceived to solve several partially interdependent collective problems

4.3.1 Collective problems to be solved

As was the case during the preceding phase, several differentiated policies needed be resolved.

4.3.1.1 Protection against water

In this area, the problem gradually shifted from the mountains to the plain. The damming proposals were joined by measures aimed at promoting the drainage of uncultivated land[27], initially during the Second World War in the context of the Wahlen Plan, and then mainly in the context of measures to improve land associated with the coming into force of the *Federal Law on the Improvement of Agriculture and the Maintenance of the Farming Community* (*Loi fédérale sur l'amélioration de l'agriculture et le maintien de la population paysanne*) (Agriculture Law) of 3 October 1951 (FF 1951, I, 141). This law resulted in the implementation of a major programme of *land improvements* (articles 77 ff.) aimed at increasing *agricultural productivity*, and more specifically at «maintaining or increasing the yield from land, facilitating its exploitation, protecting it against devastation or destruction caused by *natural phenomena*» (article 77, al. 1). This last point links the

[27] Some of these areas were reclaimed to the detriment of wetlands.

agricultural objective with the objective of protection against water. The land improvement projects were not, however, to be implemented at the expense of other uses of water.

4.3.1.2 Protection of water

The problems of water quality are particularly serious in the lakes of central Switzerland which suffer from advanced *eutrophication*. A proposal by Zigerli, a member of the National Council, would give rise to the adoption of article *24quater* of the Constitution and to the *Federal Law on the Protection of Waters of 16 March 1955* (*loi fédérale sur la protection des eaux*) and the order for its implementation of 28 December 1956[28]. Article 24quater reads as follows: «The Confederation has the right to legislate to protect surface and underground waters against pollution. The provisions defined in the law shall be implemented by the cantons, under the superintendence of the Confederation».

As the implementation of the water treatment projects required significant financial commitments, almost immediately after the implementation of the law, the local authorities and municipalities requested more federal aid (Zurbrügg 1965, p. 320)[29]. Thus, *the order was revised in 1962* authorising the state to contribute between 10% and 15% of costs"[30]. Industrial wastewater treatment plants were excluded from this federal subvention but many of them were connected to local authority installations. Levels of state funding increased very quickly (cf. Figure 11) and strongly motivated the construction of local-authority and inter-local-authority water treatment plants. However, the situation varied considerably between cantons. For example, the canton of Valais did not build its first wastewater treatment plant until 1972.

In 1967, the Federal Council established a working commission whose task was to prepare the revision of the law. The main thrust of the policy adopted up to this point, i.e. the promotion of *mechano-biological treatment in central plants, was reinforced* (Bussmann 1981, p. 210). The subsidies were not allocated to decentralised plants.

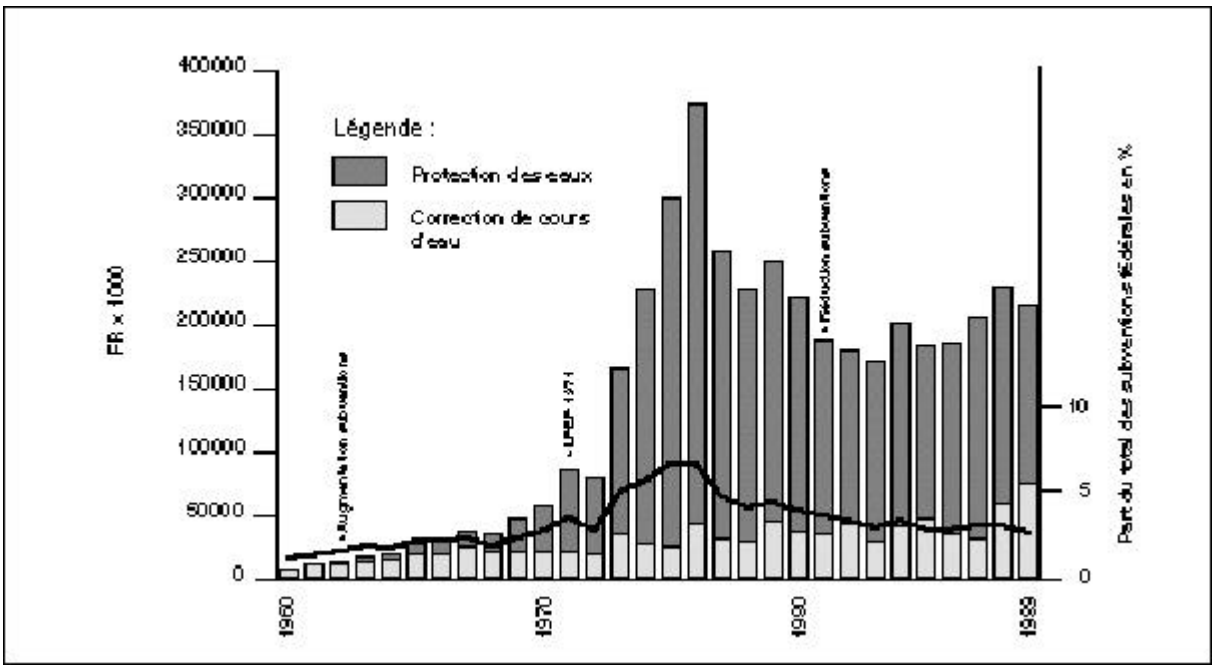
---

[28] The two texts came into force on 1 January 1957.

[29] Report of the Federal Council to the Federal Assembly on its managment in 1958, p. 24.

[30] *RO*, 1962, p. 105.

Figure 10: The evolution of subsidies for the construction of water treatment plants in Switzerland (Source : Reynard 1997).



The most heated debates in the federal chambers (Bussmann 1981, p. 213 ff.) concerned the matter of federal subsidies. The *LPEP* came into force on 1 July 1972 at the same time as the General Decree on the Protection of Waters (*Ordonnance générale sur la protection des eaux*) (*RS*, 814.201). The Decree on the Discharge of Waste Water (*Ordonnance sur le déversement des eaux usée)* (*RS*, 814.225.21), which introduced *emission and immision limit values*, was promulgated on 8 December 1975. However, despite the resulting efforts, the pollutant load in the lakes and rivers remained largely unchanged and eutrophication was on the increase. Phosphates in detergents were not banned until 1986. The Decree on substances which are harmful to the environment (*Ordonnance sur les substances - Osubst*) came into force on 9 June of the same year, i.e. 1986 (RS 814.013).

The Federal Law on the Protection of Waters against Pollution (*Loi fédérale sur la protection des eaux contre la pollution - LPEP*) of 1971 and its general decree, which introduced some draconian measures, particularly with regard to construction permits, aimed to accelerate the implementation of water protection objectives. On 6 November 1974, the Federal Council modified the general decree on the protection of waters, particularly with respect to construction and subsidies and instigated a shift in the direction of greater *autonomy for the cantons*. Article 17 of the *LPEP* was modified on 1 January 1981 to allow for the *subsidising of decentralised structures*.

4.3.1.3 Use of water

The Law on the Use of Hydroelectric Power (*Loi sur l'utilisation des forces hydrauliques -LFH*) of 22 December 1916 (RO, t. 33) granted the Confederation *«high superintendence over the use*

of public and private watercourses for hydroelectric power» (article 1) to the detriment of the cantons. The *«communauté»* (i.e. canton, district, local authority or corporation), to which the right of disposal of power generated from public watercourses is allocated, was, however, determined by the canton» (article 2). On the other hand, it was the remit of the Federal Council to enact «the appropriate general provisions to ensure and develop the rational use of hydroelectric power» (article 5). Article 11 contains the provisions allowing the use of hydroelectric power generated from watercourses despite the opposition of local «*communautés*». In contrast, by granting *concessions* for the generation of hydroelectric power, the owners (local authorities, corporations, districts and cantons) would be entitled to annual fees from the concessionaires (article 38 ff.). The law also contained provisions governing fishing (article 23), navigation on the rivers Rhine and Rhône (articles 24-27) and the transportation of logs on rivers (article 28).

As was the case with the other two water policies, efforts to establish co-ordination and combination were implemented in the contexts of policies for protection of and against water. This is particularly true of article 22 of the *LFH* which at the suggestion of the nature conservation organisation «Heimatschutz» (protection of habitats), introduced a provision stipulating that the «*beauty of sites* must be preserved. It must be conserved intact if this is in the major public interest. Factories must not spoil, or should avoid spoiling, the countryside». This article was frequently quoted in subsequent cases opposing the construction of certain hydroelectric installations. Co-ordination with navigation services is guaranteed in article 24 which reminds that «the construction of factories must ensure the navigability of watercourses and make allowance for future navigational developments». These provisions show that, from the outset, the policies for the use of the energy function of water were co-ordinated with both other use policies and environmental protection policies.

In 1945, the Federal Council published a «message» (draft legislation) proposing the revision of the law governing hydroelectric power to allow for an important modification enabling the Federal Council to override the opposition of the cantons and local authorities if the provision of a facility was justified in the *public interest*. This revision failed to make it through the parliamentary chambers in 1947.

4.3.2 Causal hypothesis and target groups

While the uses of water and the policies associated with them were changing, the target groups and causal hypotheses also altered and diversified.

The target groups in the area of *protection against water* changed: in addition to the owners of forests in mountain cantons, farmers were also affected by the reorientation of policy in this area. It was believed that improvements to farmers' living conditions as well as the conditions for agricultural production would enable them to increase the country's agricultural production.

In the area of *water protection*, political action during this phase was based on the same causal hypothesis the first period: certain human activities pollute the hydrosystem. Thus, it is a question of taking measures to prevent pollution entering the natural system. However, the target groups now included not just *industrial enterprises* but also *public bodies* (and, indirectly, the households). Agriculture was not, however, involved (article 5 of the *LPEP* of 1955) - except with respect to waste water from buildings - until the 1980s.

With respect to the *use of water*, the target groups included the different groups of users of the resource water and mainly the *hydroelectric companies*. The hypothesis in this instance was that this use of water involves a prevailing public interest for Switzerland and that the use of water for this purpose must take priority over other uses.

4.3.3 Intervention hypothesis and choice of instruments

State intervention into the economic and natural functioning of the management of the resource water is based on *three sets of hypotheses.*

Firstly, the Confederation imposed a *series of obligations* by means of the three laws on the policing of waters (1874), the protection of water (1955) and hydroelectric power (1916): the obligations to correct water torrents and watercourses and to purify water which were accompanied by a strong incentive to allow water to be used for the production of electricity. Secondly, the different problems observed could be resolved by means of *technical solutions* (correction of watercourses, centralised treatment, implementation of vast hydroelectric power structures). Thirdly, this type of intervention required major investment; this was not a problem for industry but the local public bodies would require *subsidies*. For this reason, the obligations are backed up with *financial aid* intended to facilitate their implementation. At the end of the period, from the coming into force of the Federal Law on the Protection of the Environment (*Loi fédérale sur la protection de l'environnement - LPE*) in 1983, a new intervention hypothesis emerged based on the *principle of causality*: anyone who causes negative effects to the environment, mainly in the form of pollution, is obliged to compensate for these effects through the payment of a tax (polluter-pays principle).

Two types of instruments were characteristic of this period: the progressive implementation of an *administrative apparatus* intended to monitor the implementation of measures and obligations associated with the sectorial public policies as well as the development of a series of instruments in the form of *financial incentives* (subsidies).

The *administrative apparatus* mainly developed from the 1950s with the coming into force of the water protection legislation (1955). In 1957, the Federal Service for the Protection of Waters was created and this evolved into the SAEFL. Under the terms of this legislation, the cantons were obliged to set up their own service for the protection of water.

With respect to *financial instruments,* at the beginning of the period, they tended to be directed at the aims of use and protection against water (subsidies for the correction of watercourses and land improvements, hydroelectric power charges). Subsidies for wastewater treatment projects were *limited and exceptional.* After 1960, the financial incentives in the area of water shifted to the aims of protection (subsidies for treatment plants). The Confederation granted subsidies to different target groups: the farmers and public bodies for all projects intended at increasing agricultural productivity in accordance with the agriculture law of 1951, and then to the public bodies from 1962, in accordance with the *LPEP*. In the area of the use of water for the production of hydroelectric power, national policy availed of a single intervention instrument: the development of *framework conditions* to promote the implementation of the right to use *(concessions).*

4.3.4 Institutional arrangements and procedural rights

The Confederation obtained the right of high superintendence of waters in its three areas of intervention. The cantons relinquished some of their prerogatives and retained only the right to organise the distribution of ownership rights (in the area of hydroelectric power) and responsibility for implementation (protection of waters and against waters).

The centralisation of competencies in the area of the use of *hydroelectric power* enabled the development of enormous projects which would have been more difficult to implement if the competency for the development of hydroelectric power had remained in the hands of the cantons. In contrast, it is clear that this rationalisation was carried out to the disadvantage of other uses of water, mainly with respect to its landscape and biological values. Eventually, article 22 of the *LFH* enabled opponents of the projects to assert their rights, often through the courts. These rights were, however, extended (for new projects) with the coming into force of the *LPE* (1983) and the Decree on the Environmental Impact Study of 1988 (*Ordonnance relative à l'étude d'impact sur l'environnement*).

As with the earlier law on fishing (1888), the *canton* is the executive authority in the area of the *protection of waters against pollution***.** The Confederation merely has a right of superintendence and federal subvention is limited. The Confederation was, however, obliged to set up a technical water protection service (article 2, order). The Federal Water Protection Service (*Service fédéral de la protection des eaux*) was created in 1957. This new service was authorised to take up contact, when necessary, with other federal services concerned with the protection of water (public health, fishing, land improvements, nature and landscape protection) *(interpolicy).*

From the 1970s, the protection of water was *centralised*, a development which involved the relinquishment of autonomy on the part of the cantons. The SAEFL (monitoring body) and the subsidy procedures played a major role in this process. In addition, the cantons and local public bodies were obliged to adopt a *plan* for the construction of sewers and wastewater treatment installations. Finally, the option of centralised wastewater treatment was consolidated with respect to the law of 1955 and this resulted in the large-scale technical implementation of water treatment.

4.3.5 Qualification of the policy design

The design of public water policies implemented during this period can be described as *partial*. Despite efforts were to co-ordinate sectorial policies, the implementation and effects remained partial. Several reasons can be given to explain this:

- Certain sectorial policies had *negative impacts* on other water policy sectors. This is particularly true of agricultural policy during the period 1940-1990.
- *Co-ordination between sectorial policies was weak*. This is particularly true of the hydroelectric power sector. This public policy was strongly centralised, it gave the concessionaire companies almost exclusive rights for a considerable duration while awarding sizeable annual payments to the owners. In terms of the economic development of the resource, it was, therefore, a policy with a strong design. However, in terms of the co-ordination of uses, the implemented policy was very unbalanced.

- The *aims were partial:* protection was concentrated solely on water quality despite the fact that the construction of numerous dams meant that the survival of the aquatic flora and fauna could no longer be guaranteed due to the quantity of water available.
- The *target groups were incomplete;* agriculture remained exempt from all water protection measures although in certain catchment basins in central Switzerland (e.g. Lake Sempach), it was the main source of pollution.
- Despite the fact that implementation was well developed, the effects did not always meet the expectations. This was particularly true of water treatment.
- Finally, policies were still «defensive» rather than «proactive», except from the 1980s when concrete measures were taken to *limit pollution at source* (banning of phosphates in detergents, *Osubst*, adoption of the principle of causality in article 2 of the *LPE*).

4.4 1991 – 2000: The trend towards integration and the ecological pervasion of the sectorial water policies

4.4.1 The collective problem to be solved

A new, more global water policy was defined in the early 1990s. It aimed, on the one hand, to co-ordinate the different uses of water and to subordinate them to the protection of the resource while guaranteeing the fulfilment of the needs of the population, and, on the other hand, to implement the protection of water, not only in terms of its quality, as this had already been done for almost half a century, but also in terms of its quantity. This new water policy was heralded by the adoption in 1991 of the third *Law on the protection of waters (LEaux)* which built on the various previous public policies in two ways: firstly, in terms of a trend towards *ecologisation* and, secondly, in terms of the trend towards *reciprocal integration.*

The main collective problems during this last phase were twofold in nature: the first involved the *rebalancing* of the different uses of water, particularly in favour of immaterial uses, such as water-landscape, and the second centred on the struggle against the *demise of natural areas and biodiversity* associated with water. The aim, therefore, was to guarantee minimum drainage which would ensure the maintenance of the biological and landscape functions of water. In other words, the objective was *the global preservation* of water, in terms of quality, quantity and landscape.

4.4.2 Causal hypothesis and target groups

The causal hypothesis behind the establishment of this integrated policy was that, in the face of economic interests, nature must be given specific protection so that its value in terms of biotopes and landscape can be preserved. In terms of the protection policy adopted up to the 1980s, it was now considered that it was no longer a question of merely protecting water quality, its quantity also had to be protected so that all of the benefits and services which it provides could be guaranteed for the future.

Given these global objectives and the increasing complexification of uses, the target groups which emerged in the course of the second half of the century were numerous and diverse: in addition to the *local and cantonal bodies* responsible for the protection of the population against natural risks, they also include landowners (mainly farmers but also the state (army) whose activities have a significant influence on the dynamics of wet milieus, the *users* of the resource water (mainly energy production concessionaires)[31], *industrial companies* etc.

4.4.3 Intervention hypothesis and choice of instruments

There are four types of intervention hypothesis for this period:

- Where the protection of companies or installation or Switzerland's economic competitiveness is at stake, it is a question of weighing up interests to chose the solution least damaging to the natural environment.
- In cases where the intrinsic value of the natural milieu is specifically threatened by anthropic structures, it is a question of providing full protection to the milieu in question.
- The principal of *causality* (in part implemented since the mid-1980s, *LPE*): those responsible for the (qualitative and quantitative) damage must assume the costs.
- The measures against the quantitative and qualitative impacts of human activities must be *co-ordinated* (interpolicy).

This translates into different types of instruments:

- A policy of selective federal *subsidy* (e.g. article 6 of the Law on the Management of Watercourses (*Loi sur l'aménagement des cours d'eau*): «Indemnities shall only be granted if the planned work complies with the framework of a *rational plan* and legal requirements. Indemnities shall not be granted for maintenance work». Moreover, in accordance with article 6 of the Law on the Management of Watercourses, the subsidies are limited to cantons with limited financial resources.
- A policy for the subjection of certain areas to complete protection of by means of *inventories*.
- The calculation of residual flows to be maintained downstream of dam structures (quantitative protection of watercourses): this flow is calculated as a function of the natural flow value (Q_{347}, article 31 of *LEaux* and articles 33 ff. of *OEaux*).

4.4.4 Institutional arrangements and procedural rights

The different sectorial laws hitherto in force were modified as a result of the adoption of the *LEaux*. This was the case for the Law on the Management of Watercourses, adopted in 1991, whose article 3, paragraph 3 stipulates that the management of watercourses must be implemented in co-ordination with other environmental policies in particular. The same applied in the case of the Law on Hydroelectric Power, which was modified in 1996.

---

[31] But not only: harnassing or supply of drinking water are also involved.

In all cases, the trend was to the centralise the competencies in the hands of the Confederation. This is particularly true of nature conservation where legal provisions were passed the Confederation despite the fact that it was the job of the cantons to implement them. The offices of the Confederation (OFEFP and OFEG) play a central role in the implementation of policy. These two offices are dependent on different departments. The implementation of the new Law on Hydroelectric Power also maintains the strong emphasis on *centralisation*. The OFEFP (monitoring instance) is the organ of central co-ordination. The calculation of minimum residual flows necessitates the implementation of appropriate hydrological methods (technical expertise). Finally, *centralisation* was also established in the area of the protection of water. The OFEFP (monitoring instance) remained the organ of central co-ordination. The planning measures, already implemented during the previous period (water evacuation plans), were strengthened and extended, mainly with the adoption of the General Water Discharge Plan (*Plan Généraux d'Evacuation des Eaux - PGEE*) in the Order on the Protection of Waters which was promulgated in 1998.

With respect to implementation, the major innovation involved the broadening of intersectorial co-ordination (interpolicy). The extension of aims necessitated increased co-ordination between federal public policies, particularly energy and agricultural policies (ecologisation of agriculture since 1993) and, again, nature and landscape conservation policy.

4.4.5 Qualification of the policy design

Despite the developments achieved during the 1990s, we believe that the current water policy still has a *partial design*; the objectives are, in effect, partly antagonistic and the internal policy coherence is not very strong. It should be noted, in particular, that the services of the Confederation (OFEFP, OFEG), whose job it is to implement policy, do not belong to the same department and do not have the same objectives. Similarly, it is not certain that the objectives of maintaining the biological and environmental diversity are always given precedence over the aims of correcting and using watercourses.

Despite these reservations, for the following reasons, it is possible to say that progress has been achieved towards the establishment of strong design:

- The *objectives* are far more comprehensive than in the past; they involve all aspects of the resource water.
- At the same time, there are more target groups from all areas of water use.
- With regard to *implementation*, it will be necessary to wait for a few years to evaluate its efficacy with respect to both the quantitative protection of water and nitrate pollution.

5. Initial indications on regime development in Switzerland

According to our definition (cf. Knoepfel, Kissling-Näf & Varone 1999), an institutional regime comprises two dimensions, i.e. the « regulative system » and the « policy design », whereby the latter

is mainly seen as the configuration of the relations between different public policies regulating the use or protection of the resource. The transformation of a regime may, therefore, affect both the regulatory system and the policy design. Hence, we need to distinguish between *changes in certain elements of a regime* and the *transformation of the regime* itself which involves the transition from one regime to another (cf. no regime, simple regime, complex or integrated regime). In order to identify the changes in regime elements as well as the transformation of regimes, we will need to combine the different phasing models that have been developed for the regulative system (cf. chapter 3) and the public policies (cf. chapter 4).

Based on the analysis of the two separate periods in the evolution of the regulatory system and policy design, we present here a first synthesis of the institutional regimes for the management of water in Switzerland for five major periods, which combine the phasing made for the regulatory system (cf. table 9) and for the policy design (cf. table 13). The methodology used to combine the two periodisations is described by Reynard, Mauch & Thorens (2000, p. 107 ff.) and Mauch & Reynard (in prep.).

Table 14: Institutional regimes for the management of water in five phases.

Phases	Regulative system	Policy design	Institutional regime
1874-1912 Complex and fragmented regime	Little degree of differentiation. Property rights regulated at the level of the cantons (prepon-derance of private property). Institallation of the sovereignty of the federal state on certain waters.	Evolution of independent sectorial public policies aiming at the regulation of 3 specific problems : protection against floods, reducing of polluted zones in urban areas and supply of the country with electrical energy.	**Complex and fragmented regime** characterised by a regulative system which is organised at the level of the cantons and a gradual emergence of three sectorial public policies. Weak range of goods and services and medium coherence.
1912-1953 Development of a complex water regime	Introduction of the Civil code (1912) Distinction between private and public waters.	Implementation of several independent sectorial public policies aiming at the regulation of certain interdependent collective problems.	**Tendency towards a complex regime** due to the installation of a differentiated regulative system and the development of several sectorial public policies which only implicate the goods and services relating to surface waters. Medium range and medium coherence.
1953-1975 Stabilization of the complex water regime	Growing limitation of disposition and use rights through the implementation of public policies for water protection.	Intesification of the implementation of independent sectorial public policies (mainly relating to water protection) aiming at the regulation of certain interdependent collective problems.	**Stabilization of the complex water regime** due to the increase in competition between different uses and the further differentiation of public policies. Weak range and medium coherence.
1975-1991 Increasing comple-xity of the regime and premises of an integration	Accentuation of the limits to the use rights (coming into force of the LPEP of 1971 and Decrees relating to this law). Coming into force of the USG.	Intensification of the overall protection of the water quality (LPEP of 1971) and adoption of the principle of protection of water in terms of quality and quantity (art. 24*bis* Cst, 1975).	**Increasing complexity of the regime** and first signs for integration. Increase of the range, while the coherence remains low.
1991-2000 Transition towards an integrated regime	Broadening of the limitations to disposition and use rights due to the coming into force of the third law on water protection (1991).	Integration of different sectorial policies with the third law on water protection (1991).	Transition towards an **integrated regime**.. Large range and high coherence.

List of abbreviations

BBl	« Bundesblatt »
BUWAL	Swiss Agency for Environment, Forests and Landscape (OFEFP)
BWG	Federal Office for Water and Geology (OFEG)
BWW	Federal Office for Water Management
CC	Civil Code
CSD	United Nations Comission for Sustainable Development
Cst	Constitution
FF	Federa Bulletin (Feuille fédérale)
GSchV	Decree on the Protection of Water of 28 October 1998 (OEaux, RS 814.201)
LEaux	Federal Law on the Protection of Water of 24 January 1991 (RS 814.20, GSchG)
LPEP	Federal Law on the Protection of Water from Pollution
LFH	Federal Law on the Use of Hydroelectric Power (WRG, RS 721.80)
LPE	Federal Law on the Protection of the Environment of 1 January 1995 (USG, RS 814.01)
LPN	Federal Law on the Protection of Nature (NHG, RS 451)
LSPN	League for Nature Protection (SBN)
OAEC	Decree on the Guaranteeing of Dringking-Water Supply during Emergencies (VTN, RS 531.32)
OEaux	Decree on the Protection of Water of 28 October 1998 (GSchV, RS 814.201)
OFEFP	Swiss Agency for the Environment, Forests and Landscape (BUWAL)
OFEG	Federal Office for Water and Geology (BWG)
OSubst	Decree on Substances (StoV, RS 814.013)
PGEE	General Water Discharge Plan
RO	Official Register
RS	Systematic Register
SAEFL	Swiss Agency for the Environment, Forest and Landscape
SFSO	Swiss Federal Statistical Office
StoV	Decree on Substances (OSubst, RS 814.013)
SVGW	Association of the Swiss Gas and Water Industry

TF	Federal Court (Tribunal Fédéral)
UNEP	United Nations Environment Programme
USG	Federal Law on the Protection of the Environment of 1 January 1995 (LPE, RS 814.01)
UVEK	Federal Departement for Environment, Transport, Energy and Communications
VTN	Decree on the Guaranteeing of Dringking-Water Supply during Emergencies (OAEC, RS 531.32)
WWF	World Wide Fund for Nature
WRG	Federal Law on the Use of Hydroelectric Power (LFH, RS 721.80)
WTP	Wastewater Treatment Plants

Bibliography

BADER Stefan, KUNZ Pierre, 1998, Climat et risques naturels - La Suisse en mouvement, Zürich, Vdf Hochschulverlag der ETH Zürich, Genève, Georg.

BROGGI M.F., WILLI G., 1990, Enneigement artificiel et conflits d'intérêts, Vaduz/Chambéry, CIPRA/ICALPE, Petite série documentaire CIPRA N° 3/89.

BUSSMANN Werner, 1981, Gewässerschutz und kooperativer Föderalismus in der Schweiz, Bern/Stuttgart, Haupt Verlag.

BUWAL / BFS, 1997, Umwelt in der Schweiz – Daten, Fakten, Perspektiven, Bern, BUWAL /BFS.

BUWAL, 1993, Situation der Trinkwasserversorgung, Bern, BUWAL, Schriftenreihe Umwelt Nr. 212.

de MILLER Roland, 1999, Matériaux pour l'histoire de l'environnement en Suisse. Patrimoine, écologisme et environnement (1815-1998), Berne, OFEFP, Documents Environnement n°106.

GERMANN R. E., 1999, Die Kantone: Gleichheit und Disparität, in: Klöti et al. (Hrsg.), Handbuch der Schweizer Politik, Zürich, NZZ-Verlag.

Hydrological Atlas of Switzerland, 1992-, Bern, Federal Office of Topography and Federal Office for Water and Geology.

JAKOB A., 1998, Banque de données de l'état des eaux: aperçu général, transfert des données, procédures d'exploitation offertes, Berne, Service hydrologique et géologique national, Communications hydrologiques n° 25.

KELLER P., FISCHER A., 1991, Installations d'enneigement. Nouvelle orientation de la politique fédérale, Berne, Office fédéral de l'industrie, des arts et métiers et du travail/Office fédéral de l'aménagement du territoire.

KLÖTI U., KNOEPFEL P., KRIESI H.-P., LINDER W., PAPADOPOULOS Y., 1999, Handbuch der Schweizer Politik, Zürich, NZZ-Verlag.

KNOEPFEL P., KISSLING-NÄF I., VARONE F., 1999, Comparative analysis of the formation and outcomes of resource regimes in Switzerland, Lausanne/Zürich, Proposal submitted to Swiss National Science Foundation, unpublished.

LEIMBACHER Jörg, PERLER Thomas, 2000, Vergleichende Analyse der genese und Auswirkungen institutioneller Ressurceenregime in der Schweiz: Juristisches Screening, Chavannes-près-Renens, IDHEAP, Working Paper de l'IDHEAP, n° 9.

LIVER P., CARONI P., 1987, Rechtsprobleme der Nutzung des Raspille-Wassers, Bern, Universität Bern, unpubliziert.

LIVER Peter, 1952, Die Entwicklung des Wasserrechts in der Schweiz seit hundert Jahren, , Zeitschrift fur Schweizerisches Recht, N.F, 71/1, 305-350.

MAUCH C., REYNARD E., in prep., European Water Regimes and the Notion of Sustainable Status: Country Screening for Switzerland, Zurich and Lausanne, unpublished report.

MOSIMANN Thomas, 1987, Schneeanlagen in der Schweiz. Aktueller Stand, Umwelteinflüsse, Empfehlungen, Basel, Materialen zur Physiogeographie, Heft 10.

MOSIMANN Thomas, 1998, Beschneiungsanlagen in der Schweiz. Weitere Entwicklung - Umwelt-verträglichkeit und Folgerungen für die Prüfung und Bewilligung von Beschneiungsanlagen, Bubendorf/Hannover, Schweizerisches Verband der Seilbahnunternehmungen.

OFE, 1999, Statistique suisse de l'électricité 1998, Berne, Office fédéral de l'énergie, Tirage à part du Bulletin ASE/UCS, n°8.

OFEFP, 1991, L'état de l'environnement en Suisse 1990, Berne, OFEFP.

OFEFP, 1994, L'état de l'environnement en Suisse 1993, Berne, OFEFP.

OFEFP, 1995, Données sur la protection des eaux en Suisse, Berne, OFEFP, Documents Environnement n° 22.

OFS, 1997, Annuaire statistique de la Suisse 1998, Zürich, Verlag Neue Zürcher Zeitung.

REYNARD Emmanuel, 1997, L'épuration des eaux usées en zone rurale, in: BENNINGHOFF M., JOERCHEL B., KNOEPFEL P. (Ed.): L'écobusiness : enjeux et perspectives pour la politique de l'environnement, Bâle/Francfort-sur-le-Main, Helbing & Lichtenhahn, Collection Ecologie & Société, 11, 133-168.

REYNARD Emmanuel, 2000a, Gestion patrimoniale et intégrée des ressources en eau dans les stations touristiques de montagne. Les cas de Crans-Montana-Aminona et Nendaz (Valais), Thèse de doctorat, Université de Lausanne, Institut de Géographie, Série Travaux et Recherches 17, 2 vol.

REYNARD Emmanuel, 2000b, Cadre institutionnel et gestion des ressources en eau dans les Alpes : deux études de cas dans des stations touristiques valaisannes, Swiss Political Sciences Review, 6/1, 53-85.

REYNARD E., MAUCH C., THORENS A., 2000, Développement historique des régimes institutionnels de la ressource en eau en Suisse entre 1870 et 2000, Chavannes-près-Renens, IDHEAP, Working Paper de l'IDHEAP, n° 6.

SCHÄDLER B., BIGLER R., 1995, Wasserhaushalt der hydrologischen Untersuchungsgebiete der Schweiz, Bern, Landeshydrologie und -geologie, Hydrologische Mitteilungen Nr. 21.

SFSO/SAEFL, 1997, The Environment in Switzerland 1997, Bern, SFSO/SAEFL.

VGL, 1995, Protection des eaux: nouvelles perspectives. Utilisation écologique de l'eau, Zurich, Ligue suisse pour la protection des eaux et de l'air (VGL).

WALTER François, 1990, Les Suisses et l'environnement. Une histoire du rapport à la nature du XVIIIe siècle à nos jours, Genève, Zoé.