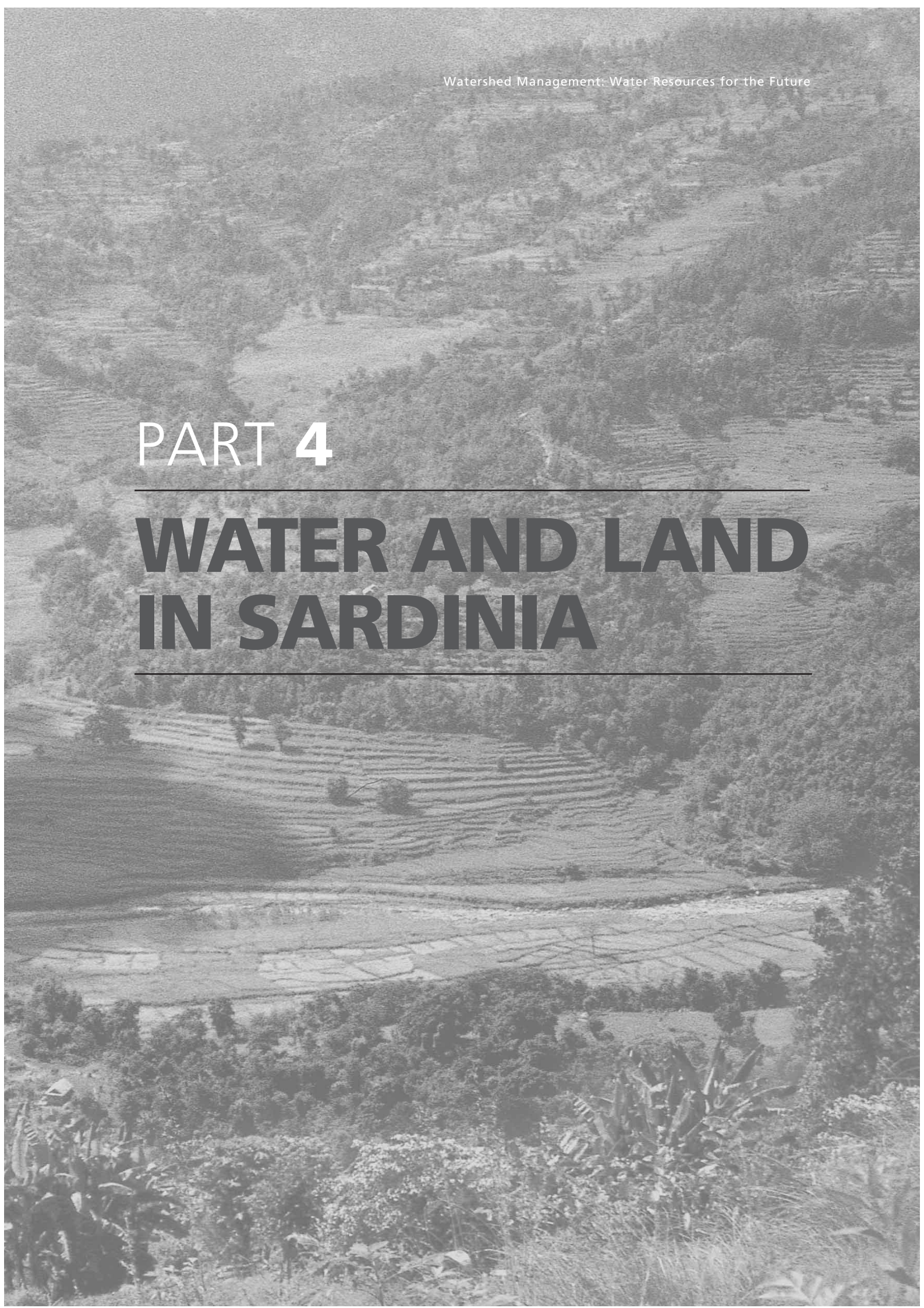

PART 4

WATER AND LAND IN SARDINIA

CHAPTER 16
THE INTEGRATED WATER CYCLE IN THE CONTEXT OF WATER MANAGEMENT SYSTEMS: THE SARDINIAN EXPERIENCE

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This report looks at aspects of establishing integrated water management in Sardinia. Launched under Regional Law 29/7 incorporating the Galli Law, this establishment followed a long period of stagnation, which is typical (with few exceptions) of all Italian regions, and then gathered speed, especially in the last two years. This was basically owing to the strict time-limits of EU Community Support Framework funding for 2000 to 2006 for the Objective I regions (especially Sardinia), due to the ongoing water emergency. This speed-up took place in a context of renewed regional attention to unsolved water problems that gave rise to new or updated sectoral plans, and the implementation of a series of financial instruments. The Government Commissary adopted urgent measures to deal with the water emergency. It also sped up execution of certain aspects such as approval of the *Piano d'ambito* (regional water sector plan), the pertinent technical regulations, and management plans and modalities for assigning responsibility for the SII (Integrated Water System).

Even with the initial delays, the launching of the Integrated Water System comprises a historic turning point for water in Sardinia. Moreover, it also illustrates the opportunity represented by the regional water sector plan in the context of the regional water system. Although the plan cannot claim to solve every water management problem, we shall focus on the potential contribution of integrated management to each characteristic and crucial element of the current water scenario. We then move on to a description of the process that led to the launching of integrated water management in Sardinia, and to the future prospects linked to the implementation of the environmental plan, and to renewed vertical and horizontal dialogue between local bodies and the regional authority.

BACKGROUND: CRITICAL AREAS AND PROCESSES

An analysis of the sectoral studies, plans, programmes and area-wide planning instruments provided some background on certain special features and critical areas within the water system. This is brought out in the following points:

- quality problems for bodies of water compatible with use, especially for drinking-water, due to the prevalent eutrophic condition of reservoir waters;
- quantity problems, in terms of fully meeting requirements for drinking-water (evidenced by the frequency of water rationing and inadequate service) or for productive uses, especially the grave situation faced by the irrigation sector;

- the mainly unsatisfactory infrastructure situation, even compared with the average situation within the southern ATOs (optimal territorial catchments), with regard to both storage capacity and the efficiency of the networks and components of the system;
- the fragmented management and excessive red tape characteristic of the current institutional scenario, with a plethora of management units in need of reorganization. This became particularly urgent with the recent inauguration of the *Autorità d'ambito* (water sector authority) and the launching of the Integrated Water System.

Scenarios concerning the quality of surface waters

The Sardinian climate features a rainy semester (October to March), when both surface and groundwater are available, and a dry semester (April to September), when only groundwater is available.

In the absence of natural lakes (except for little Lake Baratz), a number of reservoirs were built as early as 1870 to meet the range of productive and domestic water requirements. Thus, while most of the need (some 80 percent) is met by surface water, the contribution of wells and springs is fairly small (about 19 percent). However, the latter contribution is often quite important from the quality standpoint.

As all reservoirs are used for drinking-water, it is essential that watershed planning and management monitor water quality. There is now a widespread decline in water quality due to the prevalence of eutrophication in almost all reservoirs, most lagoons and some coastal areas.[1] The result is generally poor or degraded drinking-water quality, mostly classified as A3 (requiring physical and chemical treatment with purification and disinfecting). Eutrophication is caused by an excessive proliferation of planktonic algae attributable to massive inflows of materials and nutrients (mainly phosphorous and nitrogen) from the catchment area. The obvious solution to the problem of eutrophication is to reduce the input of pollution from the basin from the various point and diffuse sources. Various status indicators (see below) show that the control of point sources of pollution is still partial, despite the various water improvement schemes and treatment plants and schemes put into effect over time. One fundamental observation is that monitoring should be more clearly defined with the launching of integrated water management. This is particularly true of the Water Sectoral Plan, which will be suitably coordinated with the Environmental Protection Plan so as to make the management of point sources tie in with the environmental targets for bodies of water. But, as evidenced by the experience of countries careful to maintain high water treatment standards, this cannot in itself ensure the containment of eutrophication, nor can it reverse the process.

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1. Based on available data from 1977, and confirmed by the document *Valutazione ambientale ex ante del Por Sardegna*, of the 103 bodies of water identified, including reservoirs, 36 are hypertrophic, 11 eutrophic and 56 mesotrophic. Concerning reservoirs, in particular, the following obtain: oligotrophic lakes (waters fully satisfactory from the quality standpoint, especially for drinking-water; e.g.Corongiù II); mesotrophic lakes (waters of only partially acceptable or dubious quality); hypertrophic or eutrophic lakes (very degraded or unsuitable water quality, especially for drinking; these include: Baratz, Benzone, Bidighinzu, Bunnari alto, Casteldoria, Cedrino, Cixerri, Coghinas, Cucchinardorza, Cuga, Gusana, Is Barroccus, Liscia, Monteleone Roccadoria, Mulargia, Monte Pranu, Nuovo Omodeo, Omodeo, Pattada, Posada, Surigheddu, and Simbirizzi).

These experiences, plus new and recent modelling of the phenomenon, demonstrate that eutrophication can only be reversed when the basin has been upgraded to minimize the amount of suspended and dissolved materials exported into the body of water. Hence, the other aspect of the problem (often overlooked in the past) should be considered: control over diffuse sources, which is related to releases of suspended and dissolved materials (in addition to waste waters these materials include soil nutrients, organic materials, etc.). The management implication is to look at water bodies in terms of global watershed management.

Because control over diffuse sources is mainly lost through loss of plant cover, the spread of farming, increased urbanization, vanishing wetlands and lowering of the aquifer, there is a clear need for a strategy of overall planning at the level of the watershed, in addition to integrated water management. This allows land-use planning on a broad scale for large areas, such as watershed or provisional watershed plans, provincial coordination plans, or regional land-use planning.

Quantity scenarios: the supply–demand balance

The crucial point here is the persistence since 1995 of a state of water emergency. Our analysis clearly reveals the severity of the problem; the negative aspects of not only weather and climate but also the management and infrastructure situation. These latter, however, are subject to direct improvement with the advent of integrated management.

The problem of water scarcity had already brought out the need for a water plan under the Sardinian Renewal Programme. This plan, presented in 1988 and never approved, nonetheless served as the planning reference document for a decade. Over the last 20 years, rainfall in Sardinia has dropped dramatically, by some 50 to 60 percent,[2] compared with the data from the period preceding the plan. This precipitated a crisis throughout the region, culminating in 1995 with the declaration of a state of water emergency (DPCM28/06/1995), extended to 31 December 2003 (DPCM 13/12/2001).

Taking note of the outdated forecasts of the Water Plan, the *Documento di base per la definizione dell'Accordo di programma quadro risorse idriche*[3] covering the institutional agreement for the State/Region programme was approved. It updates the estimates with reference to the current water scenario, requirements and usable water resources in the region. This is still current, and has been substantially absorbed into the Environmental Plan.

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2. One study (*Studio dell'Idrologia Superficiale della Sardegna*, Eaf 1992) has shown that from 1986 to 1992, the mean annual flow dropped by about 80 percent, with peaks of 65 percent at some stations. Another study (*Studio SAR, Delitala et al., 2000*) showed that during the following period (1995 to 2000) only the 1995/96 season had average rainfall, whereas all succeeding years showed a deficit. In the most recent years, the greatest shortfalls in the last 60 years were recorded, including the crisis years of 1994/95 and 1999/2000.
3. Government Commission for the Sardinian Water Emergency, this is the base document as proposed by the Sardinian Region for the definition of the Framework Programme Agreement: *Il problema idrico in Sardegna – analisi e verifica del bilancio idrico al maggio 2000/Individuazione di interventi finalizzati al riequilibrio* 2000.

Concerning water resources, this document shows that the total estimated available supplies for 2000, was 690 million m^3/year. The amount that can actually be delivered is reduced by losses along the way to 621 million m^3/year, subdivided over the territory as in Table 2.

Based on available supplies and current population, this gives an available volume of water of 260 m^3/year/resident for the year 2000. As pointed out in the paper *Valutazione ex ante ambientale – POR Sardegna 2000-2006*, this is decidedly inferior to the threshold of 1 000 m^3 per year per inhabitant. This paints a picture of an area in which water scarcity now poses a severe limitation to the primary needs of domestic consumption, economic development and the protection of nature.[4] The index value for Sardinia is, in fact, similar to those for some areas of North Africa and the Middle East, but much lower than those for Algeria (730), Tunisia (450) and Syria (550).

Resource availability is further limited by the drop in rainfall, and because the maximum authorized capacity is less than effective capacity (owing to problems with reservoir testing). It is also lower than the gross delivery amount defined periodically by ordinances of the Water Emergency Commission.[5] These factors also lessen the chances of capitalizing on periods of heavy rainfall.

The same document shows an estimated total demand of 1 160 million m^3/year of drinking-water for 2000 (see Table 1).[6]

TABLE 1
Total demand

WATER SYSTEMS	DEMAND (million m^3/year)			
	DOMESTIC	IRRIGATION	INDUSTRIAL	Totals
Northern Sardinia	102	170	28	300
Eastern Sardinia	20	79	2	101
Central Sardinia	31	212	5	248
Southern Sardinia	140	346	25	511
Total	293	807	60	1160

4. Various authors and the Worldwatch Institute. *State of the World* 1993 and subsequent years.
5. One example is the Liscia reservoir which has a storage capacity of 68 million m^3, an authorized capacity of 68 million m^3 and a gross authorized delivery of 33 million m^3.
6. Indicatively, earlier provisions of the 1988 Water Plan gave an estimation of 2 708 million m^3/year.

Assuming a requirement of some 20 million m^3 for the transient population, primarily tourists, the average daily supply of drinking-water measured in the holding tanks of urban water networks gives some 450 litres/inhabitant. This is right off the scale and is an unequivocal indication of very high losses concentrated in the water distribution networks. There are two further critical elements with respect to requirements:

- Reservoirs generally serve a variety of users, with priority given to drinking-water. This has a major impact on other uses, especially for agriculture, and is a frequent source of conflict concerning water for drinking and irrigation purposes.
- Demand, in the absence or scarcity of dual networks for reusing treated wastewater, is not diversified with respect to the quality compatible with use.

A comparison of supply and demand shows a water supply deficit of some 600 million m^3/year, about half of the total requirement, broken down by area as shown in Table 2.

TABLE 2
Supply–demand balance

AREA	SUPPLY (million m^3)	DEMAND (million m^3)	DEFICIT (million m^3)
Northern Sardinia	176	300	-124
Eastern Sardinia	76	101	-25
Central Sardinia	137	248	-112
Southern Sardinia	232	511	-280
Total	621	1160	-549

The above data clearly show that the water deficit is mainly concentrated in southern Sardinia (amounting to 55 percent of potential demand). Central Sardinia also has a clear deficit, but less so on the eastern side. However, in the northern part of the island, certain clearly deficit areas (the Temo-Cuga and Liscia systems, and the Mannu di Pattada system to a lesser extent) are flanked by the Coghinas, part of the Mannu di Pattada and the Mannu di Ozieri systems, which have available water surpluses.

These are the problems. We have now to turn to an analysis of how the integrated water cycle management system can help restore balance in the supply–demand equation, one of the thorniest knots of the water issue. As mentioned, the SII (Integrated Water System) concerns only the drinking-water component and thus can only indirectly and partially affect supply and demand. On the other hand, the Water Authority through its watershed plan or provisional plans is responsible for the planning aspects, and therefore for ensuring the water balance for each division. Nonetheless, the Environmental Plan in its pursuit of cost-effectiveness and management efficiency also calls for interventions to reduce demand by reducing material and commercial losses within the networks, and using dual networks and water tariffs to discourage

unnecessary use of drinking-water supplies. It also acts directly on the resource (e.g. increased use of alternative sources such as wells and springs or desalination), reusing wastewaters, safeguarding small local sources, and working to improve communications between local bodies (and their needs) and the regional body through the environmental agency.

Infrastructure considerations

According to the Environmental Plan, a widespread crisis affects Sardinian hydraulic infrastructure. This is evidenced primarily by the extent of water network losses (including apparent losses due to the failure to compute the real volume of water delivered). These can be estimated by comparing the volume of water actually billed and the volumes coming into the network. The index is very high (about 60 percent), owing to the frequent failure to account for volumes delivered. As the volumes of water currently put into the network in the optimal catchment are 283 million m^3/year, some 180 million m^3 are lost each year, between physical and commercial losses. The Plan identifies the following components pointing to the critical status of infrastructure:

- 40 percent of the networks are in poor condition, and 49 percent of the internal distribution networks are poorly maintained;
- supply (including the transient population) equals 153 litres/inhabitant/day. This is less than the modal figure for southern optimal catchments of 242/litres/inhabitant/day, and is mainly attributable to insufficient rainfall recharge last year.

In addition to these problems, where action is needed to boost the efficiency of system components, connections need to be established between reservoirs so as to right the balance of water distribution and support and strengthen the water supply systems identified in the Plan.

Sewage coverage (percentage of users connected to the network) is about 75 percent, less than the average figure (85 percent) for southern Italian catchments, The extent of coverage (percentage of single and group users served by treatment plants), at about 68 percent, falls short of the average figure of 84 percent for southern optimal catchment. These data emerge from a comparison of the need for treatment and the demand met. For an equivalent population of about 5 million inhabitants, the available supply covers 2.6 million for multi-user plants and 0.5 million for single user plants.

There are many small treatment plants serving separate urban centres. This points to the still-incomplete implementation of the sewage network and treatment plants and to a system re-engineering plan developed by the relevant administration. Where implemented, it would permit the many small towns with or without treatment plants to pool their resources. Problems envisaged by this plan include:

- extension of the sewage system;
- completion of treatment plants and upgrading systems, according to norms set by Law I5/99;
- maintenance of existing infrastructure (47 percent of the sewage system is in poor condition, as are 55 percent of the treatment plants);

- incorporation of a purification cycle in treatment, allowing irrigation use of treated waters. At present, treatment is secondary[7] in 77 percent of cases. 6 000 listed[8] discharge sites need to be monitored, especially those in sensitive (mainly coastal) areas.

The infrastructure analysis clearly indicates a need for proper planning of infrastructure improvement interventions. The potential benefits and relevance of the Regional Water Plan will be most apparent in this sector. IWS objectives include enhancing infrastructure by intervening on critical sites. In this sense, the Environmental Plan has a twofold role for ascertaining the situation of infrastructure and management, and for coordinating interventions.

Management scenarios

In addition, examination of the Environmental Plan reveals management problems, related to the fragmentation of this sector. This starts with resource management, especially for watersheds involving various entities (e.g. various land reclamation consortia and industrial development consortia). This fragmentation increases when we look at the management of water abstraction, delivery and the sewage systems (see Table 3).

TABLE 3
Management

	Abstraction (% municipalities)	Distribution (% municipalities)	Sewage system (% municipalities)	Wastewater treatment (% municipalities)
ESAF (regional water supply and drainage instutution)	71	59,9	48	51,2
Govossai Consortium	5	5	1,9	3,2
Siinos	0	0,3	0,3	0,3
Municipality of Cagliari	0	0,3	0,3	0
Municipal management	19	33,4	46,7	36,1
Land reclamation and industrial consortia	5	1,1	2,9	9,/year

7. At present three plants have purification treatment: Cagliari Arenas Is., and the Municipalities of Villasimius and Palau (Sassari). The first two reuse treated waters for irrigation.
8. Regional cadastre of discharge sites (updated December 1999).

Table 3 reveals the widespread presence of ESAF. This body was set up by the Region in 1957 to provide directly (or through conventions drawn up with municipalities) for the management, maintenance or expansion of water supply and drainage systems, with a focus on water system management. A considerable share of management also fell to the municipalities, generally for economic questions, and sometimes acting as consortia, for both water abstraction and distribution, and especially for sewerage and treatment networks. Subsequently management responsibility for water systems and for sewage and treatment plants is frequently highly dispersed.

The launching of the SII (Integrated Water System) had a direct impact in that it delegates responsibility for the entire water cycle to a single manager in the ATO. It reduces service costs through integrated management and the increased scale of the area concerned. Indeed the priority objective of the Environmental Plan is to overcome existing economic imbalances through organizational and infrastructural interventions

THE INTEGRATED WATER SYSTEM IN SARDINIA

As a premise to our illustration of the situation, the implementation of the national water sector reform has failed to produce impressive results in Sardinia, and, with few exceptions, elsewhere. However, following a fairly stagnant period (by mid-2001 only 23 ATOs had been organized), the process has steadily and satisfactorily advanced in the past two years. Of the 91 optimal catchments under the Plan, some 84 have been inaugurated, reaching 96 percent of the population concerned. Of these, 66 have completed their survey, and 47 have approved the Environmental Plan. The conclusion of the first phase of application of the law (the attribution of responsibility), now totals 2 510, including in Sardinia.

This reform has the (not exclusively economic) goal of overcoming fragmentation and the division of economic management among individual municipalities. It adopts a business-oriented organizational model to ensure integrated water services. This means integrated management of the public services of abstraction, collection and distribution of water for domestic purposes, sewerage and treatment at optimal territorial coverage to justify the high investment costs inherent in the sector. Thus the reform has admittedly economic objectives, but there is also an official policy whereby all waters are declared to be in the public domain, and considered “common goods of present and future humanity”. The role of local entities in decision-making is also recognized.

In Sardinia the objective of water reform is also reorganization for a more efficient infrastructure and enhanced quality of service with closer attention to the environment and territory. A special feature of the Sardinian management situation is the direct, provisional (under art. 35 of Law 28/12/2001, n. 448) attribution of managerial responsibility to a single-manager joint-stock consortium responsible for the sector, as a means of aggregating existing managerial bodies within the Sardinian optimal catchments

The reform also demands a more selective official stance *vis-à-vis* the regionally based institutional powers vested in local bodies and agencies responsible for management within the region as administered by the Environmental Authority. We can thus identify three levels, corresponding to the division of resource planning, resource management planning, and management implementation.

The identification of the various entities and instruments is complicated in Sardinia by both the lack of watersheds plan, and ongoing water emergency. To summarize, and to delineate the scope of the Environmental Authority, we should highlight that resource planning, programming, monitoring and attribution are partly the responsibility of the Region and partly the responsibility of the Watershed Authority, while implementation is the responsibility of a single manager under the terms of a standard agreement and set of regulations based on the Environmental Plan.

We next describe the individual phases of implementation of the integrated water system as specified by regional and national law.

Definition of the target area: the identification of target areas generally aims to do away with fragmented management and optimize the sector on the basis of physical, demographic, technical and administrative parametres. The watershed or sub-watershed are respected, as are customary attributions of water resources.

Definition of the draft law: the Municipalities and Provinces reviewed the draft law put forth by the Regional Council. They highlighted critical points with respect to the system of representation. In its final form, the law was adopted by the Regional Council and approved by Municipal Councils in 2002.

Establishment of the environmental authority and approval of the Environmental Plan: The Water Emergency Commissioner assumed the leadership of the Environmental Authority, at the same time approving the Environmental Plan and the standard convention. The establishment of the Environmental Authority specifies an obligatory consortium of Municipalities and Provinces within the ATO, which was completed in September 2003.

Attribution of responsibility for the Integrated Water System: By regional ordinance, the company "Acqua Sarda," a joint-stock consortium, became the single manager. The company is responsible for implementing the investment plan called for under the Environmental Plan, in accordance with the procedures set by the convention to develop management-related activities for the integrated water system.

The ***Environmental Plan*** represents the base document for technical specifications for integrated management of the various aspects of the water system, as indicated above. This Plan defines the strategy for efficient, cost-effective management. Under the Plan, local bodies determine interventions and management procedures for implementation by the single manager in accordance with Plan objectives. The Plan includes:

- an annual workplan focusing on selected targets;
- a financing plan indicating available external resources and taxable resources, and setting water tariffs for the entire management area; and
- the management plan.

Critical points in the water system currently addressed by this Plan, include:

- resource scarcity in terms of quality and quantity, due also to reduced rainfall and water use conflicts;
- ageing water infrastructure due to low investments in recent years;

- need to adjust treatment plants to the provisions and schedules of the law;
- fragmentation and severe economic imbalance in existing management.

The Plan recognizes the need for substantial investment in infrastructure. The resources of the EU Community Support Framework will be insufficient for this purpose, and therefore additional funds are needed. This will be provided by an increase in tariffs of 1.07 Euro for the first year.

The analysis and especially the severe financial and infrastructural status of the current management led to the following terms of Plan strategy, over a timeline of 26 years:
- immediate intervention of all physical and commercial factors to maximize recovery of financial resources;
- a massive investment programme of 775 million Euro in the first six years (corresponding to the Community Support Framework programme period. This is backed mainly by public funds, and is aimed at enhancing the infrastructure capital;
- pursuit of infrastructural improvement in the years following with smaller investments of 250 million Euro and preference to maintenance interventions.

This strategy gave rise to the following guidelines for intervention, which identify a series of interventions needed to achieve specific strategy objectives:
- enhanced efficiency of distribution networks and reorganization of commercial relations;
- upgrading treatment plants by the end of 2005 as per Italian law;
- reclamation, protection and tapping of all significant underground sources;
- interventions in the high-risk water emergency areas;
- maintenance of treatment plant electrical and mechanical systems;
- upgrading water supply systems serving tourist areas;
- implementation of the programme of interventions under the PRGA.

Plan objectives also include the development of the information system for monitoring hydraulic networks and management, a new policy for saving water, and quality control of the system.

CHAPTER 17
ASPECTS OF ENVIRONMENTAL DEGRADATION IN SARDINIA

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ENVIRONMENTAL DEGRADATION RESEARCH ACTIVITIES

The concept of a research project on land degradation-linked issues was tackled in Sardinia in the early 1980s. The objective was to use the island as a project area illustrating the much broader area of southern Europe. A series of factors that have been and remain causes of desertification emerged from a small meeting of EC officials and Italian experts, held in the early 1980s. Prominent among these factors were fires, overgrazing, erosion, and both planned and unplanned urban growth.

A larger meeting met in Mitilene, Greece at the invitation of the European Community (EC) to discuss the issue and review examples of land degradation problems in the various Mediterranean regions. The findings were published in *Desertification in Europe* (Fantechi *et al.* 1986).

The issue was not again reviewed until the birth of the MEDALUS Project in 1991. The author worked in Sardinia to identify processes leading to land degradation (as described above) and ways of mitigating them. Problems of degradation primarily arise out of the management of environmental resources. Where natural resources are overestimated, it was found, they are also degraded.

Policy and market decisions are often the fundamental causes that expose an area to the decline if not the actual disappearance of its resources. In Sardinia, for example, overgrazing due to an abuse of the livestock carrying capacity of the land, combined with the inherent nature of pasturelands, led to an expansion of open grazing on the land. Here, the practice of setting fires and then ploughing to produce grasslands in sloping areas favoured soil degradation. This is visible even in the two soil maps of Sardinia drawn up in the 1960s and 1990s, which show a substantial increase in bare rock and areas of very thin soil cover.

One possible way of slowing and reducing the processes of land degradation is to promote a changeover in stock-raising methods in favour of stabling stock at certain periods, producing hay and grasses, and adding concentrated feedstuffs to the diet. This would also lead to less wear on land areas and would have obvious social and environmental benefits.

The market did and still does demand increasing amounts of cheese, the sale of which is a major factor in reducing the import/export deficit. Economic calculations that fail to factor resource degradation vs. rational resource management into the equation can easily give a false picture.

Similar considerations apply to tourism and afforestation solely for productive purposes, often with exotic species. These are common practices over much of the Mediterranean area, and demand a joint search for technical and political solutions. The most common lack is a study of resource susceptibility based on a comparison of user demands and the specific characteristics of an area, plus a study indicating possible future development of user activities.

The objective of our research on causes of desertification in Sardinia was therefore to develop technical, economic and policy strategies designed to mitigate the decline of resources of fundamental importance to humanity, through changes in how the land is managed.

The number of cases reviewed places Sardinia squarely in the middle as representative of almost all problems concerning the consumption of non-renewable resources, as well as some highly significant examples of the correct utilization of environmental resources.

Our research in Sardinia covered the following aspects of land degradation:
- experimental research into erosion, at points in a catchment and in the catchment as a whole, involving basic patterns of land-use;
- consumption of developed soils on recent alluvia as a result of quarrying;
- impact of fires on plant cover degradation and on processes of desertification;
- soil contamination by heavy metals in mining areas;
- excessive tapping of aquifers, and saline intrusions;
- consumption of soils due to urban growth and the impact of tourism on coastal areas;
- impact of exceeding livestock carrying capacity on soil compaction and degradation;
- impact of exotic species on soil degradation;
- causes and processes of soil degradation in forest areas;
- causes and processes of degradation in cork forests.

SARDINIA'S CLIMATE

Climate, soils and vegetation should be considered before deciding watershed management strategies. In Mediterranean environment, climate differs very greatly from one year to the next.

One constant is irregular rainfall. Thermometer readings tend to be more constant. Wind can vary from year to year in terms of wind direction, intensity and the number of windy days. The following diagrams show the variability from the mean, reflecting both rises and falls. Very dry years are often followed by short periods of heavy rainfall. This has a disastrous effect on erosion and flooding at the local level (see Table 1). Gaining a grasp of weather and climatic variability implies very important issues concerning land management, especially watershed management.

A review of some of the stations reveals the extent of the problem, as is the case for Cagliari and Escalaplano.

FIGURE 1
Annual rainfall in Cagliari, 1853 to 1999

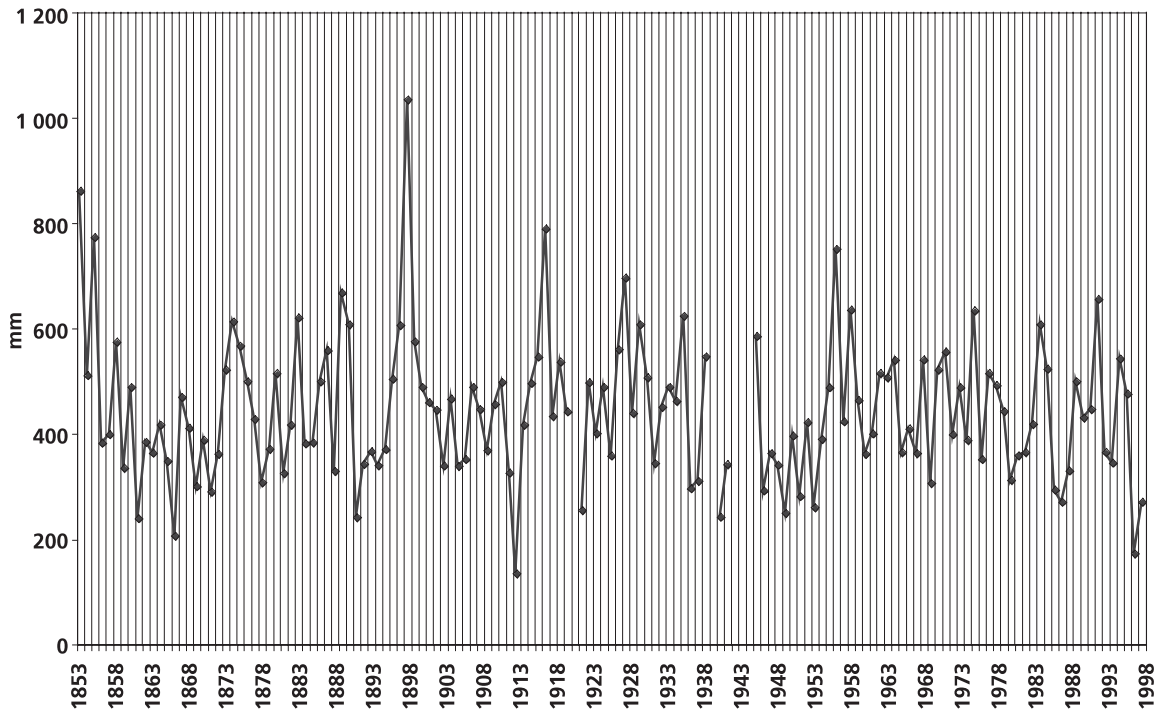


FIGURE 2
Monthly rainfall and temperature in Cagliari, 1996 to 2000

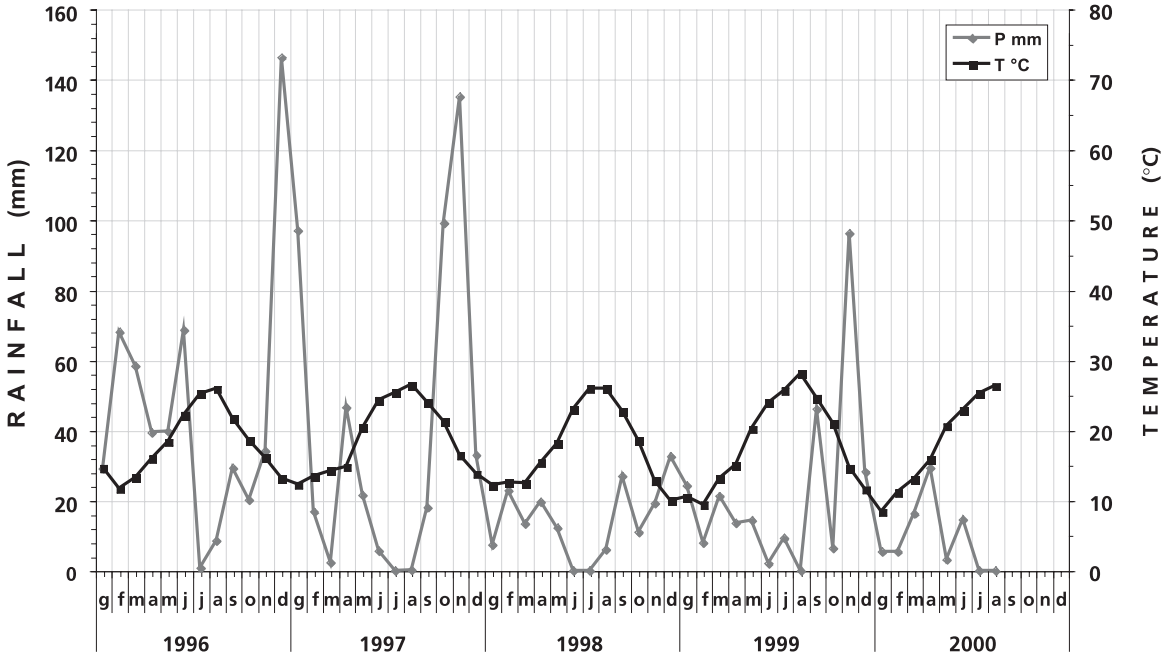
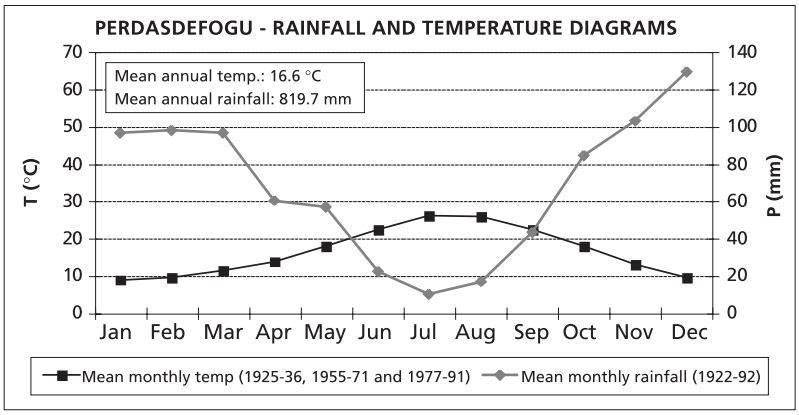
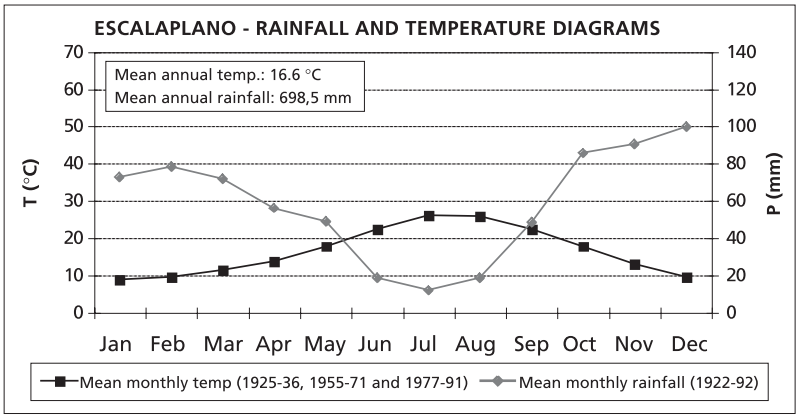
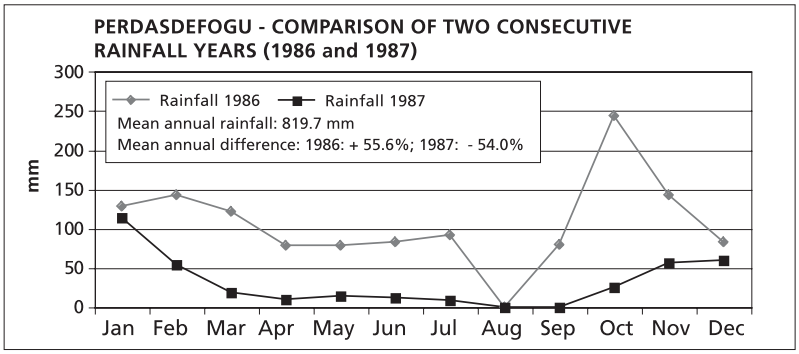


FIGURE 3

Rainfall and temperature diagrams







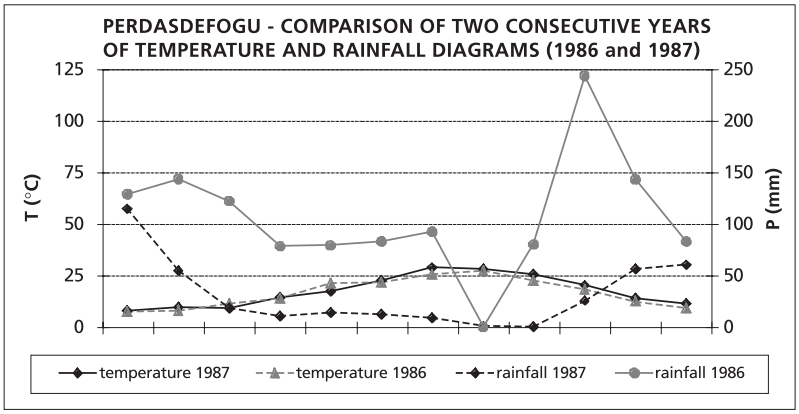


TABLE 1

RIO S. LUCIA: Flooding 12-13 Nov 1999 (EAF data)						
	R (mm)	start		end		interval
24 h	599.8	19.00.00	12 Nov. 1999	19.00.00	13 Nov. 1999	24.00.00
12 h	581.2	19.00.00	12 Nov. 1999	7.00.00	13 Nov. 1999	12.00.00
6 h	493.0	20.37.05	12 Nov. 1999	2.37.03	13 Nov. 1999	5.59.58
3 h	332.4	20.31.07	12 Nov. 1999	23.31.03	12 Nov. 1999	2.59.56
1 h	133.4	20.41.29	12 Nov. 1999	21.41.27	12 Nov. 1999	0.59.58
30'	73.0	21.19.02	12 Nov. 1999	21.48.54	12 Nov. 1999	0.29.52
15'	44.6	21.25.56	12 Nov. 1999	21.40.48	12 Nov. 1999	0.14.52
10'	32.8	21.29.35	12 Nov. 1999	21.39.33	12 Nov. 1999	0.09.58
5'	19.0	20.44.19	12 Nov. 1999	20.49.15	12 Nov. 1999	0.04.56
9 h	572.8	19.25.00	12 Nov. 1999	4.25.00	13 Nov. 1999	9.00.00

PRECIPITATION FOR 12 NOVEMBER 1999 IS OLIAS - CAGLIARI (UniCA data)		
Total in 24 hours	302.0	
	Duration (min.)	Amount (mm)
Rain event characteristics	35	17.6
	50	40.2
	180*	273.2
60 minutes	Interval	Amount (mm)
Peak rainfall	From 22.05 to 23.05	133.8

*Including the first 40 mins of 13 Dec.

Data clearly show that demand always outstrips supply and that there is need for a new strategy for water use and watershed management. Figure 4 concerning the Flumendosa system shows the following.

- Rainfall is so highly variable as to make it difficult if not impossible to rely on mean annual rainfall as a guide. In planning terms, there is no such thing as an average year of highs and lows.
- Variations from the mean show that climate and weather are not reliable, especially in terms of water storage for both surface and groundwater resources.
- Extreme rainfall events are more regular than most people and most projects and plans realize, especially as concerns irrigation.

- The frequency of very heavy rainfall is particularly high in the autumn months, when the soil is at its most vulnerable.
- Soil vulnerability is dependent on the type of land use and the soil type.
- Future land use needs to give prime consideration to the compatibility of climate, land cover and land use.
- Water use needs to be evaluated in terms of years of lightest rainfall.
- The duration of the dry period affects pasture production, and therefore the per hectare livestock carrying capacity of the land should be evaluated in terms of minimum rainfall years.

FIGURE 4a

Flumendosa – Campidano hydraulic system: net volume supplied for irrigation

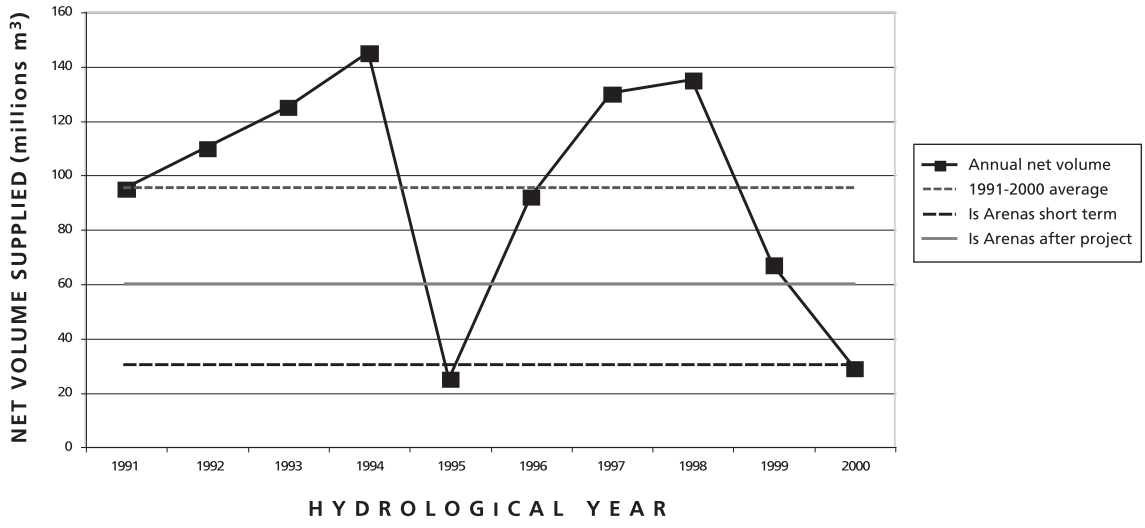
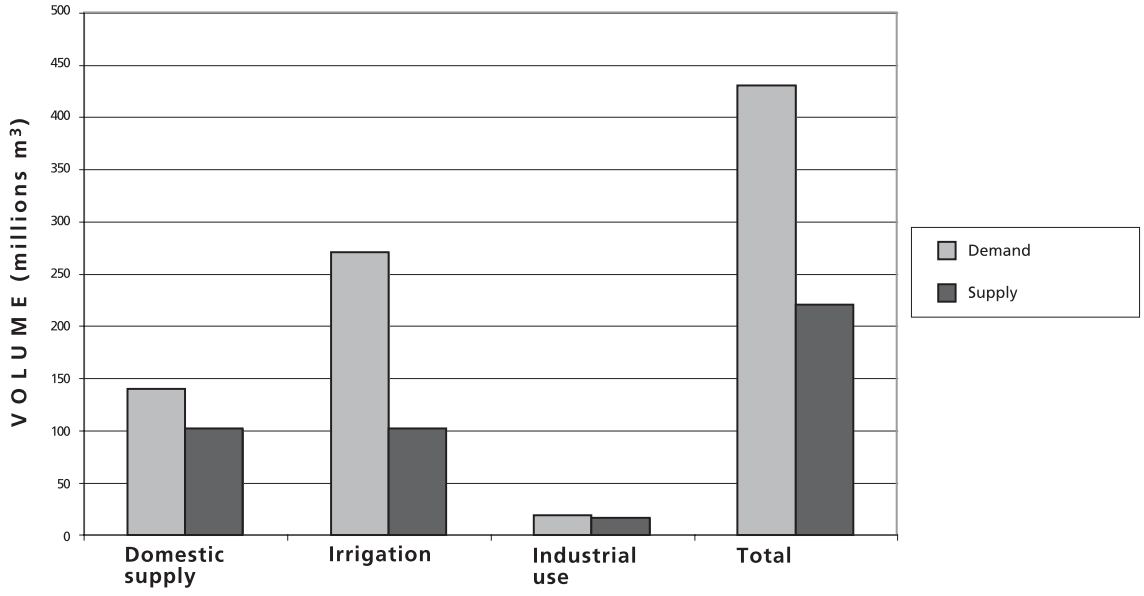


FIGURE 4b

Flumendosa – Campidano – Cixerri: five-year average demand and supply



DEGRADATION PROCESSES AFFECTING SOILS

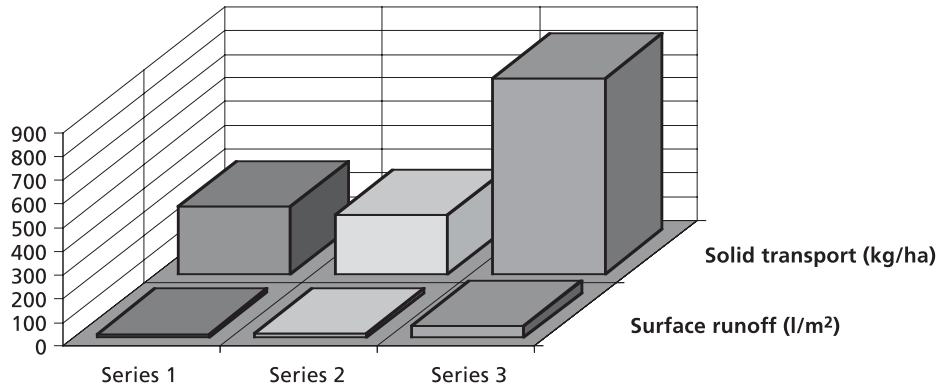
An experimental study on erosion processes due to land use was carried out in 1992 in an area of southern Sardinia representative of environmental contexts found throughout the island.

Eighteen experimental plots were established on three slopes with three different types of land use (Mediterranean scrub forest, burned scrub forest, *Eucalyptus* afforestation). The plots were distributed evenly over each of the three land use types on each of the three slopes, on all of which grazing had been banned. Data were taken on runoff and solid transport, and a weather station collected weather data.

The resulting erosion figures, while below acceptable limits, appear high with respect to the environmental situations under review, in which the speed of alteration of the substrata and soil formation are extremely low.

Erosion in the area under *Eucalyptus* (Figure 5), is higher than the erosion recorded under shrub and grass cover.[1]

FIGURE 5
Erosion data 1992 to 1996



1. This shows that Eucalypts are not effective soil protectors. This was revealed by the presence of linear erosion phenomena, reduced biodiversity and lowered organic material content in the superficial soil horizons. And because plants also grew more slowly, afforestation with exotics proved unremunerative in economic terms as well.

Quarrying activities

Quarrying of inert materials takes place even on recent alluvia with highly fertile soils. The study done in the alluvial plain of Rio S. Lucia revealed how the first four classes of soil use capacity are affected, i.e. those with the highest farming potential. Quarrying activities cause irreversible losses in soils that are both highly productive and scarce in Sardinia.

TABLE 2

Soil consumption due to quarrying activities in the alluvial plain of Rio Santa Lucia

SOIL USE CAPACITIES	PARTIAL CONSUMPTION FOR EACH UNIT			
	Ha	Relative%	m^3	m^3/ha
VII - VI	8.40	3.24	25 200	3 000
III - IV	2.60	1.01	19 500	7 500
I - II	248.00	95.75	1 860 000	7 500

Source: Modified from Puddu and Lai, 1995.

Fires

Fire is often used to clear brush and increase pastureland, especially in marginal areas. But the continual use of this practice, combined with overgrazing on the same areas, is a source of soil degradation and even the eventual disappearance of soil.

The total area of pasture in Sardinia is estimated at 1 500 000 ha. This figure must be halved if we also reckon in areas degraded to the point of desert by fires and erosion.

The most highly degraded areas overlie fairly unalterable substrata such as quartzite, granite and dolomite, on which reconstitution is impossible except over an excessively long period of time.

Table 3 clearly illustrates how grazing areas coincide with burnt-over areas, demonstrating the effects of overgrazing.

TABLE 3
General statistics of recent fires in Sardinia

YEAR	NUMBER OF FIRES	AREA (Ha)			
		Forest	Pasture	Other	Total
1984	2 155	1 563	n.d.	n.d.	17 327
1985	4 895	9 121	45 227	2 635	56 983
1986	3 282	4 229	31 035	6 133	41 397
1987	3 809	7 607	27 141	1 001	35 749
1988	3 239	9 433	40 417	3 925	53 775
1989	1 770	6 883	18 006	1 125	26 014
1990	2 911	6 309	26 823	939	34 071
1991	4 382	5 462	37 859	5 572	48 893
1992	4 937	5 775	25 686	1 711	33 172
1993	4 558	24 378	50 162	4 678	79 218
1994	3 857	17 064	48 208	5 907	71 176

From the Environmental Protection Authority of the Autonomous Region of Sardinia.

Contamination by heavy metals

The problem of heavy metals as soil and water contaminants was reviewed in both qualitative and quantitative terms in three areas with varying degrees of contamination.

Mining activities ceased many years ago in these areas. The management and protection of sludge flotation ponds has been abandoned, entailing serious consequences in terms of stability, accelerated erosion and sludge transport, with sediment intrusions into streams, recently flooded areas, dams and the sea.

The soils involved, initially highly fertile, have been irreversibly contaminated. The superficial horizons now show high values of lead, and significant amounts of zinc, manganese and cadmium.

TABLE 4

Values of heavy metals in selected soil profiles

ELEMENT	TOTAL AMOUNTS (PPM)	EXTRACTIBLE AMOUNTS (PPM)
Lead	2 000 ÷ 7 625	0.09 ÷ 10
Zinc	4 000 ÷ 9 425	26 ÷ 61
Manganese	3 500	
Cadmium		40 ÷ 70

Aquifer overuse and soil salinization

As in all arid or semi-arid areas (or in any case areas with severe water deficits), Sardinian agriculture, especially intensive agriculture, needs artificial inputs of water for cultivation.

The geography, morphology and soil characteristics of Sardinia, combined with climatic variability, make irrigation essential in Sardinia, not only in the summer months but also at other seasons of the year.

The tapping of aquifers in coastal areas, which has skyrocketed with the boom in tourism, is not properly managed. Unfortunately, the excessive drain on underground water has altered the balance with marine waters, provoking saline intrusions that contaminate aquifers and cause saline deposits on soils.

Steadily rising soil contamination in Sardinia has been recorded in parts of the Gulf of Cagliari, the lower Flumendosa Valley and other coastal plains. Studies done on the Rio S. Lucia have shown higher figures for salinization in areas around the coasts and lagoons, with peaks of 9.29 g/l.

This phenomenon is common to all Mediterranean coastal areas.

Urbanization

Urbanization in Sardinia has been intensively studied in terms of direct soil consumption in the last 15 years. The study on urban expansion in the Cagliari hinterland done in 1982 under the finalized CNR (National Research Council) Project Soil Conservation laid the groundwork for further contributions on the subject of changing land use and land management in Sardinia from historic times to the present. It turns out that the major impact of soil consumption has been on the most fertile soils.

The MEDALUS Project inaugurated a phase of in-depth research into these issues. It has now been demonstrated that urbanization in coastal areas — mainly due to the development of tourism and the expansion of industrial areas — has been unplanned and uncoordinated. The last 30 years have witnessed a spontaneous building boom with serious consequences for soil and water resources. The impact of urbanization on farmlands is not limited to the simple removal of land suitable for agriculture. It also entails a series of modifications in the physical and chemical nature of the soil, with ensuing losses or reduction of their intrinsic properties and a subsequent loss of fertility. Contamination of aquifers from saline intrusions and metals of various origins has had a highly negative impact.

TABLE 5
Consumption of agricultural land in the Cagliari hinterland

SOIL USE CAPACITY CLASSES	% CONSUMPTION 1954 - 1977
I	37.19%
II	23.07%
III	52.06%
IV	6.62%
VIII	35.12%

Source: Aru *et al.*, 1983.

The municipalities most affected by resource consumption in southern Sardinia include Cagliari, Quartu S. Elena, Capoterra and Assemini. Those most affected in the northern part of the island include Sassari-Porto Torres and coastal areas from Siniscola to Santa Teresa di Gallura.

Many soil and land use studies have been done in Quartu and Assemini, focussing on land assessment from the standpoint of both use capacity and the susceptibility of soils to specific uses (agriculture, building, grazing and livestock production) (Fantola and Lai, 1994; Aru *et al.* 1995).

The extent of the damage to agricultural areas is particularly high in the Quartu area.

TABLE 6
Extent of damage to farmlands in the municipality of Quartu S. Elena

EXTENT OF DAMAGE	AREA in m^2	PERCENTAGE
Inhabited area	3 378 335	19%
Severely damaged area	1 395 413	8%
Moderately damaged area	2 710 251	15%
Agricultural area	9 120 539	51%
Dumps	121 893	1%
Excavated areas	1 060 875	6%
Total	17 787 306	100%

Overgrazing

Overgrazing is a major source of land degradation in the semi-arid parts of the Mediterranean. Sardinia, with its age-old tradition of livestock farming, is particularly concerned. Grazing is the most common use of land in Sardinia, covering an area of 789 499 ha, or 33.14 percent of the national territory. The livestock carried by this area of land total 3 131 467 sheep, 286 831 head of cattle and 228 275 goats, plus horses, pigs and buffalo. The application of the land capability assessment methodology to the Soil Map of Sardinia shows that only 19.31 percent of the region is suitable for intensive agriculture (Classes I to IV), whereas some 65.86 percent of the territory is partially suited to extensive farming.

The major impacts of exceeding livestock carrying capacity include:
- defoliation and destruction of plant cover;
- removal of nutrients;
- mechanical impact on soils and subsequent compaction of the superficial soil horizons;
- variations in the entire hydrologic soil cycle.

Research in Sardinia mainly focussed on: a) defining a direct connection between the agro-pastoral system and land degradation; and b) assessing the impact of grazing on soil compaction.

The problem could perhaps be solved by enhancement of fodder resources and careful programming of livestock production.

Degradation of forest soils

Observations made in 1995/96 on forest soils in the montane sector of the Rio S. Lucia catchment clearly show alterations of various kinds and varying degrees of intensity. These are more apparent in areas where the original forest cover has been degraded (or is gone altogether), owing to direct or indirect human intervention.

Degradation of the original oak forest into its current form primarily involves the transformation of tree forests into coppice. It is safe to assume that openings caused by earlier felling allowed the installation of negative processes such as accelerated mineralization of organic matter and destruction of the clay-humus complex, further amplified by steep slopes. Even in those areas that are thickly covered by vegetation the signs of diffuse erosion are clearly visible. This is mainly attributable to the thinness of the organic horizons (mainly neoformations), and the raised necks of plants and stumps.

The complete elimination of the forest cover (especially downstream) by tree-felling and fires determined major changes in the floral composition and physiognomy of the vegetation, turning it into thermoxerophilous scrub, with obvious impacts on soil formation.

Grazing, primarily by sheep and goats, causes indirect damage by reducing renewal. Direct impacts include the formation of animal trails and the ensuing soil compaction, reduced permeability and qualitative alteration of litter, and hence the slowdown or (localized) halt of the processes of renewal.

Reduction of cork oak forests

Forests where *Quercus suber* is prevalent have long undergone modification of their vegetation structure, owing to the removal of cork bark plus practices such as grazing, with the ensuing regression of these highly vulnerable ecosystems, which are particularly susceptible in soil terms.

The principal causes of imbalances in Sardinia's cork forests have been clear for a long time now, especially as concerns the soil and vegetation aspects. Humans are the main agents in all typologies of cork oak forest. The primary causes of imbalance are forest fires, overgrazing and farm practices, aggravated by pest attacks by defoliators, and root rot.

Cork forest mortality in Sardinia is mainly the result of fires, which are often linked to the conflict between grazing and forest, but also to the practice of intensive farming in cork groves, and occasionally to severe drought.

The basic components of soil degradation in cork forests are reduced biodiversity, reduction or absence of natural renewal and the loss of humified organic matter and its function of promoting soil and slope stability through water retention and runoff control.

Impact of afforestation with exotic species

Meeting regional needs for wood has been a Sardinian target for many decades, involving major financial outlays for industrial-scale afforestation with exotic species.

Rapid-growth plantations of Eucalypts and *Pinus radiata*, the major exotics, often produced discouraging results in terms of wood production, or were wiped out by the premature destruction of forest cover by fire.

Soil conservation problems under such plantations are severe due to the impact of mechanized reforestation operations (brush clearing and ploughing) and subsequent silvicultural practices.

The municipality of Siliqua (Cagliari) has a vast eucalyptus plantation, now under study. The trees were planted on sloping, fairly impermeable, skeleton soils. Any profits from this operation need to be set against the ensuing environmental damage (erosion, alteration of pre-existing plant cover, loss of biodiversity). Additional evidence for this can be found in the I. Olias study area (Capoterra, Cagliari) under the MEDALUS Project.

There has been a slight drop, however, in the use of exotics in human-made plantations recently; especially those financed by the European Union in favour of autochthonous species. Even here the absence of reliable land capability assessments can easily lead to failure.

The above discussion clearly points to the need to develop future land use strategies designed to mitigate the phenomena described. These should not be based on policy decisions, and are sufficiently differentiated to match the range of environmental settings. There is no "one size fits all" solution for the European Union as a whole: nor even for the Mediterranean region.

Sardinia is the region with the greatest soil variability in the Mediterranean. There is a great diversity among the single components of Mediterranean landscapes, especially with regard to soil, climate and plant cover. What is needed, therefore, is a community-level strategy with a different thrust for different countries, regions and communities. There needs to be constant feedback between the needs of a plan targeted at the community level, and local or multilocal planning in terms of practical application. This has been the underlying rationale of Sardinian planning for Quartu S. Elena and Assemini. For the first time in Italy local urban planning here included not only urban planning *per se*, but agricultural and forest planning as well.

REFERENCES

Aru, A. *et al.* 1986. *Suoli delle aree irrigabili della Sardegna*. Piano Generale delle Acque, RAS.

Aru, A. 1984. Aspects of desertification in Sardinia, Italy. *In* R. Fantechi, N.S. Margaris, Mitilene, eds. *Desertification in Europe*. Proceedings of the Information Symposium in the EEC Programme on Climatology, pp. 194–198.

Aru, A. 1995. *Il ruolo della pedologia nella pianificazione e nella progettazione con particolare riferimento alla Sardegna*. Paper presented at the Congress of the Società Italiana del Suolo, Il ruolo della pedologia nella pianificazione e nella gestione del territorio, Cagliari 6 to 10 June.

Aru A., Baldacchini, P. & Vacca, A. 1982. *Nota illustrativa alla Carta dei Suoli della Sardegna*, Dip. Scienze della Terra, Univ. Cagliari, Centro Reg. Program., Ass. Program. Bil. Ass. Territorio, Regione Autonoma Sardegna.

Aru A., Madeddu, B. & Kahnamoel, A. 1995. Soil contamination by heavy metals from mines. In Proceedings of the *Conference on Land Use and Soil Degradation - MEDALUS in Sardinia*, (Edited by G. Enne, G. Pulina and A. Aru). Sassari (pp.265–283).

Aru, A., Baldaccini, P., Malquori, A., Melis, R.T. Vacca, S. 1983. *Il consumo delle terre a causa dell'espansione urbana del territorio intorno a Cagliari*. Prog. Finalizz. Conservazione del Suolo, Sottoprog. Dinamica dei versanti, n. 94, C.N.R.

Aru, A., Brundu, G., Camarda, I., Kahnamoel, A., Madeddu, B., Roxo, M., Puddu, R., Satta, V. & Vacca, A. 1994. *Assessment and management criteria of desertification in selected Mediterranean areas*. Working Paper No. 31. Presented at the 3rd MEDALUS II Group Meeting and Scientific Conference, Athens 19-24 May 1994, 20pp.

Fantechi, R. and N.S. Margaris (Ed.s) 1986. *Desertification in Europe*

Fantola, F. & Lai, M.R. 1994. *Il contributo della Geopedologia nella pianificazione territoriale: Il piano urbanistico del Comune di Quartu S. Elena (Sardegna meridionale)*. 8th National Congress of the Association of Geologists, 21-23 January 1994, Rome.

Montgomery, K.E. 1966. *Land capability classification*. Soil Conservation Service, USDA Handbook N° 210. Washington DC.

Lai M.R, Loddo S., Puddu R., Aru A. & Baldaccini P. 1994. Il Rilevamento Geologico e Pedoambientale del Bacino del Rio Santa Lucia. *In Atti del convegno: "Il MEDALUS in Sardegna". Sassari.*

Lai, M.R., Loddo S., Puddu, R. & Serra, G. 1995. *Lo Studio Geopedologico nella Pianificazione degli Interventi di Difesa del Suolo e di Mitigazione della Desertificazione*. Salvaguardia della risorsa pedologica nel quadro della legge n. 183/89. Il bacino del Rio S. Lucia di Capoterra. In Atti del congresso della Società Italiana di Scienza del Suolo: "Il Ruolo della Pedologia nella Pianificazione e Gestione del Territorio". Cagliari.

Previtali, F. 1996. *Soil Degradation Processes and Land Use in North - Western Sardinia (Italy)* Procs. of the International Conference on Land Degradation, Adana, Turkey, 10-14 June, 1996.

Puddu, R. & Lai, M.R. 1995. Quarrying activities in the Rio S. Lucia catchment basin (southern Sardinia, Italy).In Proceedings of the *Conference on Land Use and Soil Degradation - MEDALUS in Sardinia*, (Edited by G. Enne, G. Pulina and A. Aru). Sassari (pp. 129-139).

Puddu, R., Tomasi, D. & Vacca, A. 1995. *Erosione ed uso del suolo. Indicazioni per la gestione e la pianificazione del territorio. Un esempio nella Sardegna sud-occidentale.* In atti del convegno Il ruolo della pedologia nella pianificazione e gestione del territorio. Cagliari, pp 77-86.

Puddu, R., Tomasi, D. & Vacca, A. 1995. *Erosion in areas afforested with Eucalyptus: A case study in southern Sardinia (Italy)*. Procs. Conference on Erosion and Land Degradation in the Mediterranean: the Impacts of Agriculture, Forestry and Tourism, Aveiro, Portugal, pp. 289-299.

Regione Autonoma Sardegna. 1991. *Piano per la difesa contro gli incendi nei boschi e elle campagna*. RAS, Cagliari.

Sanfilippo, E. 1987. I boschi. Una risorsa fondamentale oggetto di forti antagonismi. In F. Boggio, R. Pracchi and A. Asole, eds. *Atlante Economico della Sardegna*, Milan, Universitarie JACA, Banca Popolare di Sassari. pp. 153-181.

Soil Survey Staff. 1992. *Keys to soil taxonomy*, 5th edition. SMSS technical monograph No. 19,. Blacksburg Virginia,USA, Pocahontas Press Inc., 556 pp.

Trastu, S., Usai, D., Aru, A., Camarda, I. & Baldacchini, P. 1995. *Prime considerazioni sulla degradazione delle aree sughericole in Sardegna (Prog. PANDA*) - Paper presented at the Congress of the Società Italiana della Scienza del Suolo, Il ruolo della pedologia nella pianificazione e gestione del territorio, Cagliari.

Treacher, T.T. 1994. *Constraints on small ruminant production in the arid areas in the south and east of the Mediterranean basin* Procs. of the 45th. Annual Meeting of the European Association for Animal Production, Edinburgh, UK, 5-8 September.

Vacca, A., Puddu, R., Usai, D. & Tomasi, D. 1993. *Experimental plots at Is Olias (Rio S. Lucia catchment area). Some data and result of Medalus I and Medalus II (first year)*. Medalus Working Paper No. 6.

Vacca, A., Puddu, R., Usai, D. & Tomasi, D. 1995. Erosion measurements in the three areas of the Rio S. Lucia catchment with different land uses.In Proceedings of the *Conference on Land Use and Soil Degradation - MEDALUS in Sardinia*, (Edited by G. Enne, G. Pulina and A. Aru). Sassari (pp. 115-127)

World Bank. 1996. *Desertification: implementing the convention. A World Bank view.* 2nd edition Land, Water and Natural Habitats Division, Environment Department. Washington, DC.

Zanchi, C. 1993. *Aspetti dell'erosione dei suoli nei diversi ambienti del bacino del Mediterraneo, in montagna ed in collina*. Procs. Conference La difesa del suolo in ambiente mediterraneo. ERSAT. pp. 57-69.

CHAPTER 18
CONFLICT MANAGEMENT IN SUPPORT OF DECISION-MAKING FOR WATER USE

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Uncertainty and vulnerability are two characteristic elements of modern society, influencing the behaviour of opinion leaders and the general public alike. Many factors underlie this trend:

- the dynamic of development with the ever-swifter pace of change and the concomitant development of modern technology;
- the steady growth of entrepreneurial competition, not only as a typical characteristic of the new market place, but also as the appearance of new actors;
- the fact that markets and economic, social and cultural behaviour are increasingly interdependent, fostering imbalances;
- the search for a new social order able to reconcile industrial civilization with pre-existing peasant society and with environmental protection;
- the lack of environmental resources (especially water) due to both natural factors and steadily growing demand, especially from the developing countries.

CONFLICT: ACTORS AND OBJECTIVES

The management of water use conflicts demands steady and hard work by all actors in seeking consensus. It requires the participation of the various stakeholders in devising and choosing among a range of alternatives. However, it should also be understood as a tool for education and awareness raising for the general public and institutions.

A genuine, ongoing exchange of information allows the public to get involved. This entails empowering the public.

However, public empowerment may meet with scepticism on the part of those who see that the real interests of the population are not represented by opinion movements and "ideal" environmental solutions. Technical solutions are often quite political, mirroring the way values and resources are distributed within society. Technology therefore needs to be, above all, politically correct and realistic. In this way public involvement becomes a tool for managing the process of making political and technical choices.

What objectives should we pursue in the course of a process of involving the various actors in conflict management?

First of all we need to ensure that both the proponents of decisions and those affected by them have credibility. This is true both of those implementing financial measures and of final users.

There has often been an insurmountable credibility gap between decision-makers and the public.

We therefore need to identify the problems and values in play, and to develop consensus among those directly concerned, financing agents and users.

There is also need to involve the right parties at the right time and in the right discussions.

TYPE OF CONFLICTS

The decision-making process involves policy-makers, technicians and the public. These diverse actors represent different interests. Policy-makers, technical experts and civil servants do not always speak the same language nor do they share the same views on decision-making. There is abundant controversy even among technicians, and we often speak of the public in generic terms, whereas it would be more accurate to speak of various social groups or publics.

Agreement or disagreement among these various social groups may involve the nature of the problem, the objective pursued or both. Most often this is an iterative process ranging from the discussion of objectives to the definition of the nature of the problem, and vice versa.

Conflicts can be divided into four main categories. Data conflicts have mainly to do with information gaps, misinformation, differing interpretations of data, and different viewpoints. Technical reports are not always written so as to address all possible requests. They often provide data in accordance with prevailing norms, but leave out information that would be important for an understanding of the issue involved. Conflicts of interest have psychological and cultural components. Value-centred conflicts are bound up with the diversity of ideologies, belief systems and the fundamental, moral values of individuals and peoples. Relational conflicts have an emotional basis, but they are also mainly founded on a lack of information and negative individual behaviour patterns.

CONFLICT MANAGEMENT

Many disagreements involve all the above. A careful, patient examination of a set of values leading to the emergence of alternatives designed to achieve consensus is needed in this connection.

While “extreme” positions must be isolated, there is also a need to find incentives for participants to identify some common ground for action. This substantially involves moving from an examination of the underlying reasons for a given conflict to the definition of solutions. The public sector should facilitate the identification of solutions, alternatives and recommendations, fostering interaction in which a compromise becomes acceptable to all.

Cooperation that builds on alternative stances to arrive at creative, impromptu solutions, without necessarily ruling out earlier views, is what is needed. The important thing is that extreme views need to be expressed and acknowledged. Adherence to an extreme view should be clearly identified and expressed, not so as to exclude it but in order to arrive at reasonable alternatives. Many decisions taken in the environmental sphere are the fruit of a search for a reasonable solution rather than the application of a rational decision.

Once extreme stances have been isolated, we need to turn our attention to the identification of the interests involved, and not simply examine solutions that involve abstract benefits. This approach to the problem is also interactive. Values as points for discussion alternate with interests as rationale for action and positions as a springboard for intervention. In this kind of negotiation players inform each other about their respective interests, generating a series of options which no single player could have imagined at the outset. Negotiation thus becomes a means of arriving at a joint solution to the problem at hand as opposed to seeking a compromise solution between opposing parties.

It is a good idea for conflict management to proceed from the starting-point of interests rather than hard and fast positions. However, what needs to be put on the table are interests that can ensure stability. Substantial interests (procedural goods, in practice) involving the material and non-material interest concur to resolve conflicts.

THE PARTIES INVOLVED

Many techniques are used in conflict resolution. But they all involve establishing a dialogue among those concerned. This process usually makes a clear distinction between communication and content, and implies engaging in dialogue while effectively communicating. Mediation is the most apt solution for facilitating dialogue among the parties and focussing on content.

Before choosing a "mediator", all actors must be clearly identified, including:
- parties with formal responsibility in the decision-making process;
- parties wholly or potentially affected by the outcome of the decisions;
- parties in a position to block or hinder the decision-making process.

The mediator must not have any sort of stake in the final outcome.

Facilitating discussion and proposing conflict resolution is a creative task. It must be designed to allow interested parties to participate in a forum where their respective interests will find expression.

A preparatory phase to resolve in advance issues that could prevent the parties from sitting around the same table is usually a prerequisite. A well-planned table for discussion is a precondition for coming up with the right incentives for all involved to work together to reconcile their separate interests.

THE ROLE OF THE PUBLIC ADMINISTRATOR

The role of the public administrator, and especially that of the technical support unit, is important. The identification of many of the factors in play is not just a question of policy decisions and choices. It depends more on the process of providing information, technical backup and the capacity to lead the discussion. This demands long and continuous experience with some institution working to disseminate information and choose solutions that are not only environmentally sustainable, but also sustainable for the public that will bear the consequences.

All this is made possible by a new philosophy, which implies a complete turnaround in the quality of the product offered (intervention, teaching, project), as well as the level of service. This can restore the real value of goods (especially those held in common) while linking these goods to their functional characteristics, re-qualifying their use values, ensuring resource access to all, eliminating their purely outward significance and, most of all, ensuring environmental and health safeguards.

Management, including conflict management, is therefore tending increasingly in the direction of "lean management" in the private sector. This gives rise to a shift from "organizing by area of expertise" to "organizing by objectives", which is increasingly now used by organizations to manage highly complex and critical problems.

REFERENCES

Delle Priscoli, J. (no date). *Public involvement, conflict management and dispute resolution in water resources and environmental decision making.* IWR Working Paper.

Potapchuk, W.R., Laue, J.H. & Murray, J.S. (no date). *Getting to the table.* IWR Working Paper.