

**SOLUTIONS FOR A COMPLEX COASTAL LAGOON: INTEGRATED
COASTAL MANAGEMENT AND VENICE LAGOON**

D. Suman^a, S. Guerzoni^b, E. Molinaroli^c

*^aDivision of Marine Affairs and Policy, RSMAS, University of Miami, Miami, Florida 33149,
USA*

^bCNR - Istituto di Scienze Marine, Riva VII Martiri 1364/A, 30122 Venezia, Italy

*^cDipartimento di Scienze Ambientali, Università Ca' Foscari Venezia, Dorsoduro 2137,
30123 Venezia, Italy*

e-mail of corresponding author: Stefano.guerzoni@ismar.cnr.it

Keywords: Venice Lagoon, ecosystem-based management, sectoral activities, integrated coastal management, sustainability.

This paper has not been submitted elsewhere in identical or similar form, nor will it be during the first three months after its submission to *Hydrobiologia*.

ABSTRACT

The Venice Lagoon (VL) is a complex ecosystem in which public participation and area-based management has often been neglected by administrative bodies involved in the planning of coastal projects and public works. In this area, the analysis of the local situation highlighted a substantial absence of coordination among the various administrative bodies in charge of planning and management at various governmental levels and in different regulated economic sectors. The manuscript analyzes public participation and collaboration with reference to the Integrated Coastal Management context (ICM). The paper examines specific requirements, constraints, and opportunities for the complex case of the VL where participatory management and institutional coordination need enhancement.

INTRODUCTION

The lack of effective integrated management in coastal areas, nearshore waters, and catchment basins and, particularly the lack of appropriate national legislation have been recognised at the European level as principal factors responsible for the degradation of coastal and marine environments (EUCC, 1999; EC, 1999a; EC, 1999b). Experience gained during the European Integrated Coastal Management (ICM) Demonstration Programme (EC, 1999b; EC, 2000) emphasizes that no single correct approach or framework exists for coastal management and the sustainable allocation of coastal resources. VL is an extremely complex area in which cultural, social, and environmental features of international significance coexist (UNESCO, 1995). Within the debate concerning protection of Venice and its future, adoption of an integrated vision and of a cross-sectoral participatory approach for the resolution of coastal issues are recurring themes. However, such concepts have usually been limited to the emphasis on major problems, institutional constraints, and solutions without the definition of appropriate tools.

The VL is an important ICM case study principally due to its regional, national, and international importance; the complexity of its coastal system; the many governmental, social, and economic actors with interests in the area; and the severe adverse environmental impacts of many of the activities occurring there. This coastal space is also important because of its cultural and environmental patrimony. Neil (2002) noted that the Venetian Republic implemented wide-ranging, innovative environmental management strategies in response to emerging coastal management issues between the XIV and XV Centuries. Seawalls and inlet jetties date from the 18th and 19th Centuries, respectively. Despite these initiatives implemented over a millennium, today Venice contrasts as a site of serious environmental degradation, high risk of coastal hazards, and an absence of sustainability. The situation has deteriorated, particularly during the last century, after the development of the industrial area

of Porto Marghera, on the western shoreline of the lagoon (Ravera, 2000). The draining of mudflats for construction and agriculture, as well as dredging of channels to accommodate maritime shipping, have both disrupted the lagoon's equilibrium with the sea and increased the pollution of the area (See Fig. 1).

THE VENICE LAGOON ECOSYSTEM

Located at the northern end of the Adriatic Sea, VL (location 45°N, 12°E) extends about 100 km along the Adriatic coast and has an average width of 50 km and average depth of 1.2 m. The area of the lagoon is 550 km² (Fig. 1). The lagoon proper forms part of a tripartite ecosystem: the catchment basin, the lagoon, and the adjacent upper Adriatic Sea. This lagoon is the most important survivor of a chain of natural lagoons of the northern Adriatic Sea.

The edges of the lagoon now form a clearly delineated man-made perimeter. A wide expanse of reclaimed land used for industrial and residential purposes, fish farms, dumps and landfills, as well as dikes and drainage canals border the lagoon to the west and northwest. Two long barrier islands heavily defended by seawalls separate the lagoon from the Adriatic Sea to the east. Water exchange occurs through three large entrances (Lido, Malamocco, and Chioggia). Each inlet corresponds to a specific basin inside the lagoon that is hydraulically separated from the others by a watershed. Adriatic tides govern water exchange in VL and have a mean amplitude of 20 cm during neap tides to 100 cm during spring tides. The average water volume in VL is approximately $3.9 \times 10^8 \text{ m}^3$. The average residence time is around 10 days, varying from 1 day for the area close to the inlets to 30 days for the internal areas (Umgiesser et al., 2003).

The average daily freshwater input to VL amounts to 2.8 million cubic meters. This hydrological pattern creates a typical brackish environment in the lagoon, with a salinity gradient that ranges from 10 ‰ near the mainland border to 32‰ at the inlets.

The Lagoon ecosystem has been subject to centuries of great human intervention and modification. Four major rivers (Sile, Piave, Brenta, and Bacchiglione) once drained into the VL bringing abundant supplies of fresh water, sediment, and organic matter. Prior to the year 1500, the rivers entering the lagoon contributed approximately 700,000 m³ of fine-grained material, most of which was deposited to form fringing salt marshes and mud flats. An additional 300,000 m³ of sand entered the lagoon from the sea to form flood tidal deltas. By 1650, all major rivers had been diverted to bypass the lagoon and discharge directly into the sea in order to avoid lagoon siltation. This diversion, followed by the construction of breakwaters at the lagoon inlets and the increased dredging of lagoonal channels for navigation purposes, has had a significant impact on the lagoon morphology. Today's sediment budget is negative. This evolutionary tendency can be seen in the progressive disappearance of salt marshes (from 90 km² in 1901 to the current 47 km²) (Favaro, 1992; Runca et al., 1993) and mud flats; the gradual and constant increase in water depth; and the disappearance of the tidal creeks.

The tendency toward erosion also applies to the barrier islands, as well as the lagoon beds. This shoreline erosion is of great concern as the barrier islands protect the lagoon and developed islands from the destructive forces of the waves in the northern Adriatic that may reach 5 m in height. Over the last 10 years, beach nourishment from offshore sand supplies has widened the barrier islands. Construction of rock groynes and breakwaters is reducing longshore sand transport and stabilizing the beach.

USES OF THE VENICE LAGOON ECOSYSTEM

The VL ecosystem concentrates a wide variety of uses, many of which are mutually incompatible.

Population. Over 1 million persons inhabit the VL Basin. The population of the historic city itself has actually decreased from 175,000 persons in 1951 to less than 70,000 today. The exodus may be due to lack of employment, high real estate values, high costs of building maintenance, and flooding events. The population of the municipal area, composed of the historic city of Venice and Mestre on the mainland, has remained fairly constant during the past half century at approximately 300,000 persons.

Tourism. Today, tourism is the economic engine of the historic city of Venice, employing over 10,000 people and generating over a billion euros in revenues annually. The city is one of the most important tourist attractions in Italy and draws over 10 million visitor days each year. The tourist industry places additional stresses on the VL. For example, visitors generate over 20,000 tons of solid wastes each year or about one third of the total amount.

Industry. Venice is an important industrial centre in Italy and the northern Adriatic region. Most of the heavy industry is located in the 2,000 ha Porto Marghera area on the mainland, 5 km west of the historic city centre. The industrial activity began after the First World War and expanded significantly in the 1950s. Plans for a third expansion were discussed in the 1960s with additional reclamation of VL wetlands, but the development of the industrial centre never materialized.

The main industries today include petrochemical processing, shipbuilding and maintenance, coal distillation, fertilizer and pesticide production, and non-ferrous metallurgical processing. Today 300 firms in Porto Marghera employ over 18,000 persons, a decrease from the 33,000 workers in 1965.

Maritime Shipping & Ports. The Port of Venice is one of the principal ports in the northern Adriatic Sea, handling approximately 30 million of cargo per year and employing over 18,500 persons. Traffic includes bulk industrial goods, containerized cargo, petroleum and hydrocarbons, as well as passengers. Over 1 million maritime passengers transit Venice each year. Over 5,000 vessels call on the Port of Venice annually, while another 500 dock at the Port of Chioggia. The Port's commercial interests generate over €1,250 million in economic activity each year. About 40% of the ships calling on Venice, including petroleum tankers, use the middle inlet – Malamocco- , while passenger and cargo vessels enter through Lido, the northern ship channel that leads directly through the historic centre of Venice. The Venice Port Authority has developed plans to transfer most of the ship traffic from the Lido to the Malamocco Inlet to reduce the risks of an accident near the historic city centre.

Fishing. Chioggia in the southern part of the lagoon is the principal fishing port in the VL and serves the northern Adriatic fleet that employs over 1,200 fishermen. Inside the lagoon, clam and mussel cultivation are important activities. Additionally, over 100 small fishing vessels engage in the Philippine clam (*Tapes philipinarum*) fishery, often using an illegal technique which blows away lagoon sediments.

Aquaculture. Over 120 fish farms ranging in size between 10 and 1,600 ha occupy the western border of the lagoon. These aquaculture facilities dammed the canals that penetrated into the lagoon's wetlands. Income from this activity amounts to approximately 6 million euros per year. Many fish farm owners also permit hunting of water fowl in their areas.

Agriculture. Agriculture is an important activity in the VL drainage basin with over 80,000 farms occupying 313,000 ha. Corn and cereals are important crops. Livestock production (240,000 head of cattle and 85,000 head of pigs) is also a major agricultural activity.

Ecotourism & Protected Areas. The 500 ha Valle Averno was designated as a Ramsar Site (Wetland of International Importance) in 1989 and is also a State Natural Reserve. The site consists of brackish and freshwater wetlands with woodlands and wetland meadows. It is an important stopover and feeding site for many species of aquatic birds and migratory waterfowl, and regularly hosts over 20,000 individuals. Aquaculture activities utilize about 300 ha of the site.

Other protected areas also exist in the lagoon, including Oasis Ca' Roman, a 40 ha site south of Pellestrina with dunes and coastal scrub forest, and six other sites identified within *Nature* and *Bird* EC Directives.

Cultural Patrimony. The "City of Venice and its Lagoon" were declared a UNESCO World Heritage Site based on numerous criteria for inclusion of cultural properties established by the World Heritage Committee (UNESCO, 2004). The Eighth Conference of the Contracting Parties (COP-8) (2002) approved Resolution VIII.19 on "Guiding principles for taking into account the cultural values of wetlands for the effective management of sites". This resolution recognised the values of cultural heritage for the conservation of wetlands. Therefore, given VL's recognition as a World Heritage Site, it would also meet the Ramsar cultural criteria (Smart & Vinals, 2004). Arguably, the cultural elements of VL related to wetlands and water would also support future designation of new Wetlands of International Importance in VL.

IMPACTS OF SECTORAL ACTIVITIES ON THE ENVIRONMENT

The multiple uses of VL have caused serious environmental problems over the past centuries. These multiple uses of this limited coastal space often conflict with each other and have also led to serious environmental degradation. Table 1 summarizes the adverse impacts of human activities on VL wetlands.

The principal modifications in the past have affected the hydrological regime of the rivers flowing into the lagoon. Most of the rivers were diverted to bypass the lagoon. More recent human impacts are the progressive urbanisation along the lagoon boundary and the rest of the drainage basin. Many intertidal areas have been filled for the development of industrial areas, such as Porto Marghera. This development has caused the loss of natural habitats, such as woodlands and freshwater wetlands, that were once present along the borders and provided a “green belt”. The disappearance of this protective green area has produced two adverse impacts: 1) the disappearance of flora and fauna and 2) the decrease of the self-purifying capacity of the ecosystem with respect to nutrients.

Nutrients originate from an increase of pollution loads deriving from urban and industrial sources, as well as from agricultural and urban runoff. Approximately 6,000 tons/year of nitrogen and 400tons/year of phosphorus are discharged in the lagoon. About 60% of this nutrient loading is due to agriculture, 20% to industrial activities, 15% urban activities, and 5% from long-range atmospheric deposition (Ravera, 2000; Burigana et al., 2003, Bettiol et al., this issue).

Furthermore, over the years pollutants and heavy metals (Hg, Pb, Cd, Cr, As, Cu, Ni, and Zn) from industrial wastes have been discharged directly into the lagoon and mix with lagoonal sediments. The environmental deterioration is manifested in the decrease in number of species of flora and fauna and the increase in turbidity of waters. The turbidity of the water has in turn led to a reduction in the growth of eelgrass, a plant whose long roots consolidate the lagoon bed and, therefore, reduce erosion.

Recent research has studied the presence of dioxins and other organochlorine species in bottom sediments and aquatic biota in the Venice Lagoon. Sources of the contamination are often discharges from the industrial district of Porto Marghera, untreated domestic sewage from the historical city of Venice and the nearby city of Mestre, as well as motorboat engines.

The Venice harbour ranks amongst the most important Italian seaports with current traffic about 30 million tons per year. Petroleum products, such as crude oil, gasoline, chemical products, used by the large chemical, petrochemical and power plants of the area, account for over 40% of this cargo. Oil traffic represents a severe potential danger for the Lagoon. Recent models demonstrate that an accident involving an oil spill in the lagoon would have a catastrophic impact on the survival of this ecosystem.

The decrease and aging of the remaining population, as well as the growing reliance on tourism as the economic mainstay in the area create severe socio-economic risks. Population decrease translates into loss of revenue and tax base, as well as diminishing incentives to maintain old buildings and the infrastructure that protects small islands.

Given the relatively small size of the city, the movement of tourists significantly impacts urban organisation. The automobile and the railway terminals, the water taxi systems, museums, and restaurant services are all organised to meet the tourism demand, rather than to serve the local population. Venice's economic base is becoming monosectoral as a result of tourism. This increases the risk of economic dependency and restricts the development of other economic activities, resulting in a loss of cultural identity. Extensive tourism produces four additional adverse impacts:

1. Visitors generate more than 20,000 tons of solid wastes each year. This is one third of the solid wastes produced in the historic centre of Venice.
2. Mass tourism damages historical buildings.
3. Tourism produces serious human congestion and crowding in the historic centre.
4. High numbers of visitors create difficulties for residents.

Because of its low elevation, the historical centre of Venice is vulnerable to flooding. From the beginning of this century, the difference in level between land and water in Venice

has changed by about 23 cm. The sea level has risen by about 11 cm, while the land has sunk by 12 cm because of subsidence caused mainly to excessive extraction of groundwater.

This situation leaves Venice even more vulnerable to even minimal tidal changes, as well as the probable sea level rise.

The average tidal range is about 50 cm in VL. In the beginning of the last Century, high waters flooded Piazza San Marco seven times per year. Today flooding occurs more than 40 times annually and up to 67 times in some years. At the beginning of the century, an exceptionally high tide (such as that of 1966) could be expected to occur once every 600 years. Now the same event would repeat in a period of about 200 years. Subsidence is now considered to be under control because of the prohibition on the pumping of groundwater. However, sea level rise continues to pose a very serious risk. A sea level rise of 30 cm by the 2100 would mean that Piazza San Marco would flood almost every high tide or during about 360 days per year.

Other risks associated with the change in relative level of land and sea include:

1. potential impacts of waves on the fragile infrastructure of the city and the salt-induced deterioration of its foundations and structures.
2. subsidence and eustasy have brought the water into contact with bricks and masonry with increasing frequency. Stone and bricks are very porous and permit the capillary rise of salt water.

Fishing activities in the lagoon are only minimally regulated. Some fishing techniques have a devastating effect on lagoon beds turning them into barren areas. The clam fishery uses a “blower” to remove lagoonal sediments. Although this fishing technique is forbidden, fishermen still practice it illegally.

The VL is a complex territorial space in which cultural, social and environmental features of international relevance coexist. The multiplicity of activities places different

demands on coastal resources, resulting in intense competition and conflicts over appropriate patterns of use. Historical and recent examples of success and failure in balancing these competing uses have characterised attempts of Venetian authorities to manage and plan multi-sectoral uses of local resources, i.e. tourism exploitation of historic settlements, fish farming, and industrial development.

The various sectoral activities all produce adverse impacts on each other, as well as on the environment. Table 2 shows the important linkages between coastal-dependent sectors. Positive and negative consequences of these linkages highlight the need for integrated coastal management.

INSTITUTIONAL RESPONSIBILITIES IN VENICE LAGOON

Institutions involved in managing VL and its resources

Venice represents not just environmental but also institutional and legislative complexity. Four levels of institutions, which operate directly in the area, administer the lagoon system (including the basin around the lagoon, the lagoon, the city of Venice, and the small towns surrounding the lagoon).

The State operates directly through the Ministry of Public Works and the Venice Water Authority (*Magistrato alle Acque*: MAV). The MAV is responsible for the administration of water, lagoon areas, and the coastline, particularly water quality and discharge permits. The defence of the lagoon from the sea is the MAV's primary task today. Under Special Law 789 of 1984, the MAV delegated the task of protection of the lagoonal morphology and defence from high waters and flooding to the new "*Consorzio Venezia Nuova*" (CVN). The Ministry of Transport and the Ministry of the Environment also possess important competencies in VL. The Veneto Region and the Province of Venice are

responsible for the development of the Regional Land Plan. This plan defines general guidelines for development for the Region. The Region and the Province are also responsible for water pollution control, and wastewater standards in the catchment basin. The Municipality of Venice (which includes the urban areas of Venice, Mestre and Marghera) and the Municipality of Chioggia, located at the south end of the lagoon, Fig. 1, have competence for the socio-economic development and the maintenance of buildings and local infrastructure in their areas.

National legislation has been central to governmental actions regarding the VL and provides institutional mechanisms to coordinate actions, as well as direct national funding for these efforts. A series of Special Laws adopted over the past 30 years have played central roles in management of the VL.

The First Special Law for the Protection of Venice (Law no. 171, 16 April 1973, “Interventions for the Safeguarding of Venice”) declared that the area represented important national interests due to its environmental, scenic, historical, archaeological, artistic, and socio-economic features. The Law created an inter-institutional committee (“*Comitato*”) composed of the Minister of Public Works (chair), Minister of Education, Minister of the Economy, Minister of the Merchant Marine, Minister of Health, Minister of Agriculture and Forestry, President of the Veneto Regional Commission, President of Venice Provincial Administration, the Mayors of Venice and Chioggia, as well as representatives of two additional municipalities. [Art. 2] The Special Law established the exceptionally broad authorities of the State (National government) in VL: regulation of water levels in the lagoon and defence against high waters (“*Acque Alte*”), lagoon boundaries, port infrastructure, littoral defence, restoration of state-owned historic buildings, canal and bridge systems, restoration of publicly-owned art, and management of natural and artificial waterbodies that could be important in saving Venice. [Art. 7]

Law no. 171 also directed the Veneto Region to develop and approve a regional comprehensive plan together with the participation of interested municipalities. [Art. 2] The regional plan would regulate development, establish environmental quality limits, delimit protected sites, open fish farms to facilitate tidal flow, and develop port infrastructure. Moreover, the Veneto Region and the Venice Water Authority were mandated to protect the territory from pollution. [Art. 9]

The first special law also instituted a Commission for Safeguarding Venice (CSV) that would have broad representation including: the President of the Region (presiding chair), representatives of national ministries (Public Works, Merchant Marine, Agriculture and Forestry), president of the Venice Water Authority, as well as numerous regional, provincial, and municipal officials. The membership of the commission was established at 20 persons. The mission of the CSV focused largely on interventions related to buildings and monuments, as well as land use modifications resulting from public or private works. The legislation established limits to the authority of the CSV. For example, if the commission voted against the President of the MAV concerning lagoon hydraulics, the decision-making authority would pass to the President of the Region and then to the Superior Council of Public Works that makes the final decision [Art. 5].

Law no. 798 (29 November 1984, “New Interventions for the Protection of Venice”) is much more specific about national funding for actions undertaken by all levels of government related to the protection of Venice. The legislation specified the precise distribution of the national funds among the different governmental levels (State, Region, Municipalities, Port Authority), as well as their destination for specific projects.

Funds were to be dedicated to National ministries for studies, projects, and infrastructure to return the hydrological equilibrium of the lagoon; address the degradation of the watershed; protect against flooding of urban areas – including construction of moveable

doors at the lagoon entrances (experimental, reversible, gradual); implement anti-pollution efforts; build coastal defence structures; maintain lagoon boundaries; protect historical buildings; and develop studies to reroute petroleum shipments in the lagoon and open fish farms to tidal flows. Law no. 798 authorized the Ministry of Public Works to grant contracts for these works and studies to a sole concessionaire [Art. 3]. The Ministry of Public Works and the Venice Water Authority granted this concession to *Consorzio Venezia Nuova* (CVN). The CVN began operation in 1987. In order to finalise the planned interventions MAV and CVN have signed 8 covenants, for a total budget 800 million euros. By the end of 1995 CVN had completed the activities corresponding to a value of 500 million euros with the cooperation of internationally-known partners and experts in coastal engineering.

This law also modified the membership of the *Comitato* whose presiding chair subsequently became the President of the Council of Ministers. Revised membership included the Minister of Cultural and Environmental Patrimony, the Minister of the Merchant Marine, Minister of Ecology, Minister of Scientific Research, the President of the Veneto Regional Council, the mayors of Venice and Chioggia, as well as representatives of two additional municipalities. The Secretary of the *Comitato* is the President of the Venice Water Authority. Article 4 clearly establishes that the *Comitato's* responsibilities include direction, coordination, and control of the execution of interventions programmed and funded by this legislation. [Art. 4]

Regional competence and funding extends to wastewater treatment and water supplies [Art. 5], while municipal authority covers restoration and maintenance of buildings and infrastructure, such as canals, bridges, and canal sediments [Art. 6].

Similarly, Law no. 139 (5 February 1992, “Interventions for the Protection of Venice and its Lagoon”) distributed funds and responsibilities among the different levels of government. This most recent special law further defined the responsibilities of the Region

(pollution prevention, cleanup in the watershed immediately adjacent to VL, establishment of environmental standards) [Art. 4] and the Venice Municipality (cooperation with the Region regarding wastewater treatment in the historical centre of Venice, maintenance of seawalls along the canals) [Art. 5].

Watershed management linked to VL management

Other attempts at environmental coordination occur between the Region, Province, and Municipalities. The Regional Law no. 32 (18 October 1996) created the Regional Agency for Environmental Prevention and Protection (“*Agenzia Regionale per la Prevenzione e Protezione Ambientale del Veneto*” – ARPAV). ARPAV is responsible for research, monitoring, and environmental outreach and supports the environmental initiatives of all three levels of government. The Regional Legislature adopts appropriate environmental legislation and drafts a Comprehensive Regional Master Plan (“*Piano Territoriale Regionale di Coordinamento*”). The Provinces conform to the Regional Plan and carry out enforcement and regulatory permitting activities. The Municipalities provide environmental services, maintain local infrastructure, and also grant permits. Inter-governmental consistency is the key, although political differences between the Municipality and the Regione and the top-heavy bureaucratic structure often frustrate smooth and coordinated planning and action.

This structure facilitates coordination within the Region. However, Venice Lagoon and its catchment basin face another obstacle to coordination action. Regional-Provincial-Municipal planning and environmental management must confront the elevated National (State) interest and intervention in VL, as evidenced by the Special Laws. As a result, the intervention of and management by the National (State) ministries of the VL in isolation thwart effective regional planning efforts. This situation calls for an ecosystem-based

management strategy and an inter-governmental coordination mechanisms for VL, its catchment basin, and nearshore waters of the Adriatic.

The National Law no. 183 (1989) instituted the Watershed Authorities of rivers, lagoons, and coastal areas. The Northern Adriatic Watershed Authority is composed of five watershed authorities specified in Law no. 183. However, no Watershed Authority exists for VL. The VL and its watershed are not linked by means of a comprehensive plan. That is probably due to the absolute control that the MAV exerts over planning, funding, and regulation of VL. Moreover, the Watershed Authorities have a role where rivers pass through two regions. However, the VL watershed exists entirely in the Veneto Region.

The “*Piano Direttore*” 2000 (DCR 01.03.2000, n. 24) is the most recent planning instrument developed by the Veneto Region for pollution prevention and for improvement of the water quality of the catchment basin flowing into the VL. This document established: (1) the cleanup objectives; (2) the guidelines and the strategies related to the operation of civil, urban, industrial, and agricultural sectors; (3) the reduction of gaseous emissions, the waste management and remediation plan for contaminated sites. The Veneto Region developed the guidelines for an initial Comprehensive Plan several years after the 1974 First Special Law, but a detailed environmental plan never emerged from this exercise.

ICM IN VENICE: A REVIEW

ICM Principles

ICM is a dynamic process in which the public authorities and the private sector develop and implement a coordinated strategy for allocation of environmental, socio-cultural, and institutional resources to achieve conservation and sustainable development of the coastal zone and its resources.

Management of coastal areas involves multiple problems, conflicts resulting from incompatible uses of coastal resources, differential productive capacities over space and time within any coastal area, linkages to the catchment basin, and multiple institutions with varying responsibilities for aspects of management. (Bower et al., 1994). Coastal areas require specific management approaches involving a system of relationships among actors that operate directly or indirectly in the coastal zones: 1) people who live, use, or are concerned through their beliefs or behaviours about the coastal environment; 2) policy makers and managers whose decisions and actions affect the behaviour of coastal people, and 3) members of the scientific community – both natural scientists who study the coastal environment and social scientists who analyse human behaviour in coastal zones (Orbach, 1995) (Fig. 2).

ICM has emerged as the most appropriate process for dealing with current and long term coastal problems (EC, 1999b; IPCC, 1996; WCC, 1993) allowing integration across geographic boundaries, economic sectors, academic disciplines, as well as administrative and institutional boundaries.

Integration has numerous meanings and is applied to many contexts in ICM. Inter-Sectoral Integration (Horizontal) involves the increasing coordination or harmonization of policies, development plans, investment, and management arrangements among different sectors, services, and agencies. Inter-Governmental Integration (Vertical) implies coordination of policies and plans from national to local levels of government.

The 1990s have seen rapid growth of interest and experimentation in ICM due to the recommendations from the 1992 Rio Earth Summit and particularly Agenda 21. Chapter 17 of Agenda 21 remains one of the most important reference texts for coastal environments. Since that date, a large number of strategies and plans have been prepared, reviewed and revised at various spatial scales, dealing with diverse management issues. Nevertheless, the number of examples in which ICM mechanisms have been successfully established in

institutional structures remains limited. Most initiatives focus on preparatory activities and pilot studies, rather than on concrete implementation phases and monitoring. Difficulties often develop when attempting to transform ICM objectives into effective actions.

Could ICM Improve Management of VL?

Sorensen & McCreary (1990) and Cicin-Sain & Knecht (1998) highlighted the interconnection of important coastal-dependent economic sectors as the central motivation for integrated coastal management. Coordination of planning, regulation, and research of fisheries, tourism, coastal hazards, and other sectors is essential because these activities all share the same coastal area, as well as the same environmental and public service systems. The potential benefits of ICM for VL are numerous. During the last 25 years important interventions to protect the environment of the lagoon and the urban centres have been undertaken. Bettinetti et al., (1996) highlighted some major environmental problems and the responses of the CVN to reverse this environmental deterioration. They also suggested that an integrated management approach was adopted taking into account the aspects of the environmental problems and their relationships with the economic activities in the estuary and its catchment basin. They reported that the restoration process of the lagoon could be implemented only through the realisation of an integrated set of measures over different time scales. Long-term measures included the reduction of pollution inputs from the drainage basin; medium term measures focussed on modification of the lagoonal and wetland morphologies and water circulation. Harvesting of macroalgae was proposed as an emergency short-term action.

ICM procedures represent a methodological background upon which a concrete proposal for the Venetian area could be designed. Such a methodological framework may support new planning and management strategies designed for the sustainable development of the VL system. The multiplicity of activities occurring in this area results in intense

competition and conflicts over appropriate patterns of use. The historical and present examples of success and failure in dealing with these issues have characterised attempts of the Venetian institutions to manage multi-sectoral uses of local resources (i.e. exploitation of historic urban areas for tourism, fish farming, industrial development, etc.).

ICM also calls for an ecosystem-based approach to environmental management. Although current management of VL is clearly an important step in this direction, the geographical scope should be expanded to include the catchment basin, as well as nearshore areas of the northern Adriatic Sea. These three geographical zones are inherently linked through hydrology, ecology, economy, and culture. Therefore, their management must also be coordinated and internally coherent. The COP-8 to the Ramsar Convention on Wetlands (2002) clearly highlighted this concept as one of its principles for incorporation of wetland uses into ICM. Principle 8 notes that ICM should also link the catchment basin, adjacent ocean, and fishery management to ensure conservation and sustainable use of coastal resources. This requires the development of an institutional coordination mechanism that facilitates cooperative environmental management and preparation of an Integrated Management Plan for the entire ecosystem.

ICM also calls for integration between governmental authorities and the general public. Brochier & Giupponi (2001b) analysed an emblematic case of the conflicts that can occur in the VL, and public reaction to administrative decisions. The case resulted in significant public opposition, which eventually caused authorities to abandon and redesign the projects. They highlighted the lack of a participatory process or an approach integrating an assessment of public opinion, as well as the absence of a holistic approach that assesses issues with a broader vision by allowing the definition of alternatives. ICM could offer positive contributions to: 1) an integrated vision of both planning and management problems, and 2) a

cross-sectoral participatory approach for the resolution of local issues (at various scales) and problems in VL coastal area.

Public participation strategies should be an essential element of a broader approach integrating economic, social, and institutional characteristics. Social inclusion should be a fundamental element of policy paths leading toward sustainable development for the Venice system. Nevertheless, the city lacks a tradition of public participation. Sors (2001) suggested that the past experience, despite some progress in encouraging public involvement, has not produced particular success in this area. Brochier & Giupponi (2001a) attributed this to the endless debate on Venice's future and the complex decisional and institutional context. Due to the high number of actors involved, the identification of appropriate approaches for managing participation and cooperation in the Venice area is a complex task.

Some factors delay cooperation and should be considered in future research on participatory planning in Venice:

- the rigidity of the bureaucratic system;
- the fragmentation of institutional arrangements, including gaps and overlaps in responsibilities within and between administrative levels; and
- the lack of implementation and enforcement of key aspects of planning and environmental legislation.

In a socio-economic and cultural environment like the Venice, participatory management should necessarily be seen as a long-term process that should start with limited pilot cases. Benefits from these initiatives could be particularly relevant by:

- Strengthening the capacity and institutional framework for addressing Venetian problems;
- Improving information flows through better communication;
- Modifying the way institutions think;

- Developing the public's willingness to participate;
- Building credibility and encouraging the public and stakeholders to trust local government.

If successful, participatory management could catalyse processes, such as raising public awareness of environmental degradation and integration of various administrations, searching for an accurate balance between top-down and bottom-up strategies in such a way that adequately considers international, national and local interests.

Scientific Integration

Coordination of scientific efforts (planning of research agendas, research themes, methodologies, funding and dissemination of results) is another important facet of ICM. The VL case displays a great amount of scientific integration with some significant gaps. Possession of scientific information and interpretation of results regarding VL have often been politicized and created serious disputes within the scientific community.

The Venice Water Authority and its concessionaire, CVN, have dominated recent research efforts in the VL. CVN's research agenda is directly linked to its interventions in the VL ecosystem and may be categorized into three broad areas research themes: civil engineering studies, environmental system studies, and socio-economic studies. The CVN directly carries out or contracts research related to engineering structures (mobile flood barriers to regulate tidal flow), vessel traffic studies, ecological restoration, beach and shoreline renourishment and stabilization, water quality and circulation patterns, sediment composition and pollution, flooding models and tidal levels, and land use of the VL catchment basin. For example, 1.5% of the MOSE budget is spent for scientific research (MOSE, Electromechanical Experimental Module, the € 2.3 billion scheme will incorporate 78 hollow metal gates, each about 20 m high and 5 m thick, placed at the three main inlets of

the lagoon. Each gate will lie flat on the sea floor under normal circumstances, with one end fixed to its foundations. In advance of particularly strong surges exceeding 110 cm above the current average sea level, air will be pumped into the hollow gates, displacing the water inside them and causing the unfixed end to rise. The project has numerous problems. Principally, it was designed to respond to an event similar to the 1966 flood, but such an uncommon disaster is likely to occur no more than once every 165 years. This makes MOSE a misdirected solution, as it will do nothing to combat the frequent minor floods that plague the city).

Despite its competence in environmental issues at the national level, the Ministry of the Environment has played a relatively limited role in research concerning VL. It is not actively involved in VL monitoring programmes but has funded some projects that synthesize data. The Ministry is the formal supervisor of the Porto Marghera environmental cleanup project, but lacks a physical presence in Venice.

The National Research Council (CNR), the research arm of the Ministry of Teaching, Universities, and Research operates several institutes located in the City of Venice, as well as in the Veneto Region (Padua): Institute of Marine Biology, Institute for the Study of the Dynamics of Large Masses, Centre for the Study of Environmental Chemistry and Technology [also the institutes in Padua, Bologna, Trieste]. Despite its name, the CNR does not exercise a research coordination function. However, one of its primary tasks is the environmental monitoring of VL. (See Guerzoni & Raccanelli, 2004)

A recent initiative to integrate scientific activities and research in the VL began in 1997 with the formation of CORILA (Consortium for the Coordination of Research Activities Concerning the VL System). An Inter-Ministerial Committee requested that the scientific community be more integrated and provided an initial 3 million euros for these efforts. CORILA is a non-profit organization overseen by the Ministry of Teaching, Universities, and Research and unites the efforts of its partners: the Cà Foscari University,

the University Institute of Architecture of Venice, the University of Padua, and the CNR. Its Board of Directors is composed of representatives of the four partners, the Ministry of Research, and the President of the Venice Water Authority. CORILA's mission is to promote and coordinate research on VL. The consortium's efforts focus on four primary themes:

- 1) economic and social aspects (analysis of socio-economic impacts of reconversion of the Porto Marghera industrial area, cost-benefit analysis of environmental conservation and restoration efforts in VL),
- 2) architecture (building restoration materials),
- 3) environmental processes (morphodynamics, chemical pollution and biotoxicity, resilience of the natural system, climate change issues), and
- 4) data management and dissemination.

Institutional cooperation makes good sense in times of scarce resource availability. However, institutional behaviour in the Venice case still leads to competition for research allocation budgets from the National Government, as well as a tendency to act in a proprietary nature with respect to data and information. Coordination of research activities has increased, but significant gaps remain.

Public-Private Integration

In February 2000, numerous governmental and industries adopted The Agreement on the Chemical Programme of Porto Marghera ("*Accordo di Programma sulla Chimica a Porto Marghera*") as a basis for action. Official signatories included the Ministry of Industry, the Ministry of the Environment, the Ministry of Public Works, the Veneto Region, the Province of Venice, the Municipality of Venice, and the Venice Port Authority. The industrial sector was represented by the Industrial Union of Venice, the Federchemistry, trade unions, chemical firms (EniChem S.p.A., the European Vinyls Corporation (EVC)), the Edison

Thermoelectricity, petroleum companies (Elf Atochem, Crion, Sapio, Agip Petroli, Esso Italiana, Api), the Ausimont, the Montefibre, the San Marco Oil, the Decal, the Agip Gas, the Ambiente S.p.A., the corporation of Siding Railway, and the Industrial Zone Corporation of Porto Marghera.

The objective of the agreement was to establish and maintain a optimal balance at Porto Marghera between environmental protection, development, and productive transformation in the chemical sector, assuming that an industrialised and modern State must accept the development of chemical sector via eco-sustainable scenarios. The accord recognized that the chemical sector in Porto Marghera represents one of the basic sectors of Italian industry. The objective is for Porto Marghera to be a pilot case “ecologically equipped area”, as defined by Law no. 112, 31 March 1998, Art. 26.

The agreement established some midterm objectives to reach the overall goal:

- * to improve and protect the environment through cleanup actions, reduction of atmospheric emissions and discharges into the VL, and prevention of risks due to industrial accidents;

- * to promote investment to provide industrial facilities with the best available technologies and increase their competitiveness at the European level. These actions would provide for job security and retraining in use of Clean Technologies.

Coordinated implementation of the various measures within the programme agreement will improve operational efficiency, optimise implementation times, reduce costs, and mitigate the inconvenience to citizens. The agreement calls for specific interventions and actions, such as:

- 1) Measures to redevelop and protect the environment

- a) Excavation of channels

- b) Dismantling of old industrial plants with subsequent demarcation of

- safety and reclamation zones
 - c) Establishment of discharge standards for VL
 - d) Guidelines for a safety plan in the dock areas
 - e) Reduction of risks in the movement of goods
 - f) Continuous tracking of transportation of dangerous goods
 - g) Voluntary agreements to obtain environmental certification for chemical industries
 - h) Integrated system for environmental monitoring and the management of industrial risk and emergencies.
 - i) Ecologically-oriented management of infrastructures and services
- 2) Investments to save jobs
- a) Investments
 - b) Employment protection

A significant part of the investments are related to the environment or to the industrial safety. Table 3 summarizes the capital investment by the various industrial enterprises of approximately € 800 million.

This agreement is significant because it represents a shift from “command and control” environmental management strategies to a more voluntary approach by the industrial sector with a high degree of self-financing and oversight responsibility. The accord also symbolizes a new era of public-private partnership for environmental cleanup and protection of a seriously degraded portion of VL. A Citizens’ Advisory Group or Citizens’ Oversight Group would even increase the participatory aspects of the agreement. This partnership concept might also have significant applicability to the wider management of VL and its watershed.

Toward Vertical and Horizontal Coordination

Inter-governmental relations must consider four levels (Nation, Region, Province, Municipality) and EU directives, as well, creating a challenging situation. A complex governance arrangement exists among different authorities with different environmental roles. Competence over various activities in VL is divided among institutions in a manner that is highly fragmented, presenting obstacles to effective coordination and cooperation among different levels of government and sectoral institutions. VL proper lacks an institutional arrangement that promotes broad institutional coordination and ecosystem-based management. Examples of partial institutional coordination among do exist. However, these are focussed on particular problems and do not adopt a holistic approach.

The *Comitato* created by Special Law 798 [Ministry of Public Works, Ministry of Culture, Ministry of Merchant Marine, Ministry of the Environment, Ministry of Scientific Research, Veneto Region, Chioggia and Venice Municipalities] focusses on flood protection, restoration of hydrological equilibrium, reversal of environmental deterioration. This coordination body is often cited as a positive example of vertical and horizontal integration in VL, and indeed it does represent all levels of government and responsible agencies. Nevertheless, the geographical scope of the *Comitato* is VL proper – rather than the catchment basin. Moreover, its focus centres on flood protection and hydrology. Environmental issues, such as wetland creation, are viewed in the context of restoration of the “natural” lagoonal hydrology. Many environmental issues (fishery management, conservation and protected areas, water quality control, oil spill contingency planning, industrial remediation, planning and management of tourism) simply do not fall under the purview of this coordination body. While the *Comitato* clearly should have a planning role, it appears to have often delegated this responsibility to the high-tech concessionaire – CVN – and, instead, concern itself with the task of how allocated State funds are divided.

The CSV created by the Special Law 171 also boasts broad governmental membership. However, its responsibilities centre on one narrow issue – the preservation of buildings and infrastructure and coordination for their maintenance. The CSV is essentially involved with analysis of permit applications rather than broad planning.

Although their emphasis focuses on National authorities and interventions, the Special Laws mandate intergovernmental coordination on several other levels. For example, Law no. 171 required that the Veneto Region develop a Comprehensive Plan with the participation of the applicable municipalities (Art. 2). Art. 3 lays out the goals of the Comprehensive Plan, while Article 4 requires that the Municipalities approve the Regional Comprehensive Plan and that their actions be consistent with the regional plan.

While these are extremely important coordination initiatives, they have focussed on flood protection, rather than the ecosystem-based management of VL. A broader ecosystem-based strategy must also include other sectors, such as fishing, aquaculture, agriculture, conservation and protected areas, industrial activities, and tourism. As well, its must coordinate management in the linked subcomponents of the broader ecosystem: VL, its catchment basin, and the nearshore waters of the Adriatic.

DISCUSSION

ICM does suggest a new model for governance of VL, clearly a resource of great social, economic, cultural, and ecological importance. The development of an institutional coordination mechanism that facilitates cooperative environmental management is essential. One possibility would be the formation of a “Venice Coastal Committee” (VCC). Members of the Committee would include representatives of the broad spectrum of sectoral institutions concerned with flood protection, water quality, shipping, industrial activities, conservation, fisheries, agriculture, and tourism. All levels of government (National, Regional, Provincial,

and Municipal) would also enjoy representation on the Committee. Representatives of key economic sectors and citizen NGOs would represent the public interest and private sectors. The geographic scope of the VCC would include the VL proper, its catchment basin, and nearshore waters, perhaps to the boundary of the Territorial Sea.

The Committee would have the following responsibilities:

1. development of a shared desired vision for the future of this broad ecosystem for, perhaps, the Year 2020.
2. analysis of the current socioeconomic and ecological problems of the broad ecosystem from a holistic perspective
3. determination of priorities for the area
4. development of strategies and interventions to address the key issues. In effect, the VCC would spearhead the preparation of an Integrated Coastal Area and Catchment Basin Management Plan. The management plan would clearly delineate responsibilities among the authorities and public; establish timelines; recommend quantifiable ecological, socioeconomic, and governance indicators; describe a social and ecological monitoring programme; and specify funding sources and requirements.
5. serve as a focal point for communal coordination and cooperation of the various existing authorities.
6. stimulate the formation of public-private partnerships for various recommended strategies and interventions and transmit concerns of the public (economic groups, NGO citizen groups, and independent scientists) to the authorities.

Sustainability

The general ICM model is designed to bring all coastal sectors, levels of government and coastal users into a rational target-setting and decision-making framework. This methodological approach has potential to support new planning and management strategies designed for the sustainable development of the VL. Indeed, a broader more holistic consideration of environmental sustainability for VL will only be possible with a new governance structure that coordinates all important sectors and levels of government in the broadly defined ecosystem. Several manuscripts on sustainable development of the VL system have emerged as part of the “*Progetto Venezia 21*”, a contribution to the local Agenda 21 experience (Musu et al., 1998; Ramieri, 1999; Sors, 2001).

VL is a unique environmental, social and economic characteristics, in terms of its physical features, rich cultural and historic heritage, and local traditions. These factors are important during consideration of proposals for sustainable development. The selection of a set of local sustainability indicators for Venice and VL is a particularly difficult task because of the atypical conditions of the city, making the definition of sustainability exceptionally challenging.

Sors (2001) considers an approach to sustainable development for the VL. He also suggests the use of *ecological footprint*, which is a measure of a society’s consumption of natural resources. It indicates the amount of productive land and water a society occupies to produce all the resources it consumes and to assimilate all the waste it generates (Wackernagel & Rees, 1996). A negative deficit signifies that the space available within a country is insufficient to support its population and, therefore, the situation is domestically not sustainable, because the population must rely on external resources. Instead of quantifying progress, the ecological footprint concept measures “environmental equity” because it assumes that all societies should be entitled to an equivalent environmental space.

In addition, it highlights the interactions between the local and global scales, and in so doing, encourages users to think about the impact of their every day actions on a larger scale.

The University of Siena calculated the Ecological Footprint (EF) for Venice Province (an approximation of VL) (Provincia di Venezia, 2004). The resulting value of the footprint was 4.68 ha eq/person (equivalent hectare/person). A very important part of the sustainability analysis of the VL through the EF (Wackernagel & Rees, 1996) is approximated by the bio-capacity (bio-productive space for each person presented in the analysed area). The estimate of the biocapacity for each person was 1.45 ha, also considering the lagoon surface. For the first time, the traditional calculation of the EF has been modified due to the peculiarity of this province. Indeed the Lagoon ecosystem, due to his high bioproductivity (contribution to the biocapacity is over 60%), is of primary importance for the survival of the province. The EF value of 4.68 ha is very high compared to the world average value (2.28 ha eq/person). Therefore, the deficit of 3.23 ha (EF minus bio-capacity) suggests that the space available is insufficient to support the population and, therefore, the situation is unsustainable. The same group also calculated the EF of the tourism activity and suggested that the flow of tourists increases the ecological deficit of the Province of Venice to more than 12%. To decrease the ecological footprint, some approaches must be adopted: reduction in consumption rates; restriction on private transportation; reduction in urban wastes; a shift toward eco-tourism or other less-consumptive models for tourism; population reduction; or restrictions on the number of tourists.

In order to consider these new holistic alternatives for the future of VL and the people who inhabit the coastal space, it is essential to create new institutional arrangements that join all appropriate governmental authorities at all levels of government. This approach also requires that the public and private sectors join together in partnerships to consider alternative scenarios and responses. The efforts of all users and stakeholders of VL and

adjacent ecosystems must adopt an ecosystem approach that considers VL plus its catchment basin and adjacent nearshore waters.

Fig. 3 summarises a possible scheme with changes from an unsustainable approach to a more sustainable one, where not only biological diversity, but also social diversity, are considered. This scheme highlights the need to avoid possible scenarios where Venice would become a type of Disneyland, exploited only by daily tourists and would lack other cultural and economic activities. An immense amount of research, legislation, and funding have focussed on the conservation and management of the city and VL over the centuries, specifically during the past few decades, as the dangers to the survival of this unique site have become more apparent. Numerous institutions at various levels of government, as well as universities, research centres, and NGOs, have dedicated efforts to study and manage parts of this unique resource. However, often their efforts are focussed on only part of the resource, rather than the whole. As a result, the sum of the efforts has not produced the expected results. Greater cooperation and synergy might offer opportunities for improvement.

Concluding remarks

Finally some points are essential to meet the previous described outcomes:

* The flood protection efforts in VL represent significant investments of resources and efforts, offer important environmental benefits, and coordinate the efforts of many institutions. The focus of the interventions is flood control, however, rather than the broader range of coastal management issues in VL. Coordinated environmental management requires a consideration of a broader suite of issues (conservation, fisheries, industrial activities, shipping, tourism, agriculture, urban development).

* The geographical space that is managed as a unit must be expanded to include the VL proper, the Catchment Basin, and nearshore waters of the Adriatic. This will be challenging because it will require a change in the existing coordination mechanisms that offer fragmented management of this space.

* Integrated lagoon and catchment basin management must directly include resource users. Integration of users and consensus-based decisions will guarantee the ultimate success of management measures. Integration of users will facilitate cooperative agreements between the government and users and non-regulatory methods of environmental management (i.e. *Accordo di Programma sulla Chimica a Porto Marghera*/Agreement on the Chemical Programme of Porto Marghera). Public participation must be the an integral part of all governance activities and decisions.

* Coordination between management of the VL, the watershed/catchment basin, the littoral zone, as well as nearshore waters must be improved. These three areas must be managed as a single ecological unit.

* The private sector, organized societal groups, and non-governmental organisations should play a greater role in management of their coastal resources. A Citizens' Advisory Committee with wide representation could offer great benefits – not only for Porto Marghera cleanup, but also for VL management, in general.

* Interdisciplinary research must be effectively coordinated to take full advantage of knowledge of the natural and social systems. This information must have clear feedback into environmental planning and management. Perhaps a Scientific Advisory Committee, formed as a subcommittee to the VCC, could help integrate scientific information into the management process.

Venice Lagoon offers rich cultural, economic, and ecological patrimony for Italy and the world. Environmental challenges have led to a complex suite of institutional responses. While positive, current efforts require a revised more holistic approach that will lead to greater sustainability for the region.

Acknowledgments

This is IGM-CNR scientific contribution No.Ms Gabriel Walton revised the English text.

References

- Bettinetti, A., P. Pypaert & J.-P. Sweerts, 1996. Application of an integrated management approach to the restoration project of the Lagoon of Venice. *Journal of Environmental Management*, 46: 207-227.
- Bettiol, C, F. Collavini, S. Guerzoni, E. Molinaroli, P. Rossini, L. Zaggia & R. Zonta (this issue). Relative contribution of atmospheric and riverine inputs of metals, nutrients and POPs into the Lagoon of Venice.
- Bower, B., C. H. Ehler & D. Basta, 1994. A Framework for Planning for Integrated Coastal Zone Management. NOAA/NOS Office of Ocean Resources Conservation and Assessment, Silver Spring, Maryland.
- Brochier, F. & C. Giupponi, 2001a. Integrated coastal zone management in the Venice area: Potentials of the integrated participatory management approach. Note di lavoro Series, n. 99.2001, 1-14.
- Brochier, F. & C. Giupponi, 2001b. Integrated coastal zone management in the Venice area: A methodological framework. Note di lavoro Series, n. 100.2001, 1-17.

- Burigana, E., C. Giupponi & G. Bendoricchio, 2003. Nitrogen surplus as indicator of agricultural pollution impact in the Venice Lagoon watershed. Diffuse Pollution Conference, Dublin, 6-171-6-176.
- Cicin-Sain, B. & R.W. Knecht, 1998: Integrated Coastal and Ocean Management: Concepts and Practices. Island Press, Washington.
- EC, 1999a. EC Demonstration Programme on ICZM - Report of thematic study D, planning and management processes: sectoral and territorial cooperation, European Commission, University of Newcastle.
- EC, 1999b. Towards a European Integrated Coastal Zone Management (ICZM) Strategy: General Principles and Policy Options. A reflection paper. Directorates-General Environment; Nuclear Safety and Civil Protection; Fisheries; and Regional Policies and Cohesion.
- EC, 2000. An assessment of the socio-economic costs and benefits of Integrated Coastal Zone Management – Final report. Fim Crichton Roberts Ltd. and the Graduate School of Environmental Studies at the University of Strathclyde.
- EUCC, 1999. European code of conduct for coastal zones, CO-DBP(99)11, 3rd meeting, Geneva.
- Favero, V., 1992. Evoluzione morfologica e trasformazioni ambientali dalla conterminazione lagunare al nostro secolo. In: Con terminazione lagunare: storia, ingegneria, politica e diritto nella Laguna di Venezia. Proceedings of the Conference “Convegno di studio bicentenario della con terminazione lagunare”, 14-16 March, 1991, Venezia.
- Guerzoni, S. & S. Raccanelli, 2004. The Sick Lagoon: Dioxin and Other Persistent Organic Pollutants (POPs) in the Lagoon of Venice. Libreria Editrice Cafoscarina, Venice, Italy.
- IPCC, 1996. Climate change 1995, impacts, adaptations and mitigation of climate change: scientific-technical analysis [Watson, R.T., M.C. Zinyowera, and R.H. Moss (eds.)].

- Contribution of Working Group II to the Second Assessment Report of IPCC, Cambridge University Press, Cambridge, UK.
- Musu, I., E. Ramieri & R. Cogo, 1998. Indicatori di sostenibilità: uno strumento per l'Agenda 21 a Venezia, Fondazione ENI Enrico Mattei Publication.
- Neil, D.T., 2002. A thousand years of human-coastal interactions in Venice: lesson from the Serene Republic. *Coast to Coast*, 318-321.
- Orbach, M., 1995. Social scientific contributions to coastal policy making. In: *Improving Interactions between Coastal Science Policy*. Proceedings of the California Symposium 49-59. Washington, D.C. National Academy Press.
- Provincia di Venezia, 2004. Calcolo dell'impronta ecologica e della biocapacità della Provincia di Venezia, 40pp (in Italian).
- Ramieri, E., 1999. Indicators of sustainable development for the city and the Lagoon of Venice, Fondazione ENI Enrico Mattei Publication.
- Ravera, O., 2000. The Lagoon of Venice: the result of both natural factors and human influence. *Journal of Limnology*, 59: 19-30.
- Runca, E., A. Bernstein, L. Postmaand & G. Di Silvio, 1993. Control of macroalgae blooms in the Lagoon of Venice. Proc. MEDCOAST '93 Conference, November 2-5, 1993, Antalya, Turkey.
- Smart, M. & V. Vinals, 2004. The Lagoon of Venice as a Ramsar Site. Provincia di Venezia.
- Sorensen, J. C. & S.T. McCreary, 1990. Institutional arrangements for managing coastal resources and environments. Renewable Resources Information Series, Coastal Management Publication N.1, National Park Service U.S. Department of the Interior and U.S. Agency for International Development.

- Sors, J.C., 2001. Measuring progress towards sustainable development in Venice: a comparative assessment of methods and approaches. Note di lavoro Series, n. 16.2001, 1-29.
- Umgiesser, G., D. Melaku Canu, C. Solidoro & R. Ambrose, 2003. A finite element ecological model: a first application to the Venice Lagoon. *Environmental Modelling & Software* 18: 131–145
- UNESCO, 1995. *La Laguna di Venezia, Cierre* (ed).
- UNESCO, 2004. “The Operational Guidelines for the Implementation of the World Heritage Convention”. Found at <http://whc.unesco.org/pg.cfm?cid=57>.
- Wackernagel M. & W. Rees, 1996. *Our ecological footprint- Reducing human impact on the Earth*, New Society Publisher, Canada.
- WCC, 1993. *Preparing to meet the coastal challenges of the 21st Century*. Conference report, World Coast Conference, November, 1-5, 1993, Noordwijk, The Netherlands. The Hague: Ministry of Transport, Public Works, and Water Management.

FIGURE AND TABLE CAPTIONS

Fig. 1. Map of Venice Lagoon

Fig. 2 Cultural ecology of coastal public policy making (source: Orbach, 1995).

Fig. 3. Scheme of a possible alternative and sustainable scenarios for the different sectors impacting the Venice Lagoon.

Tab 1. Relationship between environmental variables and activities (modified from Smart and Vinals, 2004)

Tab. 2. Impact of activities in rows on activities in columns.

Table 3. Capital investment in Euros.

Tab 1. Relationship between environmental variables and activities (modified from Smart and Vinals, 2004)

Resource affected	Activity causing the impact	Consequences for the wetland
Water	Diversion of river courses out of the Lagoon	Alteration of the biocenoses Erosion of saltmarshes and sandbanks
	Groundwater reclamation	Subsidence Great frequency of unusually high tides
	Dredging of shipping channels	Increase of the speed and volume of surface flows in the Lagoon Erosion of shallow areas and saltmarshes
	Release of urban waste and fertiliser runoff	Eutrophication Micro-biological pollution
	Release of industrial waste waters	Toxicity (bio-accumulation) Destruction of wetland biocenoses Increased turbidity of the water
	Motor boats	Water pollution Increase in the “moto ondo”, and resulting erosion by water
	Aquaculture	Water pollution
Geomorphological Systems	Reclamation of intertidal areas	Destruction of morphological character Loss of natural habitat (woodlands and freshwater wetlands) Disappearance of wildlife Decrease of self-purifying capacity of the ecosystem
	Excavation of channels	Alteration of morphological character and hydrological conditions Increase in erosion of shallow areas
Fauna	Over-fishing and inappropriate practices	Impoverishment of the fish fauna Erosion of the bottom sediments
	Introduction of alien species	Impoverishment of native species and loss of biodiversity
Vegetation	Motor boats	Loss of saltmarsh vegetation
	Introduction of alien species	Impoverishment of native species
Landscape	Reclamation of intertidal areas	Loss of landscape values
	Solid waste and rubbish	Loss of landscape values Increase in health risks

Tab. 2. Impact of activities in rows on activities in columns

	Urban Wastes	Port Activities	Industry (Marghera)	Flood Control (Mose)	Tourism	Agriculture	Fishing in Venice Lagoon	Aquaculture	Hunting	Environmental Conservation	Coastal Defense
Urban Wastes		0	0	-	-	0	0	0	0	0	0
Port Activities	0		+	-	+	0	0	0	0	0	+
Industry (Marghera)	0	+		0	0	0	0	0	0	0	+
Flood Control (Mose)	0	0	0		0	0	0	0	0	0	+
Tourism	-	+	-	+		0	0	0	0	+	+
Agriculture	0	0	0	0	0		0	0	0	0	+
Fishing in Venice Lagoon	-	-	-	-	0	0		0	0	+	0
Aquaculture	0	0	0	0	0	0	0		+	0	+
Hunting	0	0	0	0	0	0	0	+		-	0
Environmental Conservation	-	-	-	-	0	-	-	-	-		+
Coastal Defense	0	0	0	+	0	0	0	-	0	+	

+ Positive
 0 Neutral
 - Negative

Tab. 3. Capital investment in Euros

Enterprise	Total
Enichem	550
EVC	60
Edison Thermoelectricity	120
Agip refinery	25
Ausimont	7
Montefibre	8
Decal	5
Agip Gas	7
Ambiente	10
	~800x10 ⁶



Fig. 1

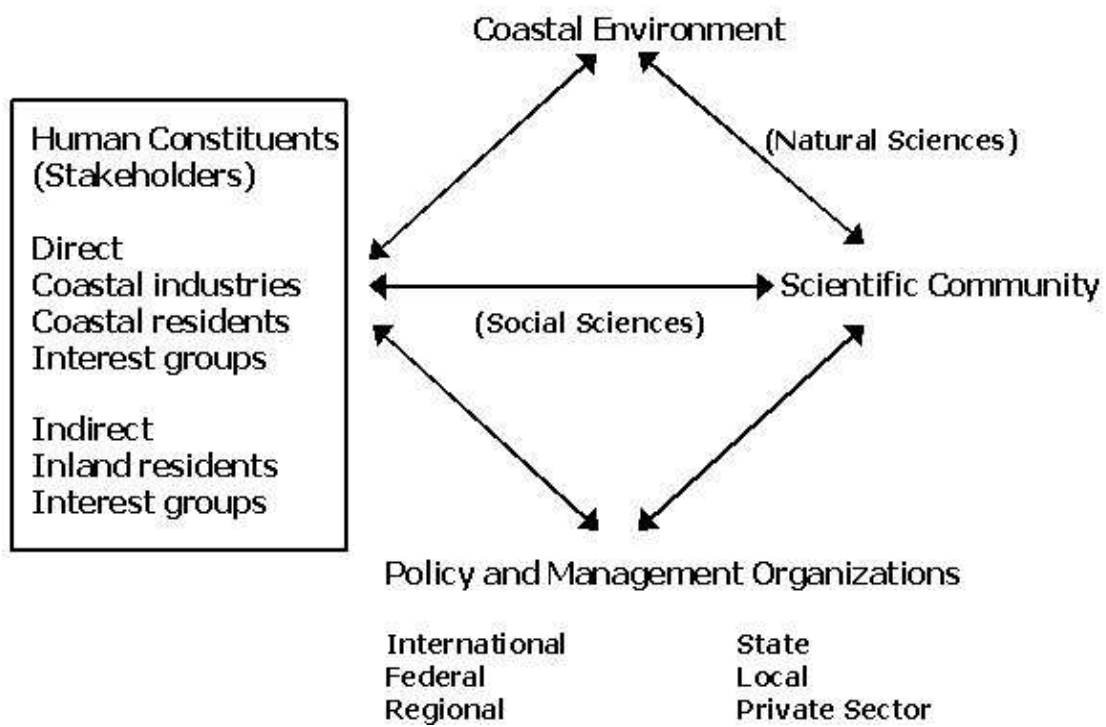


Fig. 2

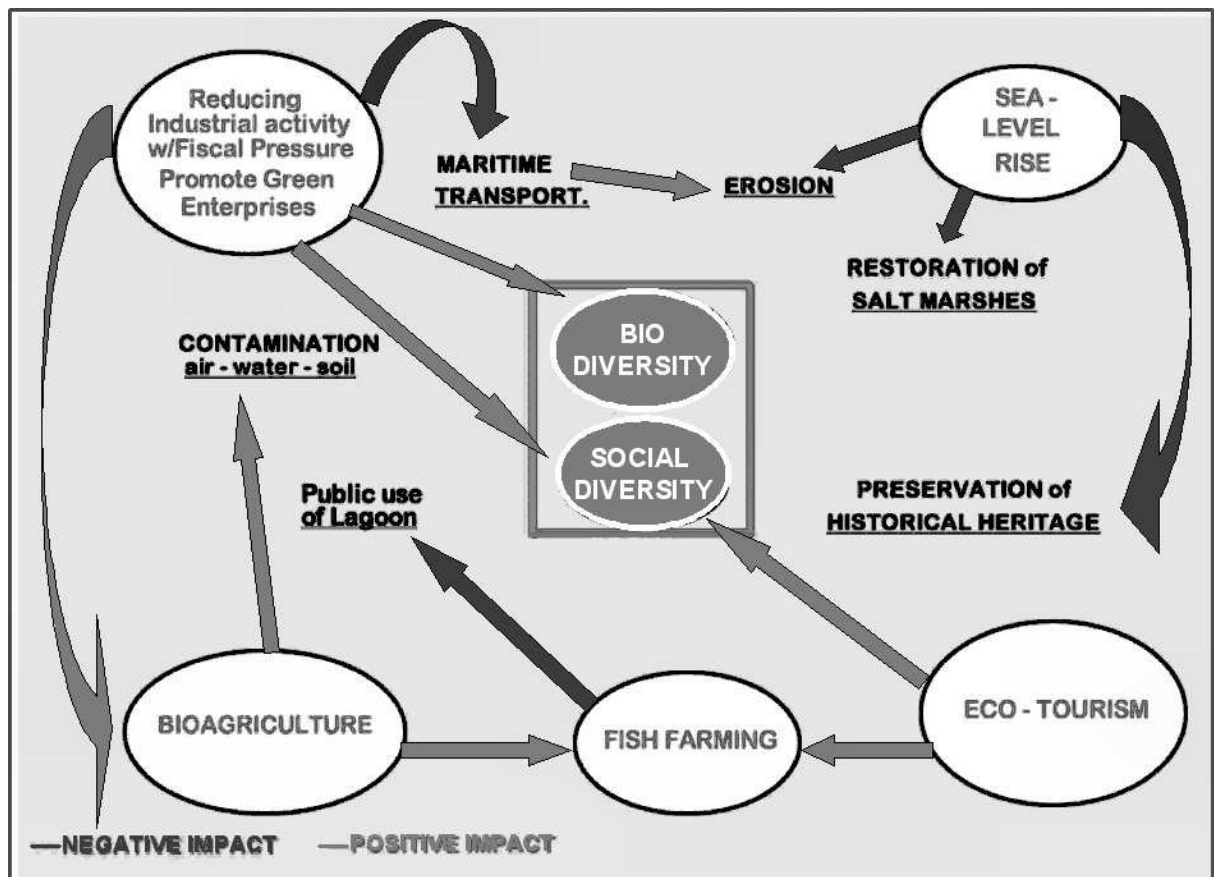


Fig. 3