Sustainability Models for the Venice lagoon fishing sector

Antonio DE PIN*

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Abstract

This research project discusses an applicative example of the evaluation methodologies of local sustainability in the context of the Veneto lagoon system, paying close attention to the activities related to fishing and to the primary sector. A specific system of indicators is used to measure and evaluate sustainability, which also monitors and verifies the suitability of the path being followed. The implemented model, Driving force-State-Response (DSR), includes the environmental, economic, social, and institutional dimensions that influence developmental sustainability. The application of this model to Venice could be a useful tool to start a process of sustainable development based on a more detailed knowledge and sharing of environmental management plans.

Résumé

Ce projet offre un exemple de méthodologies d'évaluation de la durabilité du système lagunaire vénitien et met l'emphase sur les activités liées à la pêche et au secteur primaire. La mesure et l'évaluation des différents aspects de la durabilité sont réalisées à travers un système spécifique d'indicateurs, proposés comme moyen de suivi et de vérification de la cohérence du parcours entrepris. Le modèle employé, Force traînante-Etat-Réponse (DSR), inclut les dimensions environnementale, économique, sociale et institutionnelle qui influencent la durabilité du développement. L'application du modèle à la réalité vénitienne peut représenter un moyen utile pour entamer un processus de développement durable basé sur une connaissance plus approfondie et sur la participation aux programmes de gestion environnementale.

1. Introduction

Despite the diversity of scientific positions, if the concept of sustainability is to become effectively operative, it must identify suitable measurement tools that are generally agreed upon and accepted. In the awareness that there are different relationships between environmental components and a greater subjective responsibility in pursuing objectives of sustainability, any analysis places the importance of the local environment in the foreground. The territory itself therefore becomes the reference point for sustainable development, and taking care of it implies knowledge of the very elements that are an intricate part of its identity.

First and foremost, it is the urban context that is the particular field of study, where the conflicts between the environment, economy, quality of life become manifest in the increased concentration of people, activities, and flows of materials and energy. The measurement and evaluation of the various aspects of sustainability are therefore a preliminary step to decisions regarding any local policies.

In Venice, the problems concerning sustainability can be seen in the special relationship between economic development and the lagoon ecosystem, which has gradually become more and more complex as a result of development that has progressively detached itself from environmental problems.

Any attempt to reassert this balance is expressed in the possibility of creating and implementing an economic activity model that is socially compatible and does not oppose the complexity of the ecosystem.

On the basis of this premise, the identification of specific suitable tools for the identification and exemplification of the diverse problems of development in the lagoon will contribute to the analysis of sustainability in the local area. The objective of the study is to research and apply new methodology to evaluate the sustainability and development of the Veneto lagoon system, with particular reference to the fishing sector and the activities related to fishery.

The indicators developed are also proposed as instruments to monitor and evaluate the suitability of the path being followed in the study of the adequacy of the objectives pursued and the degree of convergence achieved, while underlining the importance of sectorial indices in the preparation of reference models of sustainability from a methodological profile, based on a systematic approach in function of a developmental outlook that is shared by the local participants.

In view of the complexity of the interactions in the fishing sector, and more generally, the major one with the other components of the lagoon system, the results proposed may become the object of further specification and study, as the convergence of the theoretical premises, if sufficient, gradually makes room for a more operative approach.

Due to the dimension and characteristics of the local situation, having undertaken a construction process of relatively specific study, tools that can be analysed immediately may play an important role in the elaboration of territorial policies, should different developmental hypotheses of the complex environmental, social and economic situation of Venice be compared.

* Professor of Agricultural Economics and Politics, University of Venice, Italy.

2. Indicators as an evaluation tool for local sustainability

The importance of the use of indicators for the evaluation of the progress of a social, economic and environmental context towards sustainability is widely recognised[1].

Since the evaluation of sustainability concerns all the aspects of the territorial field, the implicit burden of their control justifies the use of specific simplifying indicators[2]. The indicator usually identifies a tool that is able to provide concise information on a more complex phenomenon and with a broader meaning, and make a trend or phenomenon visible that is not immediately perceivable, going beyond what it is actually measuring[3]. Thus, the indicators both quantify and simplify information, favouring communication and comparison. Defined as a measure that can be represented either numerically or graphically, they contribute to the evaluation of the level of sustainability that has been achieved. To be effective, they must interlink the diverse environmental, economic and social aspects of a community. Indeed, apart from identifying the current conditions of a system, as a result of monitoring, used in a local field they can also represent an important planning tool, that is functional to the preparation of the city's environmental and territorial policies[4]. Agenda 21 Locale identifies the indicators that act as a support, as well as in the evaluation of environmental impact, for the construction processes of territorial planning and which, as a measure of control, can be used to verify the results obtained in comparison to the strategic objectives, thus offering a comparison between the overall transformations, alterations, resource flows and consumption that are either being carried out or planned, and the speed with which they are regenerated[5].

An important aspect is inherent to the participative dimension starting from the stage of indicator selection - the involvement of stakeholders strengthens the decisional result in function of a greater convergence of the objectives[6]. The opportunity to let the individual communities choose their indicators independently, together with the agreement as regards their utility becomes a prerogative of the decisional processes, entailing the responsibility of the diverse territorial actors[7]. Since they are a tool but not the goal for local environmental policies, they must be selected in such a way that they describe the field in question completely[8].

During the selection process, the evaluating aspect influences numerosity and it is therefore appropriate to identify a precise hierarchy amongst them[9].

An important critical element is inherent to the determination of objective values that define environmental quality (reference benchmark). This is linked to the threshold concept that can also be identified, depending on the particular characteristics of the local territory[10].

In particular, those bodies, both national and international, which tried to respond to the issues defined by Agenda 21, are responsible for the methodological development of the indicators[11]. More specifically, the methodological development of the indicators was carried out with reference to the approach followed by O.E.C.D and known as the (P.S.R.), "Pressure-State-Response" model, which gives a causal interpretation of the relationships between society and the environment [OECD, 1998].

The determining factors of the model imply the presupposition that the "pressures" man exerts on the environment modify the "state", both qualitatively and quantitatively, and the reactions to these changes, whether natural or induced, by environmental, economic or social policies, represent the "responses". The pressure indicators are aimed at the evaluation of the effects of anthropic activities, as regards how much they reduce or degrade resources or present an excessive load[12]. However, those regarding the state supply indications for the contingentality of environmental quality, with the objective of monitoring any modifica-

1. A complementary system of sustainability measurement is offered by the national environmental accounting, the objective of which is the integration of the economic and environmental aspects. The approaches that have been developed consider the defensive costs; the evaluation of natural capital; the evaluation of the depreciation of the natural resources with market; the evaluation of all the relationships between the economy and environment (SEEA-Satellite methodology system for integrated Environmental and Economic Account). The latter offers an overall integrated overview of national and environmental account using satellite calculations that offer a monetary and physical evaluation of the relationships between the economy and environment, thus determining the Ecological Internal Product (green EIP), which encompasses the costs associated with environmental decay and the quantitative exploitation of natural resources. Environmental accounting also finds specific application in the micro-economic field, linking the evaluation of productive activity in terms of revenue with the protection of natural resources, leading to the configuration of the Net Environmental Revenue, that links the aspects connected to company profitability with the social and environmental ones [Gatta, 1999; Mordenti ed al, 2002].

2. If environmental accounting has the objective of integrating the economy and environment, the use of indicators makes it possible to insert the evaluation of the social component. The first examples of indicators that have been elaborated, however, consider human development more than sustainability. (E.g. the Human Development Index, made up of the average of the variables: life expectancy, level of education, gross domestic product per head). The need to include other variables, for example of an environmental nature, opened the path to a broader vision of sustainability.

3 The selection approaches of the indicators can be identified at a local or international level, or can refer to the assessment of an individual project. In particular, the most important international experiences refer to the Pressure-State-Response Model proposed by the Organisation for Economic Cooperation and Development which later led to the Driving force-State-Response model as well as the ABC model of the International Institute for the Urban Environment, which foresees Area specific indicators, identified at a local level; Basic indicators and Core indicators, which supply essential information for the measurement of local sustainability, all make a comparison with other situations possible. At a local level, the most important experience is that of the application of Agenda 21 in which the choice of indicators involves the local community, based on a bottom-up approach, and favouring the broadest adhesion to the situation in question.

4 The indicators of local sustainability make it possible to evaluate the degree of progress towards the objective of the city's sustainable development in a manner that is both simple and synthetic. The choice of the indicators is functional to the definition and implementation of an action plan for sustainability, in conformity with local political choices [Cogo, 2001].

tions[13]. The response indicators are mainly aimed at assessing the effectiveness of environmental and territorial policies, with the aim of encouraging further study for the proposal of specific actions, particularly in the local field[14].

The conviction that sustainability is not only made up of the environmental component also gave rise to the opportunity of including other dimensions of the situation, for example the economic, social and institutional dimensions that are part of the characteristics of the Driving force-State-Response scheme (DSR)[15].

By introducing further variables of analysis, this approach strengthens the role of the various components of sustainability and their relationships, inducing a more detailed vision. In this manner, analysis will then include all the factors that are pertinent to the territorial field that influence developmental sustainability. The field of interpretation is expanded to the complex of the interacting reality between man and the environment[16]. Within this scheme in a broader meaning of the pressure concept, the driving forces represent all the activities and processes that may generate an impact on local sustainability.

3. Characteristics of the sustainability model for the Venice lagoon

The Driving force-State-Response scheme has been adopted in the model developed for the Venice lagoon, in which the four dimensions of sustainability, environmental, economic, social and institutional, are organised into subjects and sub-subjects, with the aim of achieving a greater adhesion to the local characteristics[17] (Tab. 1).

As regards the first dimension of sustainability, that of the environment, the subjects developed refer to the lagoon waters, air quality, the ground and naturalistic heritage. Thus, the subject "lagoon waters" is subdivided into the groups "water pollution, hydro-geological instability and fishing activities". The role of the drainage basin is analysed using the driving force identified in the annual deposits of nitrogen and phosphates, which contribute to an increase in concentration in the waters (state). The depollution plan for the lagoon and the dynamic monitoring network represent the current actions of contrast, while the evolution of macrophytes and macroalgae represents one of the effects of the qualitative decay of the waters (response).

As regards the hydro-geological instability, the pressure factors refer to the annual loss of sediments, the creation or destruction of typical morphology, the number of exceptional floods, the development of eustasy and subsidence, as well as the wave motion, with the responses being identified in the reopening of the valli da pesca in the project for the morphological recovery and in that for the defence against flooding[18].

Porto Marghera plays a considerable role as regards the subject "air quality", the polluting emissions of which and the number of accidents with pollution (driving forces) add to the harmful concentrations (state), the cause of the increase of specific illnesses such as tumour (response).

Porto Marghera is also of considerable importance as regards the subject "ground" due to the production of waste

[5] The indicators "measure the state of the environment's health and the pressure of current developmental models in relations to the environment's ability to maintain conditions of integrity and productivity", Agenda 21 locale [UN, 1992].

[6] Favouring governance that is carried out by means of the mobilisation of a group of subjects, with a differentiated position as regards hierarchy and statute, the effect of which is a result of the product of their actions, but cannot be directly traced [Balducci, 1999].

[7] According to a bottom-up approach, which identifies agreement in the local field. The same OECD states that "the indicators must be referred to and interpreted in their appropriate territorial context, taking into consideration the characteristics of each site relative to ecological, geographical, social, economic and structural aspects" [OECD, 1998].

[8] The requirements generally accepted for the selection of an adequate set of indicators are those of significance, relevance for the local surroundings, ease with which they can be measured, comprehensiveness, sensitivity to change, coherence, synthesis, scientific validity, reproducibility, disaggregability, expediency [Pileri, 2002].

[9] Numerosity is implicit in the functions they are attributed, such as: identification and definition of the problems; decision support; monitoring (control), together with involvement (information, communication, encouragement of the population); comparison (with other situations); arrangement of local information basis [Moriani, 2001].

[10] The threshold can be defined as the limit above which an environment, or resource, no longer presents acceptable characteristics for human consumption (limits of healthiness), or for biological life, or there is no possibility of returning the environment to its previous condition. In the presence of a single factor the threshold is easier to identify. Thus, Directive 2000 of 23.04.98, Water quality, makes a distinction between the "imperative" value, minimal ecological value, and "guide" value, good ecological value, corresponding to "higher state", identified as the objective of quality.
In a complex environment there are further problems in evaluation. In this case, the process of comparative evaluation in obedience to local characteristics, may make it possible to have references as regards the operatively usable quality references on the strength of reciprocal analysis.

[11] First and foremost the United Nations (UN), with the Commission on Sustainable Development (UNCSD), the Division on Sustainable Development (UNDS) and the UNEP (United Nations Environmental Programme) responsible for the organisation of the Earth Summit of Rio de Janeiro (1992) and Johannesburg 2002; the Organisation for Economic Cooperation and Development (OECD), national environmental Agencies; research institutes; regional and local governments.

[12] They indicate the primary determinants, or rather the generating factors of pressure on the environment. In the case of Venice for example, these could be represented by atmospheric emissions from the industries in Porto Marghera, the discharge of pollutants in the lagoon, and by the various factors of hydro-geological disturbance.

[13] Such as the concentration of pollutants in the air, the water and lagoon sediments.

[14] Thus, the creation of environmental awareness is highlighted in the public domain by the efforts made implementing environmental reporting and in the induction to correct and sustainable behaviour in the policies of companies by adhering to forms of voluntary environmental certification. In the case of Venice for example, the response actions are represented by the Plan for the depollution of the lagoon, the Project for defence from flooding and the areas under protection [Scotti, 1994-95].

[15] Proposed by the Commission on Sustainable Development (UNCSD) of the United Nations.

from productive activities (driving forces), in part dangerous, while the extent of pollution is offered by the contaminated areas (state), the response of which was an appropriate land reclamation plan.

From an environmental perspective, the characteristics of the naturalistic heritage in the lagoon are of particular importance. The evolution of the lagoon fauna and flora (driving force) attests the importance of the wetland for many species and the response that has been provided so far is insufficient for the areas under protections. The importance of the habitat is highlighted by the modifications that have occurred in the sites of naturalistic value and in the variations the lagoon biotopes have undergone, all variables that have been identified as important driving forces.

As far as the economic dimension is concerned, the subjects have been developed in traditional sectors with the addition of that of tourism due to its importance. The characteristics of the secondary sector are derived from the fundamental role of Porto Marghera, where the variation and distribution of the number of those employed, the business area and companies all represent driving forces, as do the energy consumption and production. In addition, there is also the subsector of minor production, including that of Murano glass production and the shipbuild-

Tab. 1. *The model Driving Force-State-Response for the Venice Lagoon*

Topic	Sub-topic	Driving Force	State	Response
Environmental Dimension				
Lagoon water	*Impact of human activities*	Annual loads of nitrogen and phosphorus in the drainage basin of the lagoon – Water discharges - Water removal	Concentration of nitrogen and phosphorus Concentration of the pollution in the water and in the sediments	Lagoon depollution Plan Dynamic monitoring network
	Hydro-geological disruption - Fishery (Tab.2) - Agriculture (Tab. 4)	Annual loss of sediment – Creation-destruction of typical morphologies - Number of exceptional high waters - Evolution of eustatism-subsidence - Evolution of wave motion	Lagoon surface marshes	Evolution of macroalgae-macrophytes Reopening of valli da pesca Plan of morphologic recovery Protection from high waters
Air quality	*Atmosphere polluting emission from Porto Marghera*	Polluting emission - Number of accident with pollution	Concentration of pollution – Businesses with high accident risk	Increase of specific diseases – Environmental investments of the businesses
Ground	*Production of waste in the Porto Marghera area - Contaminated areas - Waste production*	Total waste of productive activities - Dangerous waste - Treated waste - Waste disposal - Annual production of urban waste	Contaminated areas	Reclamation Plan of contaminated areas - Percentage of separate collection
Natural resources	*Species - Areas*		Fauna resources - Floristic resources	Species respecting the Ramsar Convention - Protected areas
Economic Dimension				
Primary sector	*Fishery (Tab.2) · Agriculture (Tab. 4)*			
Secondary sector	*Economic development of Porto Marghera - Minor production*	Variation - distribution of the employees and the firms for the sector activities - Production - consumption of energy - Glass industry of Murano, employments-firms – Ship building firms		Investments of the firms
Third sector	*Economic development - Port development*	Variation of the firms and employment at Porto Marghera and in the historical center - Variation of the shops in the historical center - Evolution of the traffic, goods, oil		
Tourism sector	*Development of the tourism sector*	Evolution of the pressure indicator - Economic contribution of tourism	Gross and net use indicators	Regulation of the flows
Social Dimension				
Population	*Quality of life*	Aging population - Cost to purchase a house - Evictions made		Rate of migration - Variation of the residents by zones

[16] The DSR was studied further, thus the driving forces can be distinguished from the pressure indicators while those of impact are added. This model (DPSIR), designed by the European Environmental Agency (EEA), has been adopted by ESEPI (European System of Environmental Pressure Indices), as part of the V Programme Summary for the environment. ESEPI represents a line of action of the European Union for the construction of an information basis that is necessary for the application of the lines contained in the Programme summary. In particular, the implementation of the DPSIR model becomes the object of the VI programme of environmental action.

[17] The construction of a set of indicators is functional to the definition of an integrated environmental management model for the coastal zone, of which Venice represents the most important example. In particular, the DPSIR model (Driving Force-Pressure-State-Impact-Response) is used to determine the state of environmental quality [Antonelli and others, 2004].

ing sector.

The development of the tertiary sector is analysed by means of the variation of the number of employees and companies, in particular in the historic city centre, where the variation of commercial activities has specific characteristics. In addition to this is the inevitable role of the port in the development, identified by analysing the traffic of passengers, goods and petrol tankers.

In the tourist sector the driving forces can be led back to the variation of the arrivals and stays, also in the form of day-trippers[19], which also influence the pressure index. However, the net and gross utilization index attests the structures' accommodation capacity (state), how much the actions to regulate the flows represent the current responses to the needs for tourism management.

The social dimension is studied using the subject "population", subdivided into the sub-topics "quality of life in the historic city centre" and "Porto Marghera", encompassing the crucial aspects of the industrial plant, such as the professional illness rate and the index of the seriousness of accidents (driving forces). The quality of life in the historic city centre is analysed using variables such as the rate of aging of the population, the cost of buying a house per square metre, monthly rent, the number of evictions carried out and the quotient of migration (driving forces) that account for the variation in the number of residents (response), that is shown to be in continuous decrease.

The characteristics of the institutional and operative dimension aim to link the aspects that refer to the pursuit of the sustainability strategies and the participation in international cooperation, through the ratification and application of the agreements that have been signed, with those that are of a more operative nature, and were identified in the analysis of the implementation status of the works regarding protection and reclamation (response).

The specification of the reference model by selecting indicators is the first operative phase and is prior to the gathering of the data and their organisation, up to the accomplishment, i.e. the calculation and representation of the indices. In particular, the participatory value of the construction activity and finding of information is to be underlined and the forecast of direct involvement by local actors becomes a fundamental premise for the ensuing adhesion to developmental policies based on a common vision of sustainability, involving the necessary modifications to individual behaviour. Indeed, the creation of the model appears to be instrumental to the need to involve the population in the construction of sustainability policies, thus making it aware it is also the author of the effects of the very decisions regarding the results.

The gathering and organisation of the data is an inescapable stage of the operative research project, while the evidence of any lack encourages the activation of processes with the aim of constructing suitable local information basis that become, in perspective, a catalysing element in the drafting of local policies.

4. A proposal for indicators in the lagoon fishing sector

According to the driving force-state-response model, the appropriate indicators aim to develop the operative potential of the plan, with the opportunity of the precise identification of synthetic objectives which will be used as guidelines for future actions and policies in the sector (Tab. 2). First and foremost, the analysis of the role of the fishing sector in the lagoon must also consider the modifications that have taken place in the substance and structure of its heritage. The indicators selected refer to the quantity and distribution of the catch (driving force), while the environmental and economic dimensions are identified in the value of the sales (state). The impact on fish resources is verified by the analysis of the companies working in the sector, and the indicators refer to the size and variation, the local centres and units and the evolution of employment (state).

As regards the environmental variable, the type of technology used is of particular importance (pressure factor) as well as its impact on the environment, which is of specific significance in clam fishing. The area reserved for the valli da pesca which underlines its importance in lagoon management and the quantities of fish product that is confiscated, which measures the degree of food safety, are also response factors as is the arrangement of the "Plan for the management of fish resources (1998)" which represents the effectiveness of the institutional dimension [Province of Venice, 1998].

An appropriate indicator for the pressure on fish resources is that of the production of annual catch (Tab. 3). In quantitative terms, the most important source of production in the lagoon is that of molluscs and while clam production can be estimated at 370 thousand quintals a year, around two thirds of the total catch, the offer of mussels is also significant at around 180 thousand quintals today. Fishing of traditional species, estimated at around six thousand five hundred quintals, highlights a worrying fall in production. Indeed, it appears to have practically fallen by half during the 1990's. The problems of pollution, the hydraulic modifications carried out as well as the use of new fishing technology have all induced the selection of the species. The changes in the resident communities and seasonal migrations have also influenced fishing activities. While this increase in catch appears to have hit all species, it is even more extreme for those with a reduced ability to escape. The diffusion of the manila clam, with a production that has doubled over the last ten years, has damaged traditional fishing even more, due to its environmental impact of its

[18] The indicators referring to fishing activities and the primary sector will be the object of successive analyses.
[19] The day-trippers are a specific segment that is increasing in importance in tourism demand.

Tab. 2. *Indicators proposed for the lagoon fishing sector based on the Driving force-State-Response model*

Indicator	Dimension	Type of indicator	Target
Evolution of lagoon fishing by species	*Environmental-economic*	Driving force	Restoration of lagoon biodiversity and preservation of fishing activity
Evolution of clam production	*Environmental-economic*	Driving force	Regulation of permits and transformation to fish farming
Evolution of sales in the fish markets of Venice and Chioggia according to origin (sea, lagoon, valley)	*Economic*	State	Increase of species from lagoon
Local units of lagoon fish sector	*Economic*	State	Rearrangement and regulation of sector
Employees in lagoon fish sector	*Economic*	State	Maintenance and requalification
Structure of fishing fleet	*Economic*	State	Preservation and reconversion
Fishing technologies	*Environmental*	Driving force	Use of technology with low-environmental impact
Expanse of valli da pesca in the lagoon	*Environmental*	Response	Increase and restoration
Quantity of fish products confiscated	*Environmental*	Response	Increased in control
Management plan for fish resources	*Institutional*	Response	Increase and rebalancing of fish resources

fishing methods, which part of the fishing sector now concentrates on. The significant environmental impact of clam culture highlights the economic damage of extortion based on the maximisation of individual catches [Cesari, 1994].

The development of fishing can be highlighted further by analysing sales according to the origin of fish species sold at the wholesale markets of Venice and Chioggia. In 2000, the fish species from the lagoon were equivalent to 9,150 quintals for a value of 3.5 million euros, divided between the Venice fish market with 7,000 quintals (76.5%) and the Chioggia wholesale market with 2,130 quintals. If the produce from the valle, the sea and freshwater is added to that of the lagoon, local production rises to 73,780 quintals, 13,920 of which are from the Venice fish market (18.8%).

Over the last decades, the fish production that appears on the lagoon markets has shown an overall decrease in offer, and the modification of the supply sources favours other national or foreign centres.

On the other hand, over the last few years, the location and local fishing units have shown an increase, no less than 65% in an individual form, all of smaller dimensions and only 13 of which are companies. Most of the local units are made up of small businesses with a maximum of 9 employees and those of an average size (10-49 employees) are a small minority (3.9%), while there is none of a larger size.

An estimate of the number of people employed is little over two thousand fishermen who are working in the lagoon, of which around one thousand two hundred are catching clams while the others are concentrating on traditional fishing. The overall fishing fleet has been estimated at around six hundred vessels, made up of boats and small trawlers; in particular, around three hundred small vessels and eighty hydraulic dredges are involved in clam catching [De Pin, 2002; Granzotto et al, 2001].

With an area of around nine thousand hectares, 70% of which is made up of an area of water dedicated to fish farming, the valli da pesca represent an important form of management of the lagoon. The area is gradually decreasing, especially due to the inactivity of certain areas, while in others an attempt is being made at assisting their recovery.

The management of fish production appears to be of a traditional nature, consisting in extensive polyculture, where relatively low productive yields also have reasonably low management costs. Only 10% of the valli are imple-

Tab. 3. *Indicator: evolution of fishing for species (quintals)*

Dimension:	Environmental-economic		*Topic:*	Lagoon water/ Primary sector	
Type of indicator:	Driving force		*Sub-topic:*	Fishing sector	
Species	Prod. 1994	%	Prod. 2000	%	Var. % 2000-94
Gò	2.650	22,0	1.120	17,4	-57,7
Whitebait	5.000	41,5	1.620	25,1	-67,6
Plaice	510	4,2	290	4,5	-43,1
Eel	90	0,7	60	0,9	-33,3
Mazanete	910	7,6	1.270	19,7	39,6
Moleche	190	1,6	170	2,6	-10,5
Schille	340	2,8	320	5,0	-5,9
Shrimps	680	5,6	560	8,7	-17,6
Cuttlefish	1.680	13,9	1.040	16,1	-38,1
Fish	12.050	100	6.450	100	-46,5
Clams	160.000	43,2	370.000	67,3	131,3
Mussels	210.000	56,8	180.000	32,7	-14,3
Molluscs	370.000	100	550.000	100	48,6
Total	382.050	100	556.450	100	45,6

Source: Statistics from various sources

menting forms of semi-intensive breeding of giltheads and sea bass.

The Venetian valley system is of no particular importance from the perspective of employment, with just around a hundred full-time employees and the same number employed in breeding and fauna-hunting activities. Over the years Valli production has remained quite constant, varying between 75-130 kg per hectare, comparable to that at the end of the 1800's and early 1900's. 60% of the species being bred are Mugilidae while the rest consists of valuable fish (sea bass, gilthead and eel). The catch trend shows a seasonal concentration during the last three months of the year, when 80% of production is caught.

If the gross proceeds for an average-sized valle are around one thousand euros per hectare, for a total turnover of 7.5 million euros, just half comes from the sales of fish, while the rest comes from hunting and agriculture.

Over the last few years, competition from imported products has led to a drop in the production prices of the valli, highlighted by the difficulties Venetian companies have in differentiating their product with suitable marketing techniques. Due to their size, the valli are of great naturalistic and environmental value. The constant interventions for maintenance they require to ensure conditions of efficient production, guarantee the conservation of this special habitat. Maintaining ecological stability underlies the conservation of the production potential of the valli [Mauracher, 2003]. Furthermore, the lagoon valli areas are also one of the most important wetlands for the hibernation of water avifauna.

5. The role of the agricultural economy in the sustainability of the Lagoon development

As a complement to fishing activities, the role of the primary sector in contributing to the sustainability of the lagoon environment is identified by the specific characteristics of the agricultural sector.

The agricultural economy has particular characteristics in the lagoon, being organised in minimal lots and in vegetable gardens, following ancient traditions. Despite its extreme fragmentation, in certain areas it has managed to reach an extremely high quality. The current agricultural poles in the lagoon are situated in the peninsula of Cavallino-Treporti, on the island of Sant'Erasmo and in the peri-lagoon area to the south of Chioggia. Although the peninsula of Cavallino was prevalently characterised by orchards, more recently the need for renewal made it advisable to turn to protected horticulture [Brussa, Frigo, 1994]. Until recent years, the importance of agriculture of the island of Sant'Erasmo was proven by the fact that it used to be the great market garden of the Venetian Republic. The company structure, the layout of the products, the characteristics of the offer all make lagoon agriculture a rare example of economy that has disappeared elsewhere, one in which the level of production efficiency allows the remuneration of the worker[20].

According to the model being proposed, above all, the sectorial indicators that have been identified for the agricultural sector consider the development of the agricultural areas which, as an expression of both the environmental and economic dimension, represent the main driving force of the sector (Tab. 4). The analysis of the farms structure (state) contributes to the identification of the economic dimension while the intra-sectorial dynamics has been identified by the development of the type of agriculture being carried out (driving force), in view of the fact that the incentive towards natural policies means a reduction in negative interaction with the lagoon environment.

The study of animal-breeding farms, that mainly intends to study the impact in the lagoon of zoo-technic activity and the development of organic productions, all represent further driving forces of the sector, thus making it possible to portray diverse aspects of the environmental dimension.

One characteristic aspect of agriculture in the lagoon is the use of the productive land and their dispersion on a territory that is mainly covered by water and morphologically unstable structures which results in an extreme fragmentation of the farms. The most extensive agricultural pole in the lagoon is that of the islands of S. Erasmo and Vignole, with 103 farms and an utilised area of 159.3 hectares (78.6% of the total). While the number of farms on the other islands is extremely small, over the years there has been a further reduction.

The marked reduction of the farms (- 34.2% in a decade) goes hand in hand with that of a decrease in surface area (-31.4% SAU), with the land being used for non-agricultural purposes, or having being reduced due to morphological changes. The use of the spaces available and the extreme fragmentation of the land have the same effect on the farms, which have an utilisable area of just 1.57 hectares.

Agricultural activities involve a large part of the natural territory, making its interaction with the environment particularly important. In the lagoon, the reduction in agricultural activities can be seen in land use, with the area of intensive agriculture falling by a third over the last ten years (Tab. 5).

Although the use of the area still favours sowing (51.0% of the total), the reduction (-29.7%) still appears to support sustainability. Of all the woody crops, the grapevine has been particularly affected by productive restructuring, and its area has been halved (53.2%) over the last decade.

Together with a decrease in the more intensely cultivated areas, there is also an increase in semi-natural and natural areas, forage crops and woods, which now make up a third of the total area[21].

[20] The lagoon is characterised by specific vegetable-fruit products that are on the list of "Traditional Products" such as the violet artichoke of Sant'Erasmo, the white peach of Venice, the Cavallino tomato, while in nearby Chioggia, the carrots, potatoes, onions and red radicchio stand out.

Tab. 4. *Indicators for agriculture based on the Driving force-State-Response model*

Indicator	Dimension	Type of indicator	Target
Total area and agricultural area used per area	*Environmental-economic*	Driving force	Preservation and adaptation of agricultural structures
Number and distribution of the farms	*Economic*	State	Preservation of the farms in the lagoon
Evolution of intensive, semi-natural, natural agricultural activities	*Enviromental-economic*	Driving force	Reconversion to natural practices
Evolution of business per number of animals bred	*Environmental-economic*	Driving force	Preservation of animal resources
Evolution of biological production (hectares)	*Environmental*	Driving force	Encourage organic production
Annual loads of nitrogen and phosphorus from the Drainage Basin per generation sources	*Environmental*	Driving force	Adaptation to values foreseen in the depollution plan of the lagoon

Lagoon agriculture is not characterised by animal breeding activities and has a very small number of animal breeding farms, which are mainly concentrated on the island of Sant'Erasmo. Over the years, while the reduction in farms (-28.0%) appears constant, that of breeding is more marked with the disappearance of nearly all cattle, and even more so for rabbits (-94,6%), pigs (- 84.7%) and poultry (-51.1%).

As regards the analysis of the pressure on the lagoon environment from the agricultural sector, those with a direct effect on the water component of the ecosystem are the deposits of elements introduced into the lagoon (driving force), the most harmful of which are nitrogen (9,300 tonnes a year) and phosphorus (1,300 t/y), coming from the drainage basin.

A comparison of these deposits shows that they are predominantly of zoo-technic and agricultural origins, with deposits that exceed those allowed[22]. In particular, the increase of the nitrogen deposits with agricultural origins makes it a major source of pollutants with a further 3,200 tonnes a year (+20,9% in a decade), followed by animal breeding activities (2,300 tonnes a year) which also have a negative potential on the environment.

6. Elements for the analysis of the economic sustainability of the Lagoon

From an economic point of view, Venice is an important pole of diversified activities - industrial, production, commercial and tourist. The emergence of a more marked tourist vocation, together with the manifestation of recent development factors highlight considerable elements of disequilibria, which are particularly evident in the industrial area of Porto Marghera. Created as a coastal production pole, it continued to develop until the end of the seventies. However, the decline of basic industrial activities resulting in reduction in workers, the diversification of activities and the dimensional scale of the businesses all led to its under-

Tab. 5. *Indicator: evolution of intensive, semi-natural, natural agricultural activities (hectares)*

Dimension:	Environmental-economic					*Topic:*	Primary sector				
Type of indicator:	Driving force					*Sub-topic:*	Agriculture				
Type of culture	Lagoon					Mainland			Total number of municipalities		
	1982	%	2000	%	Var. %	1982	2000	Var. %	1982	2000	Var. %
Sowing	209,2	60,1	147,0	51,0	-29,7	3.046,1	3.660,2	20,2	3.255,3	3.807,2	17,0
Vines	69,3	19,9	32,5	11,3	-53,2	355,6	136,0	-61,7	424,9	168,5	-60,3
Other wooden crops	12,3	3,5	12,1	4,2	-2,0	15,0	61,6	312,0	27,2	73,7	170,4
Family market gardens	0,2	0,1	0,8	0,3	344,4	30,4	38,2	25,8	30,6	39,0	27,7
Intensive agriculture	291,0	83,6	192,3	66,7	-33,9	3.447,0	3.896,0	13,0	3.737,9	4.088,3	9,4
Permanent crops and grazing	4,8	1,4	10,2	3,5	111,2	64,0	73,8	15,2	68,9	84,0	22,0
Arboriculture of wood			2,7	0,9			46,8			49,5	
Seminatural agriculture	4,8	1,4	12,9	4,5	166,9	64,0	120,5	88,3	68,9	133,5	93,8
Woods			6,2	2,1		23,4	66,6	184,2	23,4	72,7	210,5
Agricultural area not used			51,7	17,9			166,2			217,9	
Other land	52,3	15,0	25,3	8,8	-51,5	600,9	2.266,2	277,1	653,2	2.291,5	250,8
Natural agriculture	52,3	15,0	83,1	28,8	59,1	624,3	2.499,0	300,3	676,6	2.582,1	281,6
Total area	348,1	100	288,4	100	-17,2	4.135,3	6.515,5	57,6	4.483,4	6.803,9	51,8

Source: Statistics based on ISTAT data.

Tab 6. *Indicator: evolution of businesses and employees in Porto Marghera par sector*

Dimension:	Economic						*Topic:*	Secondary sector				
Type of indicator:	Driving force						*Sub-topic:*	Economic development of Porto Marghera				
Sector	Businesses						Employees					
	1965*	%	2000	%	Var. ass.	Var. %	1965*	%	2.000	%	Var. ass.	Var. %
Food	9	3,9	5	1,7	-4	-44,4	419	1,3	154	1,2	-265	-63,2
Energy, water, gas	14	6,1	7	2,4	-7	-50,0	1.088	3,3	722	5,7	-366	-33,6
Construction materials	16	7,0	7	2,4	-9	-56,3	2.595	7,9	589	4,6	-2.006	-77,3
Chemical	23	10,0	16	5,6	-7	-30,4	14.233	43,3	3.339	26,2	-10.894	-76,5
Mechanic	57	24,9	46	16,0	-11	-19,3	4.645	14,1	2.382	18,7	-2.263	-48,7
Steel and iron	15	6,6	10	3,5	-5	-33,3	6.487	19,7	1.257	9,9	-5.230	-80,6
Oil	23	10,0	12	4,2	-11	-47,8	1.460	4,4	483	3,8	-977	-66,9
Other sectors	72	31,4	185	64,2	113	156,9	1.963	6,0	3.801	29,9	1.838	93,6
Total	229	100	288	100	59	25,8	32.890	100	12.727	100	-20.163	-61,3

* Year of maximum employment
Source: Statistics based on data from Ente Zona Industriale di Porto Marghera

going a crisis, which was parallel to the emergence of problems of chemical pollution, with deposits and absorption of toxic substances in the sediments [Fabbri, 2003].

In the historic city centre of Venice, the progressive transfer of the economy towards the tertiary sector has led to a clear marginalization of the artisan sector, the survival of which is linked to specific products that play a considerable role in tourist specialisation. The high quality is due to the prosperity of glass production on Murano, a specific employment pole of the Venice economy. Other artisan activities included those linked to the traditional economy such as lace production on Burano and the construction and repair of boats [Brussa, Porcellato, Vecchiato, 1995].

To exemplify the characteristics of the economic dimension of the lagoon, several indicators that can be developed according to specific subjects are proposed, such as the economic development of Porto Marghera and the tourist sector.

In particular, the variation of the number of employees and business by productive sector (driving force), where the considerable drop in employment seems to have a direct effect on the economic sustainability of the lagoon environment, has been identified as an indicator of the quality of the economic development of the industrial pole of Porto Marghera (Tab. 6). The crisis of the last decades has resulted in a considerable change in the industrial structure, and the drop in employment and number of businesses has affected nearly all the basic productions. In particular, the drop in the number of employees, from 32,980 in 1965 to 12,727 in 2000 (-61.3%) appears to be even more marked in the steel and iron sectors (-80.6%), in construction and building (-77.3%) and the chemical sector (-76.5%), while the oil (-66.9%) and food sector (-63.2%) show a marked restructuring. The increase in businesses, rising from 229 to 288 units (+ 25.7%) is exclusively due to the "other sectors" (+156.9%), which have now become the most important source of employment (29.9%), since those of the basic productions have dropped considerably, in particular those of construction and building (-56.2%), energy (-50.0%), petroleum (-47.8%); those of the following sectors are also substantial: food (-44.4%), chemical (-30.4%), iron (-33.3%). However, the industrial pole still preserves some of its specific characteristics and the most important sectors remain the chemical, oil, mechanic and steel sectors. The increase in the production of the main sectors leads to the belief that the restructuring that was carried out favoured investments in high work productivity, while the development of new forms of integration, the creation of new productive branches and business networks are the result of adaptation to the current economic situation. The development policies followed were, however, certainly incompatible with the view of environmental sustainability. However, the needs for eco-compatible development directives might not succeed in moderating economic sustainability, thus resulting in a drop in revenue.

The decrease in the prerogatives of production activity as a driving force for development is opposed by the increasing role of tourist demand. The danger linked to this clear specialisation appears to be inherent to the theory of the life cycle of tourist destinations[23], which becomes even more explicit when economic activities that compensate it begin to disappear. On the other hand, it is this very tourist activity that can be interlinked with the needs for environmental protection, and this could represent an incentive for the pro-

[21] Increased awareness as regards the responsibility for pollution by agricultural practice, regarding both the water and coastal beds, led to the creation of a specific consortium that aims at the conversion of market gardening with integrated methods that have a low impact on the environment.
[22] Dr. Min. of the Environment 09.02.1999, values allowed: nitrogen 3,000 tonnes a year; phosphorus 3,00 t/y.

posal of new modes to enjoy the lagoon.

The main indicator of pressure or social impact of the tourist sector is that of the ratio of visitors and residents, in reference to over-night stays, or also to day-trippers[24]. The increase of the index, from 27.5 in 1981 to 50.1 in 2001, confirms the dramatic impact of tourism, in particular in the historic city centre, thus stimulating control policies of tourist flows (response)[25]. The tourism market is expanding constantly with 1,730,330 arrivals and 3,293,693 visits in 2001 alone. Only one third of the visitors, however, stay over night, with an average stay of 2.4 days. The majority of the visitors are day-trippers, calculated at 6 million a year. There are two aspects to the problem of day-trippers - economic and managerial, contributing in lower economic terms than the tourist resident, but with significant social costs[26].

In addition to the visitors in the historic city centre are those of the coast of Cavallino (5,863,795 in 2001), the Lido (558,010), and Mestre (1,762,981).

The tourism pressure in Venice resulted in an expansion of the accommodation area. Indeed, the number of tourists who stay overnight in Venice is limited by the amount of accommodation, with a total of 22,469 beds in 2002, of which only 11,994 were in the historic city centre[27]. Consequently, the index of gross utilization, calculated by relating the number of visitors to the potential capacity, i.e. the number of beds expressed in day-bed totals, highlights an extreme exploitation of the hotels in the historic city centre (0.73 in 2000)[28].

The contribution of tourism to the local economy can be studied in more detail using specific economic indices such as the analysis of the effect on employment and the local tourist units, making it possible to appreciate the degree of specialisation that has been achieved.

The concentration of tourist activities seems to be more marked in the historic city centre and on certain islands such as Murano, encouraged by the glass industry. The sectorial economic dependence of the districts of San Marco and Castello is also considerable, encompassing a third of the total of those employed in tourism. Here, around one fifth of the employees (19.4%) work in local tourist units, 23.6% of the total, with an incidence of paratourism at 41%.

7. Conclusions

The application of the driving force-state-response model to the situation of the Venetian coastal area could be a useful tool to start a process of sustainable development based on the closer study of the knowledge and agreement of management plans for the lagoon environment. The aim of this study was to present an initial applicative approach of methodologies aimed at implementing and assessing a coherent path of sustainable development at a local level and including multiple sectors.

In view of the fragility of the lagoon, the consideration that the analysis of the sustainability of lagoon development prompts a study of the interaction modalities of the various converging activities adopts the hypothesis that the relationship between the lagoon ecosystem and economy must primarily place the need to protect the environment first. The development path should therefore respect the principle of not compromising the natural environment.

On this basis, before focusing on the characteristics of the fish sector, adoption of the driving force-state-response model must first lead to an understanding of the determining factors of impact for the various sectors of the economic and environmental systems. The identification of indicators favoured those able to exemplify the local characteristics. In this context, interaction in the fishing sector area is extremely complex. Achieving a higher sustainable production level comes up against numerous environmental incongruities, inter-sectorial conflicts and prospects of recon-

[23] This theory foresees a phase of starting, take-off and maturation, followed by a phase of revival or decline. In the phases of the life cycle, not just the number of visitors vary but also their composition, with consequences in terms of costs and benefits. The theory makes it possible to correlate the load capacity with long-term sustainability [Pearce, Kirk, 1986].

[24] The assessment of the sustainability of tourism is based on the concept of load capacity, "The load capacity of tourism is the physical, biological, social and psychological capacity of the tourist environment to tolerate the development and tourist activities without reducing the environmental quality and satisfaction of the visitors" [Pearce, Kirk, 1986]. A distinction can be made between the capacity of the bio-physical and socio-cultural load of the structures, linked to the estimate of "maximum use", which does not, however, guarantee the sustainability of the tourism phenomenon with time [Moriani, 2001].

[25] The growth of cultural tourism in Venice has resulted in dramatic competition between the tourists and residents as regards the use of the historic city centre. The urban revenue of tourism also means an increase in the price of housing, the exodus of the residents and the conversion of activities to tourism.

[26] While the precise limit of residential tourism lies in the availability of accommodation, where demand is determined by the mechanism of prices, day-tripper tourism is more difficult to determine and the evidence of its growth and the impossibility of regulating it can lead to an excess of the load capacity, resulting in the unsustainability of tourist development [Van der Borg, Russo, 2001].

[27] If the accommodation capacity determines the satisfaction limit of demand, the most important indicator is that of the socio-economic capacity load, i.e. the number of visitors that can be accommodated without compromising the social-economic functions of the city. The calculation of this has led to the proposal of specific estimate models such as unfocused linear planning, based on the maximisation linked to the revenue from tourism. The linear constraints refer to accommodation availability, catering services, parking and transport, and waste disposal capacity. In particular, the daily visitor limit is set at 22,500 with an estimate of 9,500 day-trippers [Canestrelli, Costa, 1991].

[28] On the other hand, the index of net utilization, which regards the days-beds available, or rather it measures the true capacity, highlights a higher utilization of hotel capacity in the historic city centre (0.80 in 2000), and on the mainland (0.70), compared to the Venice Lido (0.57) and Cavallino (0,48). However, the capacity of the additional hotel facilities, in particular on the coast (0.07), on the mainland (0.33) and in Cavallino (0.49) seems less exploited, while the Venetian city centre confirms its attraction capacity (0.74).

version. The resources of fishing and aquaculture show a considerable productive decline but if the reduction of the expanses of water, hydraulic modifications, and water pollution are evidence of interference from external sectors, the use of modern fishing technology, the advantage of new species, the modification of the fishing activities, all represent intra-sectorial driving forces. For example, diffusion of the manila clam resulted in the partial conversion of the fishing activities, with, however, further impact on the environment. As a result, the decrease in traditional species appears to be particularly high.

An understanding of the specific sectorial impact factors becomes propedeutic to the definition of a coherent integrated operative management plan for the lagoon area. Accordingly, the adoption of the driving force-state-response model is not only useful for the identification and analysis of the phenomena but also for the devising of subsequent intervention policies. The affirmation of valid operative methodologies encourages the creation and implementation of local information basis, which still appear to be lacking and are an unavoidable part of the procedure of applied research.

The development of suitable data banks supports the implicit informative and communicative aspect of the construction of sustainable policies. Indeed, the involvement of local actors increases the collective awareness of the problems, while participation at a micro-economic and sectorial level facilitates responsibility being assumed. Without these requisites, it is not possible to make changes in life style, which are a prerequisite to undertaking a path of local sustainable development.

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