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Indicators of sustainable development for the city and the lagoon of Venice

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INDICATORS OF SUSTAINABLE DEVELOPMENT FOR THE CITY AND THE LAGOON OF VENICE

1. INTRODUCTION

1.1. Indicators of sustainable development

Indicators are instruments that represent information concerning complex and broad phenomena in a brief and understandable way. The meaning of an indicator extends beyond what it really measures (for example a decrease in barometric pressure can represent arrival of bad weather conditions). In a hypothetical information pyramid indicators would be placed on a level between analytical data - the base of the pyramid - and indexes, aggregation of indicators that represent the apex of the pyramid.

Indicators of sustainable development were officially introduced by the Earth Summit of Rio de Janeiro. The chapter 40 of the Agenda 21 document states:

Indicators of sustainable development need to be developed to provide solid bases for decision making at all levels and contribute to self-regulating sustainability of integrated environment and development systems [UNCED, 1992]

Even if there is no agreement on a common conceptual definition of sustainability, there is a general need to measure and assess the sustainability in different geographic and spatial contexts. Indicators can be seen as instruments that enable us to visualise the level of sustainability and its temporal trend. They can be used to evaluate if a system is approaching or moving away from sustainable objectives.

At local level concepts like sustainability and sustainable development are usually taken in context of urban systems since in these systems they acquire particular importance. Cities with their disproportionate consumption of natural resources and energy as well as production of waste and pollution contribute greatly to the global unsustainability. Gravity of this contribution becomes evident if we consider that the 75% of the population of industrialised countries (Europe and North America) and of Latin America lives in the cities and that by the end of the century the 50% of the world population will be concentrated in urban systems. Moreover city represents the context where the interrelation between economic development, environmental protection and preservation of quality of life is a greater problem in terms of

sustainability, mainly because of the high concentration of human activities and population. Cities can also be victims of the global problems that themselves contribute to cause. For example Venice is threatened with extinction by the possibility of rise in sea level due to a climate change.

Indicators of sustainable development assume a very important role in improving the process toward sustainability in local systems. Even if considered in a global prospective use of such indicators at a local level must be related to local problems, objectives and policy options. Transposition of general guidelines and criteria and the exclusive use of general indicators at a local level can compromise the meaning and the relevance of such instruments for a specific context. It is therefore important that together with general indicators (*core indicators* [IIUE, 1995]), that reflect a general view of a sustainable city, specific indicators are developed in order to describe the peculiarities of the studied area and its problems.

Local Agenda 21 experiences can contribute in a consistent way to the selection of the most appropriate set of indicators. These processes attempt to involve the different local actors in defining possible sustainable development objectives and in highlighting the most important economic, environmental and social problems that act as obstacle in the path of their realisation. For each problem indicators can be selected and used to evaluate whether in future the sustainable objectives will be satisfied or not. In the Agenda 21 process indicators of sustainable development can assume another important role since they provide reliable information to the participants and thus permitting a discussion on controversial topics without prejudices.

1.2. Indicators of sustainable development for Venice

This paper summarises and discusses the results of an investigation in which the principal aim was the definition and calculation of a set of indicators of sustainable development for the municipality and the lagoon of Venice. At the conclusion of the research a broad report was produced [Musu, 1998]. In the report each indicator is described in detail and the methodology used to collect data and to calculate the indicator is discussed. The report also analyses the spatial-temporal distribution of the indicator and evaluates it in relation to a target, an objective

or a comparison value. The present paper briefly reports the results of the research in the form explained in the methodological approach and tries to summarise some overall conclusion.

The research is part of a bigger project called “*Venice 21 Project*” that was started by the Fondazione Eni Enrico Mattei in 1996. This project aims to contribute to the local Agenda 21 process by providing the analysis of the principal aspects concerning the sustainable development in Venice [Musu, 1997; Dente, 1997], the definition of possible future sustainable scenarios and the elaboration of a set of indicators of sustainable development.

In 1997 the Municipality of Venice initiated the Agenda 21 experience and being the political subject responsible for the participatory approach created a specific Agenda 21 Office. The process was organised in three working groups (productive activities and environment, urban quality and transport and sustainable tourism) that analysed the different problems perceived as priorities in defining a sustainable local action plan. The first phase of the experience concluded at the beginning of the current year and produced a final document [Venezia Ricerche, 1997] on some proposals for a sustainable reorientation of the system. The participants and the Municipality have expressed the willingness to start a second phase in the near future. The “*Venice 21 Project*” refers to this process. As explained in the methodological approach the research on indicators of sustainable development for Venice not only tries to provide an informative contribute to the Agenda 21 experience but also used its results for the selection of the indicators. Our intention is to discuss the result of the present research within the context of the Agenda 21, if a second phase is to be started. This would enable us to redefine the final set of indicators in relation to the real priorities expressed by the local actors and the population.

1.3. The studied area

Geographic context for the calculation of the indicators was identified as the area of municipality of Venice, which in this paper is also referred to as Venice. This area was chosen both for the relative availability of data and because the previous studies concerning sustainable issues referred to this spatial context.

In defining the indicators concerning environmental and natural aspects of the lagoon (for example the yearly discharge of nitrogen and phosphorus released into the lagoon from the

drainage basin or the yearly number of migrating aquatic birds in the lagoon), a larger spatial context, the Venice lagoon ecosystem, was considered since an analysis restricted to the municipality area would have produced meaningless results [Torricelli, 1997].

The studied area is characterised by a high geographical and environmental complexity and a variety of different spatial contexts coexist in it. The historical centre of Venice - which in this paper is also referred to as the city of Venice - with its incredible artistic and cultural wealth is situated in the middle of the lagoon, one of the most important European wetland ecosystem. The small urbanised islands of the lagoon - the most important of which are Murano, Burano and Sant'Erasmo - and the urbanised littorals of Cavallino, Lido and Pellestrina, that separate the lagoon from the Adriatic sea, are also part of the municipality of Venice. Each sublocal area is characterised by its specific peculiarities. In the overall area the intensive artistic, naturalistic and bathing tourism is one of the most relevant causes of the local unsustainability.

Within the mainland the city of Mestre and Porto Marghera are the most important urbanised areas of the municipality of Venice. Mestre, together with the smaller area of Marghera, is a quite large city, characterised by typical problems of modern urban systems (traffic congestion, air pollution, noise pollution, green space scarcity, etc.). Porto Marghera is the industrial area of Venice and is directly connected to the lagoon by the commercial and industrial harbour. The industrial activity, particularly in the past, has often been in conflict with the protection of the lagoon ecosystem, other human activities (for example fishing) and with the preservation of the quality of life of people living close to the industrial area. Mestre and Porto Marghera are a part of the drainage basin, a 1877 km² area that conveys rain and river water into the lagoon. The function of this basin is very important because together with the water it transfers into the lagoon large amounts of pollutants originating through different human activities such as agriculture and animal-breeding, and by domestic sources. Within the drainage basin there are 101 towns and villages and about 1,500,000 inhabitants.

2. THE METHODOLOGICAL APPROACH

2.1. The selecting criteria

In defining a set of indicators for the municipality and the lagoon of Venice we tried to consider the highest number of issues concerning the local sustainability and the quality of the studied system. The chosen approach was therefore rather broad and general. In this approach the three main aspects of sustainability - environment, society and economy - were investigated and the interrelation between these was analysed in order to define the final set of indicators. For simplicity and clarity of presentation of the results the selected indicators are divided in three groups: quality of the environment, quality of life and quality of economic development.

For selection of the indicators of sustainable development, different technical criteria were chosen considering the international literature about similar experiences [Cogo, 1997]. In order to be effective a local indicator should be:

- *meaningful* for the assessment of the local sustainability. It has to clearly show whether the defined sustainable objectives or targets have been reached;
- *relevant* for the local context. Indicators must refer to those aspects of sustainability that are perceived at the higher level of importance by the citizens and actors working and living in the studied area;
- *easily measurable*. Data and information used to compute the indicator must be easy to collect and update;
- *easily understandable*, even for the people who are not specialists;
- *sensitive*. It must change when a phenomenon is varying in space or in time. In short it must be able to show the spatial and temporal variability of the phenomenon;
- *coherent* with the other selected indicators. Not only do indicators have to refer to a common global sustainable objective, but they also have to represent the social, environmental and economic aspects of the local sustainability in a way as complete as possible;
- *concise*. It must be able to summarise complexity without losing important information;

- *reproducible*. It should be possible to reproduce the methodology used to calculate the specific indicator;
- *reliable*;
- *calculable* for smaller spatial contexts (for example neighbourhoods) or for social groups;
- *economically convenient*. If possible collection of data should be easy and cheap in order to obtain frequent updating of the indicator.

It is obvious that it is unlikely that a single indicator will satisfy all the above criteria, and in reality some of them carry more weight over the others during selection of the final set. In the present research measurability, simplicity and local relevance were considered as most important criteria. Since, besides the theoretical definition of an optimal set of indicators, we also wanted to be able to calculate and evaluate them, *availability of data* at the local level was further considered to be an important criterion. Collection of data was the most time consuming and difficult phase of the research and involved more than 25 different bodies (local and national research institutes; local, regional and national authorities; private and public companies). A list of contacted bodies is reported in appendix 1. Some indicators that had been previously chosen for their local relevance and importance, were not considered in the final set because data for their calculation was either unavailable or only partially available. A list of such indicators is contained in appendix 2.

It is very important that the chosen indicators are perceived as meaningful and relevant in the local context by the population and by the actors interacting at various levels with the different aspects of sustainability, especially when their selection is linked to a local Agenda 21 experience. In this sense it is very useful to choose the optimal local indicators by means of a participatory approach. In our case this was not completely possible because the research was only partially integrated with the local Agenda 21 process held in Venice and because there was not enough time for this process to go through the selection of indicators of sustainable development. Nevertheless, we thought it was very important to consider what people expressed during the Agenda 21 meetings. Environmental, social and economic problems perceived as priorities by the participants were taken in great consideration during the selection of the final set of indicators. In future we would be very interested in discussing the results of

our research in the context of the Agenda 21 experience if a second phase will be launched in Venice.

The overall selection procedure produced a final set of 45 indicators: 16 describing the quality of the environment, 15 describing the quality of life and other 14 concerning the quality of economic development. This final set could not be considered conclusive mainly due to a lack of discussion with the people and local actors and because we were not able to calculate some relevant indicators due to the unavailability of local data. Moreover it's our opinion that a set of indicators should be frequently verified and updated because with time new problems linked to sustainability can arise and some existing problems can be solved. This research and the resulting set of indicators of sustainable development can therefore be considered as a starting point that we hope will be integrated into future investigations.

2.2. Target, current situation and temporal trend

For every indicator we defined, when possible, a target, the current situation in relation to sustainability and the temporal trend.

As explained in the introduction the studied area is characterised by a high complexity and environmental, social and economic conditions can vary greatly within it. In the broad report of our research [Musu, 1998] we analysed every indicator in detail and in order to consider this variability we calculated the values of most of the indicators at sublocal levels (for example the city of Venice, the city of Mestre, the lagoon islands and the littorals). In this paper we have tried to present the result in an as brief as possible way and therefore target, current situation and temporal trend refer to the overall studied area. Only for a few indicators, due to their variability, it was necessary even in this paper to make a distinction between the different smaller spatial contexts.

The target normally represents a quantitative summary of the objective. It allows us to assess whether the indicator is moving towards or away from sustainable conditions. In this research the targets are mainly used to evaluate the indicators and rarely represent an objective to be reached in a fixed time. They are expressed either as numbers (representing objectives to be satisfied in an undefined time or limit not to be exceeded) or as a progressive improvement of the indicator (for example in the case of waste per capita production the target we

considered is its decrease). For some indicators, in particular for those concerning the quality of the economic development, it was not possible to define a target. In some cases the evaluation of the indicator was performed by comparing the value of the same with the values in other similar local contexts (for example Padova or Treviso) or with mean regional or national values.

The current situation expresses whether the indicator shows a sustainable or an unsustainable condition in relation to the target or to the value considered for its evaluation. This qualitative judgement of the indicator very often summarises a much more complex situation and therefore must be considered with caution. It was not always possible to clearly define whether the indicator shows a sustainable condition or not. In some cases we preferred to indicate an intermediate or uncertain situation. Finally, for some indicators it was not possible to define the current situation at all, for example because a target or a reference value was not available.

The temporal trend expresses whether the indicator is decreasing or increasing in time and it does not specify if the indicator is approaching to or moving away from the target (in some cases this information can be obtained by comparing the target, the current situation and the temporal trend). As in the case of the current situation for some indicators it was not possible to define the temporal trend for the unavailability of updated data or of historical series.

3. RESULTS AND DISCUSSION

3.1. Quality of the environment indicators

The selected indicators of sustainable development concerning the quality of the environment are grouped in five classes: soil, air, water, natural environment of the lagoon and hydrogeological imbalance of the lagoon. The first three themes are typical examples found in urban sustainability reports [Maclaren, 1996], whereas the last two are specific to the city of Venice situation. The city is in fact placed in the middle of the lagoon, a rich and greatly diverse wetland environment. The lagoon and the city of Venice, besides being threatened by different kinds of pollution, are suffering from a general hydrogeological imbalance which is

dramatically evident in the erosion of the lagoon morphology and in the number of exceptional high water events.

The table 1 lists the chosen indicators and for each of them reports a target, the current situation, the temporal trend and the geographic context for which the indicator is relevant.

Evaluation of the indicators for soil

For this particular theme four indicators were selected. Three of them concern the problem of waste production and disposal that can represent a great threat for the soil environment. The last indicator refers to the presence of contaminated areas in the lagoon as a result of past illegal or environmentally unfriendly waste disposal activities.

- *Yearly per capita urban waste production.* In the overall municipality this indicator, as the yearly total urban waste production, kept constant in the period 1991-1996 after a marked increase. At a sublocal level the indicator increased in the city of Venice and in the coastal islands even in the period 1991-1996, whereas in the same period it decreased in the mainland and in the city of Mestre. In 1996 the urban waste per capita production was: 567 kg/p/y in the municipality, 391 kg/p/y in Mestre, 653 kg/p/y in the city of Venice, 713 kg/p/y in the coastal islands and 490 kg/p/y as average value in 100 Italian cities [Legambiente, 1997]. It is evident that the indicator depends on the tourism impact. The indicator calculated for a group of people composed by the number of real inhabitants and the number of overnight tourists in the municipality (510 kg/p/y in 1996) is still higher than the urban waste per capita production in Mestre and in other “more sustainable Italian cities”¹. Per capita waste production seems to be too high and unsustainable in the city of Venice and in the coastal islands. The sustainable objective should be the reduction of the indicator to match the level measured in Mestre.
- *Yearly percentage of sorted waste on total urban waste production.* Since 1985 this indicator has continuously increased. In 1996 the percentage of sorted waste in Venice (11.8%) was greater than the average value of 100 most important Italian cities [Legambiente, 1997] (6.6%), but still far from the values measured in many important European cities (for example the percentage of sorted waste in Copenhagen reached the 48% already in 1993 [EEA, 1995]) and in “more sustainable Italian cities” (in 1996 Sondrio 34%, Milan 30%,

Alessandria 26%, Varese 25%, etc.). If the percentage of sorted waste will increase in the next few years with the same rate measured during the last 5 years, Venice will be able to satisfy the first target set by the Ministry of the Environment (15% before 1999) [D.L. 22/1997]. Besides, we think the current percentage is still too low especially if compared with the European context. It is also important to consider that the rest of collected urban waste (about 88% in 1996) is totally disposed in dumps. We therefore think that the current situation of waste disposal in the municipality of Venice is unsustainable.

- *Yearly hazardous waste production.* The evaluation of this indicator is very difficult since only available data refers to 1991 (about 121,000 t/y). The hazardous waste production of the municipality of Venice in 1991 contributed very greatly (77%) to the provincial production. This is mainly due to the industrial activity of Porto Marghera.
- *Number of contaminated areas.* 26 contaminated areas have been found in the territory of the municipality of Venice (data refers to the end of 1997). These areas are mainly the result of past illegal hazardous waste disposal activities. They represent an unsustainable threat for the environment, in particular for the lagoon, and for the population and prevent the alternative use of large spaces. The long term objective must be the total sanitation of such areas. It is important to stress that the reported number can not be considered as exhaustive since other surveys are necessary to locate unknown contaminated areas.

Evaluation of the indicators for air

For this theme six indicators were chosen. The first indicator evaluates the general condition of air quality. In order to analyse the impact of specific substances on the environment and on population we selected other three indicators describing the concentration of the main air pollutants. Moreover main pollutant emissions in the atmosphere were considered in order to evaluate the impact of different human activities. Finally an indicator concerning noise pollution, a typical problem of many modern city, was developed.

- *Yearly percentage of bad air quality days.* The indicator was calculated only for Mestre, since urban air pollution does not constitute a real problem in the city of Venice. It is determined by the yearly number of days during which the “attention levels” for ozone, sulphur

¹ In 1996 lower production was measured in Sondrio (300 kg/p/y), Vibo Valentia (340 kg/p/y) and Matera (361

dioxide, nitrogen dioxide and carbon monoxide² are exceeded. The indicator is always below the target of 5% and shows a sustainable condition and a good air quality for Mestre, at least in relation to the considered pollutants.

- *Yearly 98th percentile of SO₂ daily concentration.* The indicator shows a continuous decreasing trend for the period 1980-1997. Except for the early 80s the indicator has never exceeded the limit of 250 µg/m³ [D.P.C.M. 28.03.1983; D.P.R. 203/1988]. In the period 1992-1997 the average value of the indicator was: 44 µg/m³ for the city of Venice and 80 µg/m³ for the industrial area and the mainland. The decreasing trend and the very low values can be ascribed to a reduction of the sulphur dioxide emission from industrial and urban sources.
- *Yearly average of suspended total particles (STP) daily concentration.* As for the sulphur dioxide, the suspended total particle do not seem to be a problem for the urban environment of Venice. In the period 1992-1997 the indicator has clearly kept itself below the limit of 150 µg/m³ [D.P.C.M. 28.03.1983; D.P.R. 203/1988]. Even in this case the low value can be ascribed to a reduction in the emissions from different sources.
- *Yearly 98th percentile of NO₂ hourly concentrations.* The indicator relative to the nitrogen dioxide generally shows a good condition and the measured levels are lower than the limit of 200 µg/m³ [D.P.C.M. 28.03.1983; D.P.R. 203/1988]. This good condition is not uniformly distributed since levels measured in urban areas characterised by intensive traffic, varying between 150 and 170 µg/m³, are quite close to the limit and exceeds the guideline value of 135 µg/m³ [D.P.R. 203/1988]. In these areas the air quality in relation to the nitrogen dioxide concentration is mediocre. The overall current situation of this indicator can therefore be considered intermediate.

It is important to stress that for a complete evaluation of the air quality other typical urban pollutants such as benzene and polycyclic aromatic hydrocarbons should have been considered. We were not able to develop specific indicators for these pollutants due to unavailability of data.

kg/p/y) [10].

² According to the Italian legislation [D.M. 15.04.1994; D.M. 25.11.1994] the attention limits are: 180 µg/m³ for ozone (hourly average concentration), 15 µg/m³ for carbon monoxide (hourly average concentration), 200 µg/m³ for nitrogen dioxide (hourly average concentration) and 125 µg/m³ for sulphur dioxide (daily average concentration).

- *Pollutant emission in the atmosphere.* The considered pollutants are: carbon monoxide, nitrogen oxides, sulphur oxides, suspended total particles and volatile organic compounds. The evaluation of this indicator proved to be very difficult since the only available data refers to the years 1990 and 1993 for point sources and to the year 1990 for non point sources. In 1990 the contribution to total pollution emission in the atmosphere in the municipality of Venice (160,000 t/y) due to the industrial area of Porto Marghera was quite high (65%). In general the pollutant emissions in the municipality from point sources decreased in the period 1990-1993 (from about 104,000 t/y to 85,000 t/y). It is difficult to understand the implication of the discharge from the industrial activity of 1650 t/y in 1990 and 675 t/y in 1993 of carcinogenic substances.
- *Percentage of inhabitants exposed to day time noise level > 65 dB.* The indicator was calculated only for the city of Mestre since noise pollution does not represent a real problem for the historical centre of Venice. Almost the 30% of the population (about 50,600 inhabitants) of Mestre is exposed to noise level > 65 dB. In relation to a target of 0%, the current situation of this indicator appears unsustainable.

Evaluation of the indicators for water

For this theme three indicators were selected. They describe the domestic waste water treatment capacity, the impact of nutrient pollution carried by the drainage basin into the lagoon and the quality of the sea water in relation to bathing activity.

- *Percentage of inhabitants connected to the sewage system.* It is only possible to obtain an approximate evaluation of this indicator since the most recent available data for Mestre refer to September 1993. According to these data the situation of the mainland seems to be fairly good (74%). The historical centre of Venice has never been provided with a real sewage and treatment system. The situation is quite complex because the current state of the old pipes and septic tanks is unknown. It is possible to assume that the limited treatment capacity of the old system is lower than in the past [Comune di Venezia, 1994].
- *Yearly discharge of nitrogen and phosphorus released into the lagoon from the drainage basin.* The yearly maximum admissible nutrients load for the lagoon of Venice is about 3000 t/y for nitrogen and 400 t/y for phosphorus [Consorzio Venezia Nuova, 1993]. The current

situation is unsustainable since the real discharge of nutrients is about 7000 t/y for nitrogen and 830 t/y for phosphorus. The main nutrient pollution sources are: domestic discharge, agriculture and animal-breeding.

- *Yearly sea water quality class for bathing activity.* Since 1985 the sea water quality for bathing activity in the Venice littorals has been classified as good or excellent. Compared to a target of good quality the current situation of the indicator is sustainable. Besides this positive result, it is important to note that the coastline system is greatly threatened by other problems like diffuse urbanisation, dune destruction and erosion.

Evaluation of the indicator for the natural environment

- *Yearly number of migrating aquatic birds in the lagoon.* The indicator concerns the number of migrating birds present during winter in the lagoon. In the last 5 years the indicator has remained constant, with an average value of about 100,000. The importance of the lagoon ecosystem from a naturalistic prospective is confirmed by the fact that in the period 1993-1997 the bird population of the lagoon has always satisfied two criteria established by the Ramsar Convention for the protection of international important wetland [Ramsar, 1971]. The two criteria are: to regularly host at least 20,000 aquatic birds and to host at least the 1% of the world population of an aquatic bird species. The second criteria has been regularly satisfied in the lagoon of Venice at least by 5 species [Torricelli, 1997].

Evaluation of the indicators for the hydrogeological imbalance of the lagoon

Two indicators were chosen for this theme. They describe the problem of periodical floods of the city of Venice and of the lagoon islands and the erosion of the lagoon morphology.

- *Yearly number of exceptional high waters.* High water occurs when tide exceeds the lower level³ of the city of Venice (80 cm in S. Marco Square). Exceptional high water occurs when tide exceeds the level of 110 cm. Between the end of the 50s and the beginning of the 60s the indicator sharply increased, mainly as a consequence of eustasy [Carbognin, 1996], natural and artificial subsidence [Carbognin, 1981]. At the beginning of the century the frequency of

³ The levels are referred to the mean sea level measured in 1897 in Punta della Salute in Venice.

exceptional high water was 4-5 times per 10 years. The current frequency is much higher (30 times per 10 years) and the values of the indicator show an unsustainable situation for Venice and the lagoon. The high water problem actually represents a threat to the existence of the city of Venice that will become worsen if the negative scenario of rise in sea level due to climate change will be confirmed [IPCC, 1995].

- *Percentage of the surface of the lagoon covered by salt marshes.* The lagoon of Venice loses about one million m³ of sediments every year to the sea. The erosion of this environment is dramatically evident in the destruction of typical morphological structures as salt marshes, tidal creeks and mud-flats, in the deepening of the lagoon bed and in the reduction of channel depth. At the beginning of the century salt marshes covered the 17% of the lagoon surface. Due to erosion this percentage is now much lower (8.8%). Different human activities, as for example digging out of deep shipping canals, have speeded up the erosive process [Rinaldo, 1997]. The current situation is unsustainable with the objective of the protection of the lagoon environment. The specific target for the indicator could be the maintenance of the existing natural salt marshes and where possible the reconstruction of the destroyed ones.

INDICATOR	target, limit or comparison value	current situation	temporal trend	geographic context
QUALITY OF THE ENVIRONMENT				
1. Yearly per capita urban waste production	decreasing	☺ ☹	↗ ↘	city of Mestre city of Venice
2. Yearly percentage of sorted waste	15% before 1999 25% before 2001 35% before 2003	☹	↗	municipality
3. Yearly hazardous waste production	decreasing	?	?	municipality
4. Number of contaminated areas	0	☹	?	municipality
5. Yearly percentage of bad air quality days	5%	☺	↔	city of Mestre
6. Yearly 98 th percentile of SO ₂ daily concentration	< 250 µg/m ³	☺	↘	municipality
7. Yearly average of STP daily concentration	< 150 µg/m ³	☺	↔	municipality
8. Yearly 98 th percentile of NO ₂ hourly concentrations	< 200 µg/m ³ < 135 µg/m ³	☹	↔	municipality
9. Pollutant emission in the atmosphere	decreasing	?	?	municipality
10. Percentage of inhabitants exposed to day time noise level > 65 dB	0 %	☹	?	city of Mestre
11. Percentage of inhabitants connected to the sewage system	100 %	☹ ☹	?	city of Mestre city of Venice
12. Yearly discharge of N and P released into the lagoon from the drainage basin	3000 t/y of N 400 t/y of P	☹	?	lagoon
13. Yearly sea water quality class for bathing activity	good	☺	↔	coastline sea
14. Yearly number of migrating aquatic birds in the lagoon	maintenance of current natural stock	☺	↔	lagoon
15. Yearly number of exceptional high waters	0.5	☹	↗	city of Venice
16. Percentage of the surface of the lagoon covered by salt marshes	maintenance of current natural stock and enhancement of the reconstruction	☹	↘	lagoon

Table 1. Target, current situation, temporal trend and geographic context of the indicators concerning the quality of the environment.

Legend:

- ☺: current sustainable situation
- ☹: current intermediate or uncertain situation
- ☹: current unsustainable situation
- ↗: increasing temporal trend
- ↔: constant temporal trend
- ↘: decreasing temporal trend
- ↕: variable temporal trend

?: target, current situation or temporal trend not available

3.2. Quality of life indicators

The indicators of quality of life represent a measure of well-being and satisfaction level of a community. In the present research the chosen indicators were grouped in five classes. The first two concern problems linked to sustainability that are particularly acute in the considered area: the demographic decline and the housing condition. The other classes that complete the analysis of the quality of life of the Venice context are: education level, health condition and urban structure condition.

The table 2 lists the chosen indicators and for each of them reports a target, the current situation, the temporal trend and the geographic context for which the indicator is relevant.

Evaluation of the indicators for demographic condition

The demographic decline is a relevant problem in the studied area that is particularly evident in the historical centre of Venice which is depopulating and contributing to the transformation of the community. Due to the importance of this problem we decided to define a high number of specific indicators which are able to show the level and the causes of the decline.

All the indicators refer to the resident population and not to the real number of people living in the municipality that also includes temporary inhabitants such as non resident students and workers for whom estimates are not available.

- *Yearly percentage variation of the total population.* In the period 1981-1996 the indicator was always negative, showing a continuous decrease in the population of the municipality of Venice from 349,663 inhabitants in 1981 to 296,459 inhabitants in 1996 (-15%). In the same period the population decline in the historical centre was much higher and the number of inhabitants decreased from 93,958 to 69,906 (-25.5%). The values of the indicator for the overall municipality (average -1.1%) and for the only city of Venice (average -1.9%) were always lower than the national and regional values (average +0.8% and +1.3%).
- *Yearly percentage of people older than 65 in the total population.* The indicator shows that an ageing of the population is occurring in the municipality as a consequence of the demographic decline. In the period 1981-1996 the indicator continuously increased from 13.9% to 21.5%. The values were higher than the national and regional average (15%-16% in

1996). In the historical centre the problem is more acute and the indicator (20.4% in 1981 and 26.4% in 1996) was always greater than the municipal average. Forecast for the year 2005 confirms the increasing trend (24% in the municipality and more than 27% in the historical centre).

- *Yearly natural variation rate.* The indicator is defined by the difference between the birth-rate and the death-rate. In the period 1981-1996 the indicator was always negative and continuously decreased from -0.35% to -0.51%. The historical centre, as for the other demographic indicators, is characterised by a worse situation. In such context the indicator decreased from -0.66% in 1981 to -1.00% in 1996. The negative trend is mainly due to a decrease of the birth-rate, which is the main cause of the demographic decline. The values of the indicator measured in the municipality of Venice are lower than the mean value for the Veneto region (-0.04% in 1996).
- *Yearly migration rate.* The indicator is defined by the difference between the number of immigrants and the number of emigrants on the total population. In the period 1981-1996 the indicator was always negative with a variable trend (-0.35% in 1996), showing a situation opposite to the positive regional average values (0.30% in 1995) characterised by an increasing trend. In the municipality of Venice the number of emigrants decreased in the considered period but it was always greater than the number of immigrants.
- *Percentage of households with less than three members.* The indicator increased in the period 1981-1996 from 50% to 59%. Within the municipality, the historical centre is characterised by the higher values of the indicator (68% in 1996). The increase in the number of households with less than three components can be ascribed to the decrease of the birth-rate and to the increase of the number of old people. The indicator shows that a lower number of families (more than 3 components) forms each year.

An evaluation of the demographic decline in relation to sustainability is quite difficult. It is possible to assert that such decrease, mainly due to a reduction of the birth and the migration rates, could negatively influence the economic, social and cultural vitality of the system, in particular for the historical centre of Venice where the problem is more considerable. One visible effect of the demographic decline is the ageing of the population that can determine an increase in the social and health care demand from old people. Together with the population

decline the historical centre is also experiencing a change in the community structure: the number of real venetian people is decreasing meanwhile the number of temporary inhabitants - as students and workers - is increasing. The risk in the future is the depopulation and the denaturalisation of the community of the city of Venice. For these reasons we think that the indicators show an unsustainable situation for the demographic condition.

Evaluation of the indicator for education level

- *Literacy rate.* In 1991 (last available data) the indicator value was practically equal to the sustainable target of 100%. In the period 1971-1991 the indicator increased from 98.5% to 99.3%. In the same period the improvement in the education level was confirmed by the increase of the percentage of people with a high school diploma (from 7.4% to 21.2%) and of the percentage of people with an university degree (from 2.2% to 5.1%).

Evaluation of the indicators for housing condition

The housing shortage is a relevant problem in the municipality of Venice and it is clearly problematic in the historical centre where it constitutes one of the cause of emigration and consequently of demographic decline. Five indicators were selected for this theme. The first two describe the physical housing quality. Other two indicators analyse the housing market and the last one analyses the emergency caused by evictions.

For the unavailability of data it was not possible to calculate the number of houses that are completely or partially unused because not being rented or reserved for short period only for tourists. Also the increase of the housing demand by temporary inhabitants which is creating shortage problem for residents was not calculated for the same reason. We think that these are important indicators for the evaluation of the housing shortage problem in Venice that future investigation in this specific field should try to calculate.

- *Percentage of houses without one or more basic services.* As basic services we considered drinking water, bathroom, toilette and heating system. The current situation of the indicator seems to be sustainable. In 1991 (last available data) only the 5.5% of houses did not have at least one of the basic services and an insignificant percentage of houses (0.03%) did not have

all the considered services. In the same year the situation in the historical centre (8.1%) and in the littorals (10.0%) was worse than the one on the mainland (3.2%). Compared to 1981 the indicator has decreased.

- *Percentage of overcrowded houses.* The indicator was defined considering the number of people living in a house and the number of available rooms. In 1991 (last available data) only the 11% of houses were considered overcrowded. On the contrary the 20% of houses were considered under-utilised, mainly because the high number of per capita available rooms. The indicator generally shows a fairly good situation since 69 % of houses respected standard condition in 1991 (not overcrowded or under-utilised houses).
- *housing cost per square meter.* The values of the indicator in the city of Venice are much higher than those measured in Mestre and on the mainland and reach costs that are not affordable by families with an average income. The unsustainable situation is stressed by the comparison with other cities that always show lower purchasing cost. If the value of the indicator measured in 1996 in the city Venice is set equal to 100 the situation in the same year in the other considered cities is: 83 in Florence, 93 in Milan, 57 in Padova, 78 in Rome and 54 in Mestre.
- *Monthly cost of housing rent.* The indicator refers to a standard house of 90 m². Its spatial distribution is similar to the housing cost one and similar conclusion can be drawn. In the historical centre of Venice the monthly housing cost in 1996 varied between 1.2 and 1.6 million liras/ 90 m². If the value of the indicator measured in 1996 in the city of Venice is set equal to 100 the situation in the same year in other cities for central areas is: 91 in Florence, 113 in Milan, 77 in Padova, 122 in Rome and 66 in Mestre. For peripheral areas the comparison values are: 95 in Florence, 82 in Milan, 66 in Padova, 79 in Rome and 63 in Mestre. The housing market in the city of Venice is influenced by the high demand from the non-residents.
- *Number of evictions.* The indicator highlights a current unsustainable situation since the number of evictions is quite high if compared with the situation in other cities of the same region. In the period 1991-1995 2,065 evictions were executed (852 in the city of Venice and 1,213 in Mestre). In the same period the indicator showed an increasing trend.

Evaluation of the indicators for health condition

For this theme two indicators were considered. The first one represents a measure of the availability of hospital facilities. This indicator is particularly relevant in a city like Venice where the ageing of the population bring about an increase in the health care demand. The second indicator represents the potential risk for population contracting tumours.

- *Number of inhabitants per available hospital bed.* Even if data for the calculation of the indicator is available only for the year 1992, the indicator can be considered representative of the current situation since availability of hospital facilities have not been greatly improved in recent years. The comparison of the value of the indicator for the municipality of Venice with other local and regional values shows an unsustainable situation for the studied area. In 1992 in the municipality of Venice the number of inhabitants per available hospital bed was equal to 96 whereas in the same period the situation in other contexts was much better: 49 in Treviso, 62 in Padova and 33 as average value in the Veneto region.
- *Yearly number of tumours per 100,000 of inhabitants.* The indicator was standardised in relation to the age distribution of the population⁴. In the periods 1987-1989 and 1990-1994 the values of the indicator in the historical centre of Venice were generally higher than those measured in Mestre and in other local contexts in the Veneto region. For example in 1990-1994 the following average values were registered for men: 394 in the city of Venice, 380 in Mestre, 395 in Asiago, 358 in Treviso, 344 in Bassano and 334 in Vicenza (regional average 372). The values of the indicators for women were smaller than those measured for men, but even in this case the city of Venice showed the worst situation. Even if it is difficult to define the causes of the higher number of tumours per 100,000 inhabitants registered in the city of Venice and partially in Mestre, it is possible to assert that the higher risk of contracting tumours in Venice is a cause of unsustainability and of a worsening of the quality of life. A future reversal of the current increasing trend can be considered a positive signal towards more sustainable conditions.

Evaluation of the indicators for urban structure

For the urban structure two indicators were chosen. The first one is the cycle track length. Even if this indicator is not able to evaluate the real use of the bicycle as an alternative urban transport, it is useful to define the availability of the urban structures that make the use of this transport easier and safer. The second indicator evaluates the availability of public urban parks and gardens. This indicator is very important since the shortage of these recreational spaces represents a great problem in the studied area.

- *Cycle track length.* The indicator was calculated only for the city of Mestre. The current cycle track extension of 16 km is completely inadequate to guarantee a safe and easy use of the bicycle as an alternative urban transport. One positive signal is the increasing trend of the indicator. In the period 1995-1997 the cycle track length doubled.
- *Per capita square meters of public urban parks and gardens.* With the exception of some specific areas (as for example the Giudecca island and the littorals) the situation of the indicator is critical and unsustainable. As target it is possible to consider the minimum standard of 9 m²/p fixed by the Italian legislation or the European average of 15 m²/p [EEA, 1995]. The values measured in the historical centre of Venice (3.2 m²/p) and in Mestre (5.2 m²/p) were quite far from the targets and even smaller than the national average value for 100 most important Italian cities (6.0 m²/p) [Legambiente, 1997]. The situation is worsened by the fact that public parks and gardens are concentrated in specific areas and according to the European Environmental Agency only the 50% of the population lives within a walking distance of 15 minutes from these areas.

⁴ For the calculation of the indicator we considered all tumours besides dermatological tumours with the exception of melanomas.

INDICATOR	target, limit or comparison value	current situation	temporal trend	geographic context
QUALITY OF LIFE				
17. Yearly percentage variation of the total population	comparison with regional and national values	☹	↕	municipality
18. Yearly percentage of people older than 65 in the total population	comparison with regional and national values	☹	↗	municipality
19. Yearly natural variation rate	comparison with regional value	☹	↘	municipality
20. Yearly migration rate	comparison with regional value	☹	↕	municipality
21. Percentage of households with less than three members	?	☺	↗	municipality
22. Literacy rate	100%	☺	↗	municipality
23. Percentage of houses without one or more basic services	0%	☺	↘	municipality
24. Percentage of overcrowded houses	?	☹	↘	municipality
25. Housing cost per square meter	comparison with other local contexts	☹ ☺	? ?	city of Venice city of Mestre
26. Monthly cost of housing rent	comparison with other local contexts	☹ ☺	? ?	city of Venice city of Mestre
27. Number of evictions	comparison with other local contexts	☹	↗	municipality
28. Number of inhabitants per available hospital bed	comparison with other local contexts	☹	?	municipality
29. Yearly number of tumours per 100,000 of inhabitants	comparison with other local contexts	☹	↗	municipality
30. Cycle track length	increasing	☹	↗	city of Mestre
31. Per capita square meters of public urban parks and gardens	9 -15 m ² /p	☹	?	municipality

Table 2. Target, current situation, temporal trend and geographic context of the indicators concerning the quality of life.

Legend:

- ☺: current sustainable situation
- ☺: current intermediate or uncertain situation
- ☹: current unsustainable situation
- ↗: increasing temporal trend
- ↕: constant temporal trend
- ↘: decreasing temporal trend
- ↕: variable temporal trend
- ?: target, current situation or temporal trend not available

3.3. Quality of economic development indicators

Indicators of economic development were selected in order to analyse the efficiency of the production and service sectors. We also thought that it was very important to evaluate the quality of the economic development in relation to its influence on the quality of the environment and that of life. The greatest difficulty we encountered in the calculation of these indicators was the unavailability of the data expressing the economic performance at a local level. Most of the economic data are generally collected at the provincial or the regional level.

The indicators concerning the quality of economic development are grouped into 6 classes. The first four classes analyse general sustainability issues: level of employment, structure of local economy, transport and resource consumption. The last two classes refer to issues that have a specific importance in the studied area: retail trade activity and tourism.

The table 3 lists the chosen indicators and for each of them reports the target, the current situation, the temporal trend and the geographic context for which the indicator is relevant

Evaluation of the indicators for level of employment

For this theme two indicators were chosen. The first one analyses the problem of unemployment in the municipality of Venice. The indicator that is normally used in this context is the unemployment rate defined as the ratio between the number of people looking for a job and the work force. Data about the work force was not available at a local level and a slightly different indicator was calculated. The chosen indicator is not as precise as the unemployment rate but is anyway useful in evaluating the general conditions of the unemployment problem. The second indicator analyses the structure of the new engagements.

- *Level on unemployment.* The indicator is expressed by the ratio between the number of unemployed persons and the population between 15 and 65 (population of working age). In the period 1992-1994 the indicator increased from 6.4% to 9.0% and in the following years (1994-1996) it showed a constant trend. In the considered period Venice was characterised by values generally greater than those measured in other cities of the Veneto region with the exception of the last investigated year (1996) when values of the indicator were more similar: Venice (8.9%), Treviso (7.6%), regional average (8.0%). Only the city of Padova showed a

smaller value even in 1996 (about 4.0%). The indicator kept always below the national average (about 16.2% in 1996). The distribution of the indicator at a sublocal level is only available for February 1997 and shows higher values in the littorals (12.4%). The mainland (9.0%) and the historical centre of Venice (8.4%) are characterised by values similar to the municipal average (9.1%). In conclusion it is possible to say that even if Venice is characterised by some of the highest values registered in the Veneto region the situation is not completely unsustainable since the last measured data (1996) is similar to those of other cities and since in the period 1994-1996 the temporal trend of the indicator remained constant.

- *Distribution of new engagements.* A correct evaluation of the indicator is difficult since data is only available for the period May 1996 - February 1997. The indicator shows a critical situation because most of the new engagements (about 50%) are for a limited time period. Only the 36% of the new engagements can be considered permanent engagements. By the available data it is difficult to assess whether this is a specific situation of the Venice labour market where the tourist sector has a great influence (27% of new engagements) requiring a lot of people only for a limited time period.

Evaluation of the indicator for structure of local economy and employment

For this specific theme two indicators were selected. The first one analyses the variation of the number of people employed in the material production activities and in the service sectors. The second indicator evaluates a specific problem of the economy of the studied area: the crisis of the industrial area of Porto Marghera that has caused a marked reduction of available jobs in the municipality.

- *Variation of the number of employed people.* The indicator is defined by the difference between the number of employed people in 1996 and in 1991. The indicator shows a decrease of this number in the sectors of material production (-19% equal to 8754 workers) and a moderate increase in the service sectors (1.4% equal to 716 workers). In particular the tourism sector has continuously increased in the past few years. In total, in the investigated period, the number of employed people decreased of 8.2% (7,858 workers). This negative trend is mainly due to the economic crisis and to the reorganisation of Porto Marghera industries [Rispoli, 1997]. It is possible to assume that in future the number of people employed in the material

production sectors will progressively decrease whereas the number of people employed in the service sectors will increase [Rullani, 1997]. Even if it is not possible to define a target for the indicator we can assert that the decreasing trend of the indicator and the specialisation of the Venice economy characterised by an increasing importance of the tourism sector are not sustainable.

- *Number of people employed in the industrial area of Porto Marghera.* The economic crises of the 70s and of the end of the 80s of the industries of Porto Marghera caused a marked reduction of the indicator which continuously decreased from 32,980 in 1965 to 13,927 in 1996. Chemical, metallurgical and oil industries are the sectors for which the problem was particularly acute. Besides the economic crisis the industrial activity has often, especially in the past, conflicted with the protection of the environment and with other human activities creating conditions of unsustainability. A future sustainable development of the industrial area will be possible only if low-polluting technologies are to be adopted, contaminated areas will have to be sanitised and existing industrial activities need to be re-structured or re-converted into other activities [Rispoli, 1997]. Positive signals are represented by the recent creation of the Technological and Scientific Park in the area of the industrial zone and by the constant trend shown by the indicator in the last few years.

Evaluation of the indicators for transport

Four indicators were selected to analyse the transport category. The first two focus on the activity of the Venice harbour which plays a vital role in the local economy. The analysis of this activity is a relevant issue in evaluating the local sustainability since maritime traffic is one cause of enhancement of erosion of the lagoon morphology. The resolution of the evident conflict between this important economic sector and the protection of the lagoon environment will be difficult but necessary. The other two indicators evaluate the growing economic importance of the Venice airport. From a sustainability point of view it would have been interesting to analyse the modal split of transport of goods and passengers in order to evaluate whether more sustainable forms of transport, such as railroads, are increasing and less sustainable ones, such as roads, are decreasing. Data for a complete evaluation of the transport modal split was not available.

- *Yearly percentage variation of maritime traffic of goods.* In the period 1985-1995 the total maritime traffic of goods in the Venice harbour maintained approximately constant but its composition changed. The weight of the commercial traffic in respect to the total maritime traffic of goods increased from 16% to 29% whereas the weights of the industrial and oil traffic decreased respectively from 37% to 30% and from 47% to 41%. This change could be considered positive in a sustainable perspective since a possible oil spill would be deadly for the lagoon environment and for the city of Venice. Regardless a conclusive evaluation of the indicator is not possible because the harbour activity negatively influences the hydrogeological imbalance of the lagoon enhancing the erosive process. The solution of the conflict between the maritime traffic in the lagoon and the protection of the lagoon ecosystem is a crucial element of the sustainable development of Venice.
- *Yearly percentage variation of maritime traffic of passengers.* In the period 1984-1995 the indicator was always positive showing an increase in maritime traffic of passengers. The highest growth was registered in the last four investigated years during which the average value of the indicator was +30.2%. The increase of the maritime traffic of passengers can be considered a positive signal for the improvement of local economic conditions and for the enhancement of job opportunities. Nevertheless a conclusive evaluation of the indicator in a sustainable perspective is not possible for the same reasons discussed in the analysis of the previous indicator.
- *Yearly percentage variation of air traffic of goods.* In the period 1989-1995 the indicator was always positive showing an increase of the air traffic of goods in the Venice airport. The indicator was only negative (-2%) in 1996 mainly due to the reorganisation of the airport infrastructures. In general in the period 1993-1996 the total air traffic of goods increased from 6110 t/y to 8923 t/y (+46%). The positive trend of the indicator shows an improvement of an economic sector that was in crisis until few years ago. From a sustainability point of view it would be interesting to analyse whether the increase of maritime and air traffic of goods corresponds to a decrease of the road traffic of goods.
- *Yearly percentage variation of air traffic of passengers.* In the period 1992-1997 the air traffic of passengers in the airport of Venice increased from 1,860,868 persons to 2,971,513 persons (+60%). The highest yearly percentage variation was measured in 1997 (+12.5%). This growth, together with the increase of the air traffic of goods, represents an improvement

of the local economic conditions and confirms the relevance of the Venice airport. At a national level this airport is the fourth in importance. Besides these considerations it is difficult to say whether the indicators concerning air traffic highlight sustainable conditions or not.

Evaluation of the indicators for resource consumption

For this theme three indicators were developed. The first two evaluate the energy consumption and the third one the water consumption.

- *Yearly per capita gas consumption.* Per capita gas consumption in 1996 in the municipality of Venice (about 970 m³/y/p) was very similar to the national average value and lower than the regional one (about 1480 m³/y/p). Between 1990-1996 the indicator kept generally constant in Venice whereas it increased in the Veneto region. Special law 171 of the 16th April 1973 [L. 171/1973] imposed the use of gas as fuel for domestic heating in Venice in order to protect the city from atmospheric pollution. Today, domestic heating represents the most important use of gas. The moderate-high level of gas consumption (same as national average) and the great diffusion of gas domestic heating represent sustainable conditions due to the low environmental impact of this fuel.
- *Yearly per capita electric energy consumption.* In the period 1981-1996 the values of the indicator in the municipality of Venice (about 6300 kWh/y/p in 1996) were much higher than national (about 3800 kWh/y/p in 1996) and regional (about 4200 kWh/y/p in 1996) average values. Although the measured consumption does not include the self-production of electric energy of the industries the high values are mainly due to the industrial activity of Porto Marghera which requires large amounts of energy. The indicator shows a highly variable trend mainly due to the influence of the inconstant industrial consumption of electric energy. In the municipality public electric energy is totally produced by two power plants that use fossil fuels (coal and oil). The high consumption and the great use of polluting fossil fuels for electric energy production represent unsustainable conditions for the local context.
- *Yearly per capita water consumption.* The yearly per capita water consumption for domestic use increased until 1990 and slightly decreased in the period 1991-1996 (-10%). In 1996 the domestic consumption in Venice (148 m³/y/p) was higher than those measured in Padova (138 m³/y/p) and Treviso (99 m³/y/p). The yearly per user water consumption for

industrial use greatly decreased in the period 1979-1996 from 1,022,300 m³/y/u to 429,500 m³/y/u. This decrease was mainly due to the crisis of the industrial activity of Porto Marghera and therefore does not represent a positive signal. Moreover the current situation can not be considered sustainable because the domestic water consumption in the municipality of Venice is very high. For unavailability of data it was not possible to evaluate the water consumption for agricultural use.

Evaluation of the indicator for retail trade activity

- *Percentage variation of number of stores.* The indicator represents the percentage variation of the number of stores between the years 1989 and 1995. In the municipality the total number of stores increased from 6412 to 6694 (+4.4%). In the investigated period, the historical centre of Venice (-8.5%) and the city of Mestre (-13.5%) were characterised by a progressive closing of grocery stores. This was principally due to the demographic decline in population which reduced consumption and in particular to the increase of the tourist demand which contributed to enhance the number of stores for tourists (mainly clothing and souvenir stores). In the period 1989-1995 clothing stores increased by 9.2% in the city of Venice and by 13.7% in the city of Mestre and the number of other stores increased respectively by 9.3% and 11.7%. These data highlight an unsustainable situation since a high number of stores are specialising to satisfy the increasing tourist demand for goods and the number of stores for residents are decreasing. The situation is particularly critical in the historical centre of Venice where some areas are not provided with grocery stores for residents; costs are higher and supermarkets are very few.

Evaluation of the indicators for tourism

Tourism is one of the most important economic activities in Venice and it creates many job opportunities. Besides, tourism is also responsible for a great impact on the physical structure, the environment and the social life of the historical centre of Venice where the majority of tourists concentrate [Van de Borg, 1997, Canestrelli 1991]. The first indicator attempts to quantify the dimension of this impact in relation to the number of inhabitants in the historical

centre. The second indicator analyses the quality of existing hotels. The evaluation of this indicator is important because a better hotel quality can contribute to enhance the number of overnight tourists and to reduce the number of tourists that visit the historical centre of Venice only for one day (“day tourists”). “Day tourists” normally have a greater physical and environmental impact on the city and a minor economic contribution for the local economy. Moreover they only visit the most famous areas of the historical centre as Piazza S. Marco and Rialto bridge enhancing congestion problems.

- *Yearly average of daily number of tourists per 100 inhabitants.* The number of tourists includes both the overnight visitors and the “day tourists”. The data refers only to the year 1992 since other estimations of the number of “day tourists” are not available. The indicator shows a critical and unsustainable situation for the historical centre of Venice where in 1992 there were 89 tourists per 100 inhabitants. The high number of tourists has a great impact on the physical structure and on the environment of the city. In the same year other European tourist cities were characterised by much lower values of the indicator: Salzburg 36, Bruges 24, Oxford 12, Florence 10, Aix-en-Provence 8 and Amsterdam 6. The indicator represents an yearly average; during some periods of the year the number of tourists per 100 inhabitants can be greater than the mean value.
- *Percentage of hotels with good quality services.* The indicator refers to the historical centre of Venice and the littoral of Lido. Even if in the period 1989-1994 (only available data), there had been a little improvement of the indicator, the situation in 1994 was still critical. Only 33% of the hotels had facilities for disabled people, 41% a restaurant, 36% heating in rooms, 32% a telephone in rooms and 22% a television in rooms. It is likely that the situation in the last four years has only slightly improved.

INDICATOR	target, limit or comparison value	current situation	temporal trend	geographic context
QUALITY OF ECONOMIC DEVELOPMENT				
32. Level on unemployment	comparison with regional and other local values	☹	↔	municipality
33. Distribution of new engagements	?	?	?	municipality
34. Variation of the number of employed people	?	☹	↘	municipality
35. Number of people employed in the industrial area of Porto Marghera	constant or increasing trend	☹	↘	Porto Marghera
36. Yearly percentage variation of maritime traffic of goods	?	?	↔	Venice harbour
37. Yearly percentage variation of maritime traffic of passengers	?	?	↗	Venice harbour
38. Yearly percentage variation of air traffic of goods	?	?	↗	Venice airport
39. Yearly percentage variation of air traffic of passengers	?	?	↗	Venice airport
40. Yearly per capita gas consumption	comparison with regional and national values	☺	↔	municipality
41. Yearly per capita electric energy consumption	comparison with regional and national values	☹	↕	municipality
42. Yearly per capita water consumption	comparison with other local contexts	☹	↘	municipality
43. Percentage variation of number of stores	maintenance of current number of grocery stores	☹	?	municipality
44. Yearly average of daily number of tourists per 100 inhabitants	comparison with other tourist cities	☹	?	city of Venice
45. Percentage of hotels with good quality services	100%	☹	↗	city of Venice

Table 3. Target, current situation, temporal trend and geographic context of the indicators concerning the quality of economic development.

Legend:

- ☺: current sustainable situation
- ☹: current intermediate or uncertain situation
- ☹: current unsustainable situation
- ↗: increasing temporal trend
- ↔: constant temporal trend
- ↘: decreasing temporal trend
- ↕: variable temporal trend
- ?: target, current situation or temporal trend not available

4. CONCLUSIONS

The investigation briefly discussed in this paper produced a final set of 45 indicators of sustainable development for the municipality and the lagoon of Venice. Sixteen of them concern the quality of the environment, fifteen the quality of life and other fourteen the quality of economic development of the studied area. The selected indicators analyse different problems of the three main aspects of sustainability: environment, society and economy. In our investigation we tried to treat these aspects not as separated fields but in an integrated way. For each indicator we defined the state of sustainability in the municipality of Venice in relation to specific objectives or targets. This was not possible for all the selected indicators, in particular for those concerning the quality of economic development. The result of such evaluation is summarised in tables 1, 2, and 3.

In the selection procedure of the indicators different criteria were considered. The most important of them were: measurability, simplicity, availability of data and relevance of these indicators to Venice. The aim of the research was not only the definition of an optimal set of indicators of sustainable development for the considered geographic context but also their calculation. Therefore availability of data assumed a particular role in the selection of the final set. Some indicators that had been previously chosen for their local relevance and importance, were not considered in the final set because data for their calculation was either unavailable or only partially available. An important contribution in the selection procedure derived by the Agenda 21 experience implemented in Venice during the same time period as our research. Even if for various reasons it was not possible to adopt a participatory approach in the selection of the indicators we thought it was very important to consider what people expressed during the Agenda 21 meetings and the environmental, social and economic problems perceived as priorities by the participants were taken in great consideration.

As explained in the introduction and in the methodological approach we are aware that the final set of indicators presented in this paper could not be considered conclusive mainly because it was not possible to calculate some relevant indicators for the unavailability of local data and because we think that a discussion with people on the selected indicators is necessary. It is in fact very important that the chosen indicators are perceived as meaningful and relevant for the local context by the population and by the actors interacting at various levels with the

different aspects of sustainability. It is our aim to discuss the result of the present research within the context of the Agenda 21 if a second phase is to be started. This would enable us to redefine the final set of indicators in relation to the real priorities expressed by the population and the local actors.

We are also analysing in which way the present research can be useful for local policy makers. For this purpose we are writing an executive summary of the detailed report, from which this article was produced, that should represent an instrument for local administrators. The executive summary will be distributed to different policy makers in order to receive back their comments and suggestions.

APPENDIX 1

LIST OF BODIES INVOLVED IN THE COLLECTION OF DATA

This appendix lists the bodies that were contacted for the collection of data. For each body the data that were requested are specified.

Quality of the environment

Chamber of Commerce: hazardous waste production;

Consorzio Venezia Nuova: subsidence, eustasy, surface of the lagoon and of the drainage basin, salt marshes surface, erosion, bathymetry of the lagoon, yearly discharge of nitrogen and phosphorus released into the lagoon from the drainage basin;

Municipality of Venice: high water events (*Tide Forecasting Centre*), air pollution, urban noise pollution (*Environmental Department*), percentage of inhabitants connected to the sewage system (*Public Works Department*);

National Body for Environment and Energy (ENEA): pollutant emission in the atmosphere;

Porto Marghera Industrial Zone Body: air pollution, industrial waste water treatment capacity, industrial noise pollution;

Province of Venice: air pollution, pollutant emission in the atmosphere, hazardous waste production and disposal, number of contaminated areas (*Environmental Department*) number of migrating and nesting birds in the lagoon (*Hunting and Fishing Department*);

Provincial Agricultural Body: agricultural pollution;

Public Hydraulic Service Company (ASPIV): domestic waste water treatment capacity;

Venice Environmental Service Company (AMAV): urban waste production and disposal, percentage of sorted waste;

Veneto Regional Authority: sea water quality for bathing activity;

Water Authority of Venice: high water events;

Quality of life

Health Ministry: number of available hospital beds;

Local Social Health Unit: numbers of tumours;

Municipality of Venice: cycle-track length (*Public Works Department*), public urban parks and gardens surface (*Public Gardens and Parks Office*), demographic data, level of education data (*Statistic Department*), housing condition data (*Housing Observatory*);

Venice Environmental Service Company (AMAV): public urban parks and gardens surface;

Quality of economic development

Airport of Venice: air traffic of goods and passengers;

Chamber of Commerce: number of employed people;

Coses: spatial distribution of the level of unemployment, number of new engagements;

Censis: number of hotels with good quality services;

Industrial Waterworks Users Consortium: water consumption for industrial use;

Italgas (Venezianagas): gas consumption;

National Body for Electric Energy: electric energy consumption;

Port Authority: maritime traffic of goods and passengers;

Porto Marghera Industrial Zone Body: Number of people employed in the industrial area of Porto Marghera;

Public Hydraulic Service Company (ASPIV): water consumption for domestic use;

UNESCO: number of tourists per 100 inhabitants;

Venice S.p.A.: number of stores;

Venice Agency for the Promotion of Tourism: number of overnight tourists;

Veneto Region Employment Agency: level of unemployment;

APPENDIX 2

PROPOSAL FOR NEW INDICATORS OF SUSTAINABLE DEVELOPMENT FOR VENICE

The present list contains those indicators of sustainable development which had been previously chosen for their local relevance and importance and that were not considered in the final set mainly because data for their calculation were either unavailable or only partially available. We thought it was important to include the list because in a future investigation the following indicators could be used to integrate the set discussed in this paper. In the extensive report of the research, for each indicator the methodology for its calculation and in some cases the possible sources of data are discussed.

Quality of the environment indicators

1. Percentage of agricultural land in the lagoon drainage basin cultivated with biological methods;
2. Percentage of high natural value areas under real protection;
3. Surface of the lagoon covered by phanerogams;
4. Ratio between the yearly number of hunted individuals of a specific aquatic bird species and the yearly number of individuals of the same species after the hunting season;
5. Number of companies under threat of industrial accident of significant magnitude;
6. Number of industrial accidents causing pollution or risky conditions for workers or for the population;
7. Drinking water quality;

Quality of life indicators

8. Percentage of drug addicts in total population;
9. Percentage of alcoholics in total population;
10. Percentage of people living in conditions of poverty;
11. Percentage of inhabitants involved in voluntary associations;
12. Percentage of schools and education centres that provide environmental education programs;
13. Yearly per capita number of urban trips using public transport;

- 14. Quality of cinemas theatres;
- 15. Yearly number of criminal acts;

Quality of economic development indicators

- 16. Dynamics of enterprises: birth rate and death rate;
- 17. Yearly number of work-related accidents;
- 18. Per capita income;

REFERENCES

- Canestrelli, E. and Costa, P. (1991) "Tourist carrying capacity, a fuzzy approach", *Annals of Tourism Research*, vol. 18, pp. 295-311;
- Carbognin, L., Gatto, P. and Mozzi, C. (1981) "La riduzione altimetrica del territorio veneziano e sue cause", Istituto Veneto di Scienze, Lettere e Arti, *Comm. Studio per la difesa di Venezia*, vol. VIII, 1981;
- Carbognin, L. and Taroni, G. (1996) "Eustatismo a Venezia e Trieste nell'ultimo secolo", Istituto Veneto di Scienze Lettere e Arti, *vol. CLIV*, pp. 281-298;
- Cogo, V. (1997) "Gli indicatori di sostenibilità: primi risultati di una ricerca per Venezia", *Working Paper* 10.97, Fondazione Eni Enrico Mattei, Venezia;
- Comune di Venezia (1994) "*Piano programma degli interventi integrati per il risanamento igienico ed edilizio della città di Venezia*";
- Consorzio Venezia Nuova (1993) "Modelling and calculation of nitrogen and phosphorus transport in the drainage basin of the lagoon" *Working Section* n.30, final report;
- Dente, B., Griggio, C., Mariotto, A. and Pacchi, C. (1997) "Governare lo sviluppo sostenibile di Venezia: elementi per un percorso di progettazione istituzionale", *Working Paper* 2.97, Fondazione Eni Enrico Mattei, Venezia;
- D.L. 5.02.1997, n.22, "Attuazione delle direttive 91/156/CEE sui rifiuti pericolosi e 94/62/CEE sugli imballaggi e sui rifiuti da imballaggio", Suppl. ord. alla *Gazzetta Ufficiale* Serie gen. – n.38 del 15.02.1997;
- D.M. 15.04.1994, "Norme tecniche in materia di livelli e di stati di attenzione e di allarme per gli inquinanti atmosferici nelle aree urbane, ai sensi degli art. 3 e 4 del D.P.R. 24 maggio 1988, n.203 e dell'art. 9 del D.M. del 20 maggio 1991", *Gazzetta Ufficiale* Serie gen. – n.107 del 10.05.1994;
- D.M. 25.11.1994, "Aggiornamento delle norme tecniche in materia di limiti di concentrazione e di livelli di attenzione e di allarme per gli inquinamenti atmosferici nelle aree urbane e disposizioni per la misura di alcuni inquinanti di cui al decreto ministeriale 15 aprile 1994", *Gazzetta Ufficiale* Serie gen. – n.290 del 13.12.1994;

- D.P.C.M. 28.03.1983, “Limiti massimi di accettabilità delle concentrazioni e di esposizione relativi ad inquinanti nell’aria dell’ambiente esterno”, Suppl. ord. alla *Gazzetta Ufficiale* Serie gen. – n.145 del 28.05.1983;
- D.P.R. 24.05.1988, n. 203, “Attuazione delle direttive CEE numeri 80/779, 82/884, 84/360 e 85/203 concernenti norme in materia di qualità dell’aria, relativamente a specifici agenti inquinanti, e di inquinamento prodotto dagli impianti industriali, ai sensi dell’art. 15 della legge 16 aprile 1987, n.183”, Suppl. ord. alla *Gazzetta Ufficiale* Serie gen. – n.140 del 16.06.1988;
- EEA, European Environmental Agency (1995) “*Europe s environment, the Dobbris assessment*” pp. 270-285;
- Holmberg, J. and Sandbrook., R. (1992) “Sustainable development: what is to be done?”, in J. Holmberg (ed.) *Policies for a Small Planet*, Earthscan, London, pp. 19-38;
- IIUE, the International Institute for the Urban Environment (1995) “*The European Sustainability Index Project*”, IIUE Delft;
- IPCC, Intergovernmental Panel on Climate Change (1995) “*Intergovernmental panel on climate change second assessment report*”, J. Houghton ed.
- L. 16.04.1973, n.171, “Interventi per la salvaguardia di Venezia”, *Gazzetta Ufficiale* n.117 del 8.05.1973;
- Legambiente and Istituto Ambiente Italia (1997) “*Ecosistema urbano 1997 di Legambiente, quarto rapporto sulla qualità ambientale dei comuni capoluogo*”, Ed. Ambiente;
- Maclaren, V. M. (1996) “Urban sustainability reporting”, *Journal of the American Planning Association*, vol. 62, n.2, pp. 184-202;
- Musu, I. (1997) “Lo sviluppo sostenibile di Venezia nell’ottica dell’Agenda 21”, *Working Paper* 1.97, Fondazione Eni Enrico Mattei, Venezia;
- Musu, I., Ramieri, E. and Cogo, V. (1998) “Indicatori di sostenibilità: strumenti per l’Agenda 21 a Venezia” *Working paper* 1.98, Fondazione Eni Enrico Mattei, Venezia;
- Ramsar (1971) “*The convention on wetlands of international importance especially as waterfowl habitat*”, 2 February 1971, Ramsar, Iran;
- Rinaldo, A. (1997) “Equilibrio fisico e idrogeologico della laguna”, *Working Paper* 9.97, Fondazione Eni Enrico Mattei, Venezia;

- Rispoli, M., Stocchetti, A. and Di Cesare, F. (1997) “ La produzione materiale nel Comune di Venezia”, *Working Paper* 5.97, Fondazione Eni Enrico Mattei, Venezia;
- Rullani, E. and Micelli, S. (1997) “La produzione immateriale a Venezia: prospettive e problemi aperti” *Working Paper* 8.97, Fondazione Eni Enrico Mattei, Venezia;
- Torricelli, P., Bon, M. and Mizzan L. (1997) “Aspetti naturalistici della laguna e la laguna come risorsa”, *Working Paper* 3.97, Fondazione Eni Enrico Mattei, Venezia;
- UNCED, United Nations Conference on Environment and Development (1992), “*Earth Summit Agenda 21, the United Nation Programme of Action from Rio*”, chapter 40.4;
- Van der Borg, I. and Russo, P. (1997) “Lo sviluppo turistico a Venezia: analisi territoriale e scenari di sostenibilità”, *Working Papers* 7.97, Fondazione Eni Enrico Mattei, Venezia;
- Venezia Ricerche (1997) “*Progetto Agenda 21 locale per Venezia. Rapporto Finale*”;
- W.E.C.D., World Commission on Environment and Development (1987). “*Our common future*”, Ed. Oxford University Press, 1987, Oxford;