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Report of Task 1 - Characterization and Diagnosis

Relevant data and information for a comprehensive conservation planning in small islands

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Conteúdo

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0 - Foreword

Islands build a particularly difficult challenge for nature conservation and sustainable development policies.

This is due to the ecological isolation and the impossibility to ensure naturally the genetic exchanges that can ensure minimal viable populations for the different target species.

Simultaneously the scarcity of economical resources (particularly space) puts a large pressure on natural areas and habitats endangering even more their survival due to direct destruction or fragmentation.

Therefore nature conservation policies must search different approaches from those of the continent where ecological interactions and ecological restoration approaches have a much larger chance of success

These approaches must be focused on two main perspectives:

- integrated management of all classified areas
- integration of that management concept in the frame of a consensual management of the entire island balancing all interests (social, economical and environmental)

In an Island environment, with strictly limited resources, consensual management approaches are of critical importance. Therefore, the ability to sample all information in a coherent framework where all evaluation procedures can be lead in a reproducible way with a comprehensive system of reference, allows an active involvement of all stakeholders in the development of the best solutions for each site and moment and the permanent reevaluation of those solutions.

It is critical that a conservation policy and conservation management do not build a burden to the inhabitants and economy of the island. On the contrary.

This is only achievable with their active involvement trough knowledge and experience exchange as well as practical involvement in the management and improvement of the entire islands, ensuring their individual benefits and maintaining their autonomy, individuality and cultural particularities.

1 - Ecological characteristics and relevant conservation challenges in islands

Islands are specific areas of land separated from a much larger mainland or other islands by a water barrier reducing accessibility and linkage, but also protecting islands biotas from certain mainland impacts such as predation, competition, and disease (Walter, 2004). They represent only 5% of the global land area, but include about one-third of the world threatened species.

Island constitutes particular biotopes with very different ecological characteristics and dynamic patterns when compared with mainland ecosystems (Tab. 1.1).

Tab. 1.1 - Main factors determining biotic existence on oceanic islands and contents (Walter, 2004, pp. 184 and 185)

Oceanic Islands	**Continents**
Evolution in Oceanic islands	*Evolution in continents*
Isolation	No or temporary geographic isolation
Small size	Huge connected area
Protection	Exposure to diffuse physical extinction factors of mainland
Natural selection in island "theater"	Exposure to diffuse biotic extinction factors of mainland
Adaptation to island environment	Natural selection in mainland environment
	Adaptation to mainland "theater"
Functional insularity	*Functional continentality*
Limited landscape diversity	Continental taxa, characters, niches, diversity, rarity, and complexity
Disharmonic biotic communities	
Survival of old relict taxa	Highly dynamic geographic area over time
Depauperate species richness	High connectivity or linkage (source-sink, met, contiguous)
Lower predator diversity	High competition
Lower disease and parasite diversity	High predation
Generalists habits and niches	Often large territories
Modified morphologies	Often huge range size
Unique radiations	Considerable environmental uncertainty possible
Endemic taxa, unique life forms	
Restricted range	

These differences involve structural, functional and evolutionary dimensions, determining that, on its origin (before its human colonization), islands presented completely different ecological dynamics as continental "fragments" (in the sense of isolated patches and therefore compared to islands in the frame of the biogeographic theory (MacArthur and Wilson, 1967) and the successive developers of the Equilibrium Theory of Island Biogeography applied to mainland isolated patches (for further references see Walter, 2004)) (Tab. 1.2).

They are also crucial to understand the major factors affecting conservation policies in islands, and particularly in small islands.

Tab. 1.2 - Differences between an oceanic island and a continental habitat fragment (Walter, 2004, pp. 189)

Property or Process	Island	Fragment
Geography	Isolated piece of land surrounded by 1000 km of water in all directions	Broken off piece of a once large habitat or land unit on the mainland
History	Millions of years old	Several decades old
Areal dynamics	Stable in ecological time	Sudden shrinkage or gradual contraction and separation from other habitat patches
Edge	Saltwater matrix	Uniform or diverse types of habitats surround the fragment that differ from it
Ecotone	None: you are either on the island or in the water	One or many depending on landscape composition
Predation	Low: most predators absent (non-volant mammals, carnivorous ants)	High: most predators are present (easy access from edge)
Stability	High except after disturbance event (from outside or volcanic eruption)	Low because of downsizing of community: large, rare, and specialist species likely to vanish from fragment
Evolution	Endemic taxa, even unique radiations possible	None: fragment may contain viable and non-viable populations of continental taxa
Invasibility	Negligible except with human support; water barrier highly protective	High because of edge effect and proximity of surrounding matrix
Robustness	High: supports all of its insular biodiversity over long-term	Low: cannot support animals with large home range; ecological decay of habitat because of edge effect
Succession	Normal stages within island ecosystem	Arrested succession: old growth will die out

The human colonization of islands involved a series of disturbances of a completely new type, materialized mainly in terms of introduction of new species, habitat change, habitat destruction, pollution (disturbance of biogeochemical processes), disturbance of the water balance (e.g. irrigation, water diversion), aimed extinction of certain endemic species to refer only the most important and generalized. The main forms of disturbance presently affecting small islands are (van Baukering *et al*., 2007):

- Land clearance for development (including logging and forest clearance);
- Agricultural and industrial pollutants and run-off;
- Waste from tourism , on land and at sea, notably from cruise ships and domestic waste (including solid waste disposal);
- Invasive alien species ;
- Climate change ;
- Damaging fishing practices (including poisoning and dynamiting); and,
- Mining and excavation for construction material (including beach mining, reef blasting and near-shore dredging).

These disturbances determine, among many others, changes in the island ecology like the appearance of new types or intensities of ecological relations or processes (Box 1.1).

Box 1.1 - Herbivory

While in the mainland natural large scale grazing systems are one major type of habitat and the large herbivores have always had a very important role in the development of herbal communities, in most islands that was not the case until the introduction by the early colonizers of goats, pigs, sheep and cattle. Today, many island present large grazed areas building a completely new environment and built up in most cases by imported herbal species - we must consider that the absence of large herbivores did not favor the formation and maintenance of large open areas and the selection of herbal light species, determining that the dominant herbal communities in these islands where shadow or semi-shadow species, that are unable to colonize the new artificial vast open meadows.

Additionally it must be taken into account that due to the inexistence of herbivory, the island autochthonous plants did not developed (spines or toxins) defense mechanisms against herbivores when compared with vicarious species of continental areas (like *Laurus azorica* vrs *Laurus nobilis* or, *Sideroxylon marmulano* vs *Argania spinosa*)

Other relevant changes involve the replacement of the autochthonous forest by production forests in many cases of alien species, determining the partial or total destruction of certain forest types by completely occupying its habitat.

Similar problems occur with the action of invasive alien species (Box1.2)

Box 1.2 Pitosporum undulatum invasion of the Myrica faya habitat in Pico Island

For example in the Pico Island (case study) the area of the *Miryca faya* forest is presently completely colonized by the strongly invasive *Pittosporum undulatum* (Fig. 1.1) determining that the "Faial Forest" and all its associated communities and species are today a strongly threatened habitat in the island.

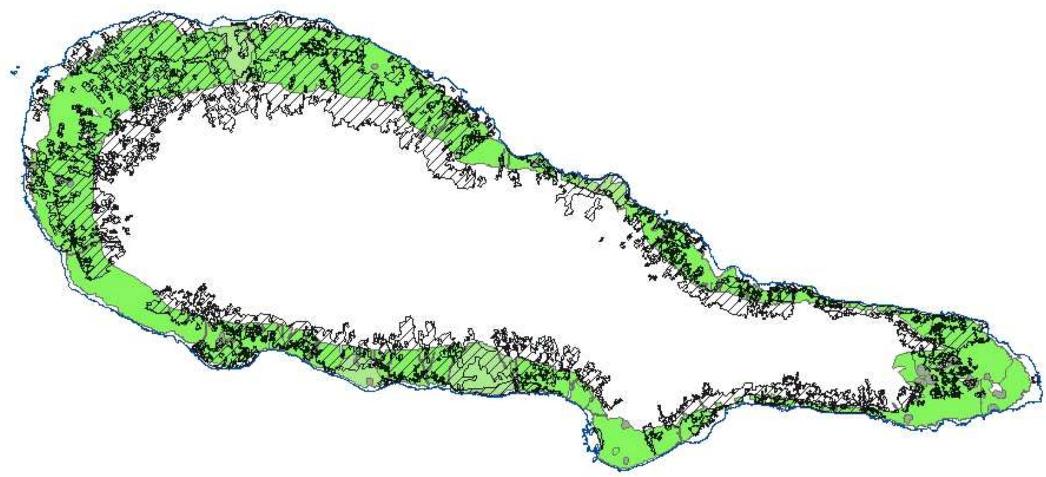


Fig. 1.1 - Natural area of the *Myrica faya* (Faial) Forest (Green) and area presently invaded by *Pittosporum undulatum* (hatched) in the Pico Island (Azores)

In this context, it is important to consider the Atlantic Macaronesian Islands (Canary, Madeira and Azores archipelagos where the recent colonization (several thousand years in the Canary Islands and less than 600 years in Madeira and Azores) lead to a "natural" pattern of evolution of the vegetation while on the continental areas the evolution of the vegetation in response to the diverse climatic changes of the last 100 000 years (at least) was always accompanied by human action (fire, cut, etc.) that eventually constrained that evolution on the contrary of the isolated islands.

These challenges to nature conservation in islands are still enhanced by the disturbances foreseeable associated with climate change and the increasing resource use associated with the human development of the islands and the resulting intensification of the pressures on different natural resources (Fonseca *et al*., 2006; Robertson *et al*. 2011) (Tab. 1.3).

Tab. 1.3 - Key issues in defining priorities for conserving biodiversity on European Islands (Robertson *et al*., 2011, pp. 13)

Key issues	**Invasive alien Species (IAS)**	**Habitat Loss Increasing**	**Resource Use**	**Climate change**	**Pollution**
Endemism	IAS pose a major threat to island endemism, for example grazing species impacting on endemic plants, predators impacting on endemic vertebrates, introduced species hybridising with endemics	The high number of endemics and their often small ranges makes them vulnerable to habitat loss, eg tourist developments along coastal habitats	Decreasing value of habitats for endemics, eg low water availability following increased abstraction or increases in grazing pressure. Increased disturbance, eg trampling of dune habitats	Changing climate and expected shifts in species distribution threatens species with limited geographic range or abilities to migrate, including many island endemics	Few direct impacts that are specific to islands
Breeding Colonies	IAS pose a major threat to many colonial island breeding bird species, through predation of eggs and of breeding animals both reducing populations and leading to colony abandonment	The loss of habitats for colonial nesting species, eg loss of turtle nesting beaches to tourist developments	Intensive grassland management may reducing value to breeding waders. Increasing disturbance of breeding colonies, eg tourism affecting turtle breeding beaches, wind farm developments affecting bird colonies. Increased fishing may reduce food availability for pelagic birds	Climate change may alter food availability or alter habitats to their detriment	Coastal breeding colonies are at significant risk from pollution events at sea, such as oil spills.
Migration points	Few direct impacts	Loss of habitat oases for migrating species	Loss of semi-natural habitats to agricultural intensification, Potential risks to migrating birds	Potential loss of key habitats used as migration staging posts	Few direct impacts that are specific to islands

			from wind farm developments		
Species refugia	IAS threaten species already excluded from mainland habitats by their presence	Development increases risk of introduction of IAS, zoonoses or increased predation pressures from domestic species	Increased agricultural intensification leading to loss of semi-natural habitats	Changing climate and expected shifts in species distribution threatens species with limited geographic range or abilities to migrate, including species using islands as refugia	Few direct impacts that are specific to islands
Special habitats	Loss of key habitats to IAS - eg dune systems invaded by non-native plants. IAS simplify natural habitats, eg through increased grazing pressure or by smothering native vegetation	Large pressures from tourism on coastal areas, loss of coastal habitats to development	Loss of wetland habitats through water extraction or increased irrigation, increase agricultural intensification leading to loss of semi-natural habitats. Effects of renewable energy developments on coastal habitats	Raised sea levels threaten coastline habitats, including coral reefs, salt marshes and risk increased erosion. Changing climate will alter the nature and species composition of habitats	Few direct impacts that are specific to islands

Last but not the least there is the urban and infra-structural development that destroys irreversibly varied areas of habitat (not only along the coast but also frequently in particular areas with landscape or morphological particularities) compromising, in many cases, habitats that are rare limited to sites and geomorphological conditions that are irreversible compromised. Similarly some infra-structures (particularly linear ones like roads) can affect the natural water balance, diverting or concentrating the water flow, leading to situations where natural wetlands are compromised or to the increase of extreme flashfloods for which the natural water courses and the built areas are not adapted.

These issues and problems have to be faced taking into consideration that <u>in humanized insular environments</u>, the identification of values and threats as well as its valuation and therefore, the definition of management objects and targets in what regards nature conservation, have to take into consideration criteria and perspectives (as well as systems of values) different (to say the least) of those adopted in mainland systems.

This derives, for example, from the fact that when considering island biodiversity it is necessary to give particular attention to genetic diversity and to the factors favoring its evolution and differentiation within each taxa, favoring, for example, the preservation of micro niches to preserve the necessary isolation requested for the preservation of that differentiation (this question is critical when analyzing continuity and heterogeneity at the island level). This question determines that, as important as the preservation of a minimal viable population, it is critical to ensure, simultaneously, its intrinsic micro-diversity and the resulting ability to respond biologically and physically to disturbances. This implies geographical differentiated approaches to each problem and the consideration of the entire island environment, factors and actors, as the conservation object.

Another critical question is the fact that each island is an individual case, and practical approaches must be adopted for that particular case (Wong *et al*., 2005).

In this context it is critical, in more or less strongly humanized island habitats, to take into particular account the way in which land resources are appropriated for given uses and how they are modified and their nature and existence eventually compromised. At the same time, it is important to know how natural systems react to these new environmental factors and processes (for example by observing colonization patterns in abandoned former used areas) and which way the species (in particular target species) have reacted to the new alien environments.

2 - Societal factors in islands environments in relation to a systematic conservation praxis

2.1 - Ecosystem based management

Islands are characterized by particular social and cultural characteristics derived from the particular conditions associated with the limited size, resources and characteristics of each island, as well as its isolation.

In the origin of the colonization, the main problem faced by the colonizers was the creation of spaces able to provide them with the particular resources (mainly agricultural) they needed. These resources, in many cases, involved not only products for self-consumption but also (or manly) staples for exportation. These survival and economical needs determined a pattern of exploration of the islands resources with no or rarely very little consideration to the preservation of nature (the preservation of particular resources like water has lead, many times, to enormous efforts and engineering works - whose costs were justified by the wealth they brought in ensuring the critical economical activities, in opposition to many ecological values that where of no interest, an obstacle or had direct economical value e.g. timber).

This land use history lead to a culture where survival is the critical factor (strongly emphasized by the risks associated with isolation) and where the option between anything contributing to survival or opposing it was very clear and deeply imbibed in the island culture and behavior. Scarcity is these populations critical object of concern, even when integrated in modern communication and transport networks. Therefore, integrating conservation concerns and promoting conservation attitudes and practices has to involve, very clearly, the conscience and founded knowledge of the advantages of those new attitudes and their contribution to their well being and security.

This perspective was clearly stated in the United Nations Convention on Biological Diversity (1992) when it stated that:

> *Ecosystem and natural habitats management seeks to meet human requirements to use natural resources, whilst maintaining the biological richness and ecological processes necessary to sustain the composition, structure and function of the habitats or ecosystems concerned. Important within this process is the setting of explicit goals and practices, regularly updated in the light of the results of monitoring and research activities.*

statement that lead the IUCN (Pirot *et al*., 2000) to define an operative concept of ecosystem based management:

> *Ecosystem-based management seeks to organize human use of ecosystems in order to strike a balance between benefiting from the natural resources available from an ecosystem's components and processes, while maintaining an ecosystem's ability to provide these at a sustainable level.*
>
> *(...)*

In brief, the purpose of ecosystem management is to use ecosystems, but not to lose them. The objective of ecosystem management projects then should be to ensure that their goods and services are available on a sustainable basis.

(Pirot *et al*., 2000, pp. 15-16)

stressing clearly that:

"People are an integral part of ecosystems and depend on other components of the ecosystems and their interactions – ecological processes – for our existence. These include the water cycle, the maintenance of stable atmospheric, climatic and hydrological conditions, and the continued production of foodstuffs and many other products and services of ecosystems that contribute to our well-being.

(...)

Ecosystem functions are the result of plants and animals (including humans) interacting with each other and with the physical components of their environment. "

(Pirot *et al*., 2000, pp. ix)

And clarifying the focus of the management action in the following way:

"(...) In general, perturbations of ecosystems are due to two causes. Some are brought about by natural phenomena such as storms that destroy a deltaic system, an ice age, hurricanes, or invasive plant or animal species. On the other hand, when humans began to develop strategies to manipulate their surroundings in order to multiply their access to the goods and services from natural systems, they became major causes of perturbation and degradation of natural systems. In general, these have been due to agricultural expansion, fisheries, deforestation, mining, the introduction of alien species, the establishment of cities and major urban centers, and migrations to new areas. As a result, ecosystem-based management should focus on the role of people as an ecosystem component, and their interactions with other components of the system.

Thus, human actions should be the focus of ecosystem management."

(Pirot *et al*., 2000, pp. 17)

stating therefore that "a *basic tenet is that conserving ecosystem functions and integrity will be, or should be, a fundamental vehicle for sustainable development".*

As a consequence:

- *A central premise of ecosystem management is that the structure and functional integrity of the system should be maintained,*
- *The primary focus for actions should be on the human actions affecting the components and processes within the boundaries that define the ecosystem.*
- *A basic principle of ecosystem management is therefore to maintain biodiversity.*
- *Ecosystem managers must recognize the inevitability of change.*
- *People are an integral part of most ecosystems.*
- *Ecosystem management projects should incorporate a knowledge-based adaptive management approach.*

consequently:

- *ecosystem management must be flexible in its approach, in order to adapt to continually changing situations and conditions;*
- *ecosystem management is only partly about ecological sciences. It has much to do with gaining an appreciation of the economic, social and cultural factors affecting the communities concerned with an ecosystem management project; and*
- *public and community participation – at all stages of project development and implementation – is extremely important for success.*

2.2 - Multifunctionality and ecosystem based management

It is in this context that, in order to promote this management approach conscience that the concept of landscape multifunctionality must be introduced as a driving concept for the perception and operation of the different dimensions of production and benefice, each landscape has to offer. Multifunctionality consists in the integration of different functions in a given spatial and/or temporal unit at a given scale. All landscapes are multifunctional but their degree of multifunctionality can vary strongly with the different environmental potentials and resources. This concept is critical for the development of a sustainable landscape management and consequently a systematic nature conservation praxis (Fig. 2.1).

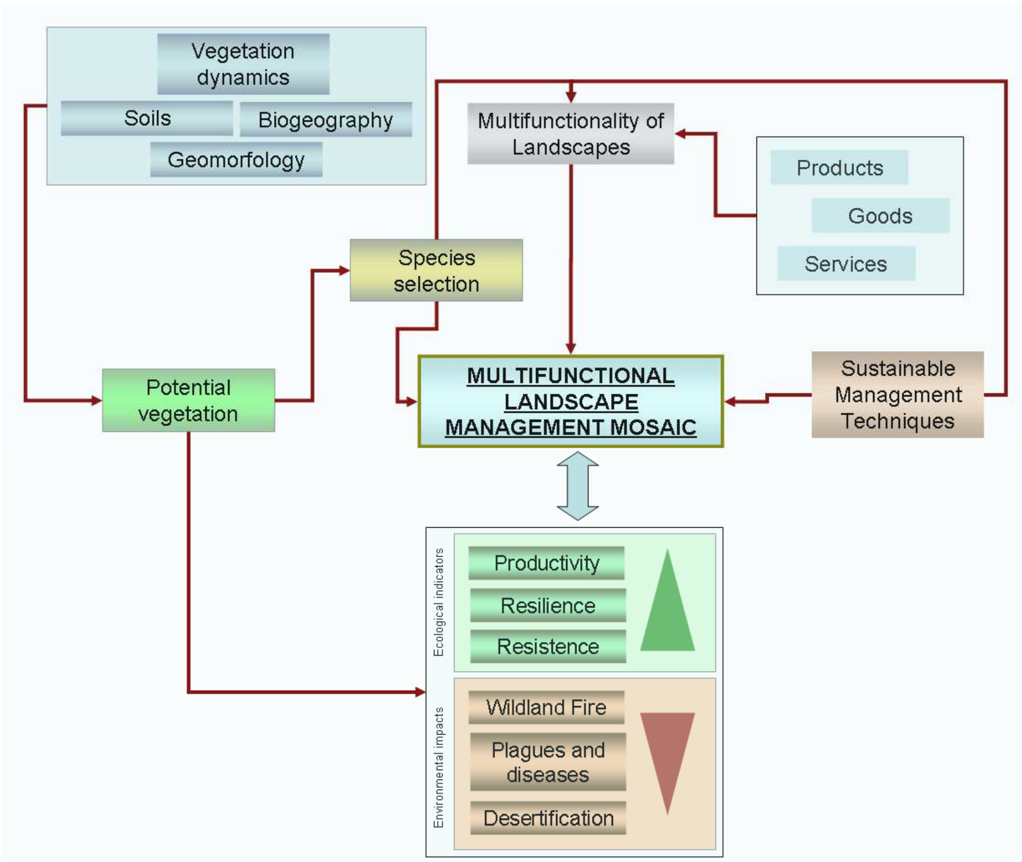


Fig. 2.1 - Multifunctional landscape management mosaic (Guiomar *et al.*, 2007)

Considering, for example, the agricultural sector it provides different kinds of functions and/or services (Huylenbroek *et al.*, 2007)):

- Green services: landscape management, wildlife management, maintenance of biodiversity, nutrient recycling and limitation of carbon sinks;
- Blue services: water management;
- Yellow services: rural cohesion and viability trough the development of ambience, heritage and a regional identity as well as the offer of complementary products like agro-tourism or agro-entertainment;
- White services: food security and safety.

These functions must be added to the traditional production functions, which build the main, if not mostly the sole aim of the management practices.

These new perspectives complement the traditional perspective of multifunctionality on one side with a broader scope of the functions associated with the rural space and on the other, with a clear concern on the social sustainability as an equally important pillar together with the economical and environmental sustainability. Hediger (2004) lists and evaluates a large set of environmental and socio-economical benefits of agriculture complementary to food and fibber production:

- Environmental benefits: rural landscape, biodiversity and habitats, ecosystem and watershed function
- Socio-economic benefits: food security, food safety, animal welfare, rural employment, viability of rural areas, cultural heritage

To this list many other indirect functions could be added like tourism, recreation or complementary employment. Nevertheless, these “new” functions are not necessarily fully compatible with the usual “core” activity of rural areas: farming. For instance inflation of real estate price due to tourist demand prevents a normal land market for agricultural production targets. We must, therefore distinguish between commodity (CO) and non-commodity outputs (NCO), which, together with the different types of public hand-outs (normally subsidies) determine the total income of the agricultural enterprise (Fig. 2.2).

Nevertheless, agriculture can be an important "landscape creator or manager" determining that its adequate management can be an important factor of enhancing the tourist or the real estate value, implying, therefore that this adequate management should be considered an additional service provided by the farmers that must be repaid as a NCO by tourist and real estate developers. This is one of many examples of the intricate network of economical relations that must be managed in terms of promoting economical development but has also to build the basis for an adequate systematic conservation praxis.

The second problem is the integration of the different stakeholders ensuring their adequate and conscious (therefore creative and involved) participation in the planning and management processes of the island. This is a critical question because when considering the different abilities for decision and acting in a management context we face the situation depicted in Fig. 2.3, where it is clear that those capable of regulate, plan, allow or forbid land uses, practices, are not those able to perform those land uses, practices and actions, determining a caesura between the sphere of decision and the sphere of action that leads normally to conflicts and even to negative results for both parts.

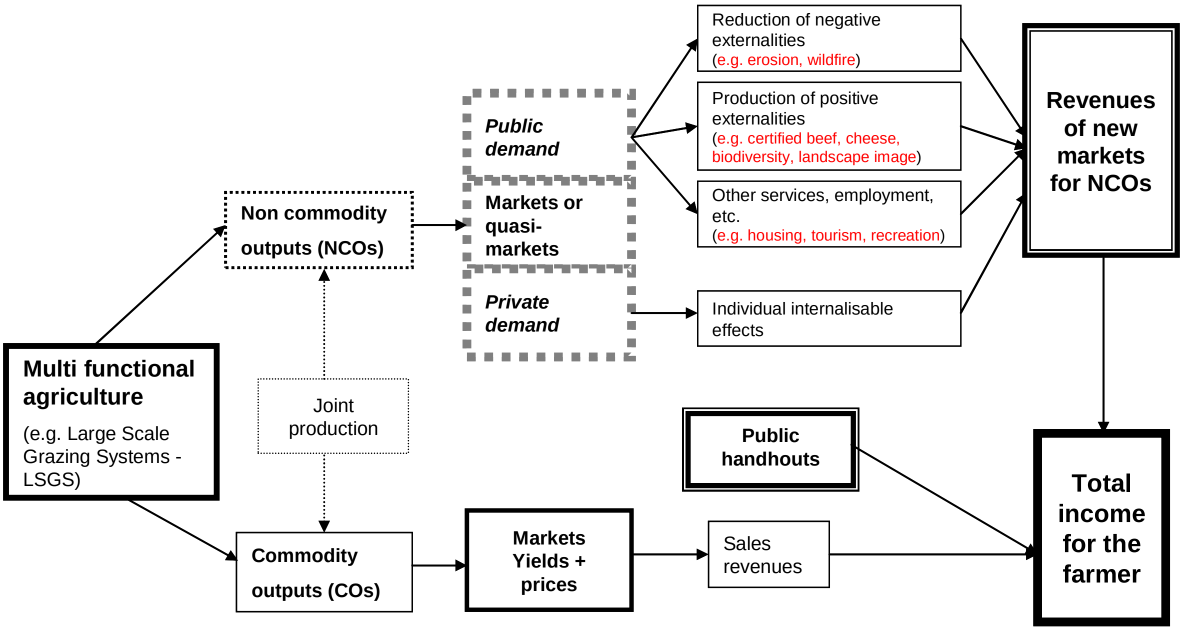


Fig. 2.2 - Multifunctional dimensions of farming exemplified for the case of Large Scale Grazing Systems (adapted from Wiggering *et al.*, 2006)

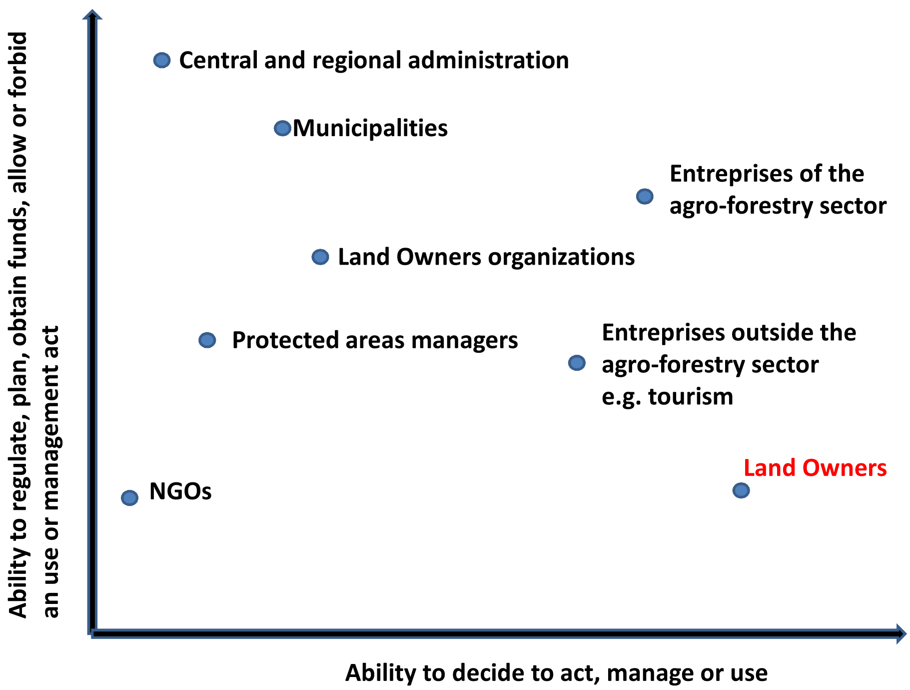


Fig. 2.3 - Different abilities to control and to act

2.3 - Development of governance systems and ecosystem based management

This approach must be central to the development of governance systems aiming at an integrated management praxis of the entire landscape (island) considering all its functions and in particular, production and nature conservation.

The first problem that must be considered is the fact that most management policies (e.g. urban, agriculture, forestry, infra-structures, nature conservation) are normally mono-functional. A good example of this tendential mono-functional approach is the document on the *Priorities for conserving biodiversity on European Islands* presented by the Standing Committee of the Convention on the conservation of European wildlife and natural habitats (Robertson *et al*., 2011), that independently of the broad characterization it presents on the conservation issues, when proposing measures restrains itself to a general policy of management/control of Invasive Alien Species, to the creation of Protected Areas and Protected Areas Networks, and general concerns about climate change and its consequences. This limited approach to a multidimensional problem is most probably responsible for the fact that despite a standing increase on the number and area of protected areas little or no gain at all is being achieved in terms of preventing the loss of biodiversity.

This situation illustrates perfectly the need for multidimensional approaches to issues that are intrinsically multifunctional.

Therefore, only through the articulation of all the different actors and their different abilities and powers can a sound integrated island management system be developed where all stakeholders are adequately and rewardingly integrated.

It is precisely in this context that Ehler (2003) proposed his list of governance performance indicators in Integrated Coastal Management (ICM) (Tab. 2.1), the "process through which the use of specific resources or portions of the coastal area are managed to achieve desired objectives (*op*. *cit*. pp. 335).

Tab. 2.1 - List of governance performance indicators in Integrated Coastal Management (ICM) (Ehler, 2003)

Phase or stage	**Feature of Governance**	**Indicators of output or outcome**
Initiation	Authority	Enabling legislation enacted Executive mandate issued Authority for national and sub-national bodies identified clearly Roles and responsibilities for ICM among levels of government clearly identified Soft and hard legal instruments identified Overlaps and gaps among institutional mandates clearly identified
	Leadership	Consensus built for common vision or philosophy Linkage of ICM with national development, economic development and environmental goals
	Institutional capacity	Interagency steering/coordination group established Scientific/user advisory groups established Initial partnerships formed Training courses for public officials held Authority and roles for different levels of government and stakeholders identified

		Rights and responsibilities (rules of the game) are clearly defined
		Consistency among actions at various levels of government (national, regional, local) ensured
		Inter-agency process and authority defined clearly
		Coordination among ICM projects and investment ensured
	Human resource development	Development of human resources to plan, implement, monitor, and evaluate ICM
		Identification of necessary leadership skills and broadcast of these expectations
	Empowerment	Local stakeholders have influence and control over ICM regime that has legal basis
	Financial resources management	Scaling of financial resources is appropriate to institutional capacity
		Financial contributions to ICM are effectively coordinated
Planning	Planning capacity	Adequate resources for planning allocated
		Appropriate staff hired, trained, and maintained
		Baseline studies completed
		Problems identified, analyzed and ranked
		Management boundaries defined
		Clear and realistic goals/targets identified and ranked
		Measurable management objectives specified
		Alternative management strategies identified and analyzed
		Costs/benefits of alternative management strategies analyzed
		Selection criteria for management strategies specified
		Ability to be adaptive and react to unpredicted change (e.g., climate change) established
		Ability to be predictive, anticipatory established
		Collaborative, participatory and transparent planning processes adopted
		Stakeholders actively participate in regular ICM planning meetings
		Access to public coastal resources assured
	Information management capacity	Public awareness program initiated
		Increased awareness of coastal issues
		Effective stakeholder participation in all phases of ICM
		Stakeholders satisfied with degree of participation
		Stakeholders have access to information related to ICM
		Assurance that ‘‘unheard voices’’ are taken into consideration
Adoption	Formalization and support	Legitimate authority(s) agree to adopt plan of action
		ICM program integrated into national environmental management & sustainable development programs
		Plan of action endorsed by constituencies and Users
		Stakeholders actively seek resources to implement plan of action
		Long-term financial support for all elements of ICM (e.g., monitoring) ensured
Implementation	Implementation capacity	Clear authority provided to write/enforce regulations to change behavior
		Clear authority to provide economic and economic incentives to change behavior
		Appropriate funding available for implementation activities
		Socially beneficial changes in user and institutional behavior as a result of management actions
		Diverse activities among institutions and projects are effectively coordinated
	Enforcement capacity	Appropriate compliance monitoring program in place
		Appropriate penalties assessed and collected for non-compliance
	Conflict resolution	Mechanisms for resolution of conflicts among agencies identified and implemented
		Conflicts among users resolved/mitigated
		Future of uses and conflicts anticipated
	Decision making	Definitive decisions taken
		Decision makers held accountable for results
Environmental and socioeconomic	Coastal and marine environmental	Improvements in water quality over a range of physical, biological and chemical parameters
		Increases in percentage of coastline suitable for bathing and recreation

outcomes	quality	Reduction of human diseases associated with water quality Socioeconomic benefits from increased tourism and recreation
	Coastal hazards	Reduction of conflicts over coastal use Socioeconomic benefits (jobs, income, revenues) from increased coastal activities
	Biodiversity/Habitat	Reduction in percentage of endangered and threatened species Improvements in structure and function of coastal and marine ecosystems Socioeconomic benefits from coastal and marine protected areas
	Fisheries	Reduction of damaging practices (by-catch) and equipment Recovery of fish stocks Increase in fish productivity Socioeconomic benefits from sustainable fisheries
Monitoring and evaluation	Monitoring capacity	Appropriate management performance monitoring is operational Appropriate users and communities involved in monitoring Monitoring and evaluation of social, economic and bio-physical context is operational Advanced monitoring tools employed when appropriate, available, and fiscally possible
Adaptation and reformulation	Evaluation capacity	Outcome indicators used to evaluate performance Evaluation of success/failure of management action fed back to planning Evaluation results used to reallocate resources Evaluation results used to change goals, objectives, management strategies, and desired outcomes

Although this list and the associated evaluation were developed for coastal areas it can be generalized to small islands (as proposed and developed by Lane (2006)).

Two question must be clarified before beginning the development and application of such a framework:

- Who are the stakeholders and what is their relative importance and role?
- What are the main forms of involvement of the different stakeholders?

Beukering *et al*. (2007) propose the following list to identify who are the stakeholders:

- Who owns the land/resources?
- Who currently uses this area (for business/residence etc…)?
- Who plans to develop in this area?
- Who uses the area legally and illegally for any access or extractive purposes?
- Who uses the site at different times of day and different times of the year?

and proposes their categorization according to two criteria:

- Who will be affected positively or negatively by the decision;
- Who has the power to influence the decision and who has no power.

what leads to three types of stakeholders:

- *Primary stakeholders experience the impacts of the project most severely either on their livelihoods or well-being. They often have little power to influence the outcome of the decision making process. This group is likely to include on-site resource users or residents, such as local businesses and local community groups. It is often the case that the primary stakeholders are not in a clearly defined group; they may be poor, landless or itinerant.*

- *Secondary stakeholders are the people with the power to make the decisions and to shape the outcome, but they are unlikely to be directly impacted by the decision. This group tends to comprise government departments and ministries.*

- *External stakeholders are those who are not impacted significantly by the project, but whose interests are affected. These people may be influential and have the power to influence the outcome and may include land developers, multinationals investing in the area, environmental NGOs or charities, trade groups and lobbying organizations.* (Beukering *et al*., 2007, pp. 31)

Their involvement should, also according to the same authors, be:

- ***Primary stakeholders**: Primary stakeholders are at the heart of any decision, and hence they need to be reached as soon as possible and encouraged to participate. If possible they should be brought together to create an active steering or consultative group. Once functioning as a steering group or consultative group, the primary stakeholders themselves should decide who can be invited to join their group.*

- ***Secondary stakeholders**: The managers of the resource and decision makers who can influence the final decision should be included throughout the process. Bringing all decision makers on board at an early stage ensures that they understand how the results are generated and what they mean. Secondary stakeholders should not be allowed to dominate combined stakeholder group meetings. In those meetings primary stakeholders must be treated equally and given as much time to talk as the secondary stakeholders.*

- ***External stakeholders**: External stakeholders tend to be more vocal and powerful and hence can be intimidating to those with less access to resources. Discussion may be inhibited if external stakeholders are present, or they can dominate meetings by shaping the dialogue to their agenda. External stakeholders should be kept informed of the on-going process, kept up to date with actions and events and carefully managed.* (Beukering et al.(2007) pp 31-32)

2.4 - Implementing effective governance systems

This type of involvement presents, nevertheless several problems, mainly what regards primary stakeholders, given that, when working at the island level their number implies the need for democratic representation and an even more accurate work of conciliating the multiple interests, targets, perspectives and expectations of all the members of the community.

Therefore, there should be no confusion between common concepts of public participation (Tab. 2.2) and integrated management. Integrated management implies the active and committed involvement of all primary stakeholders given the fact that ultimately they are the responsible for the effective use and management of each land parcel and, if they don't perceive their effective benefice in a certain type of management they will not change from their "experienced" management or they will resist passively or actively to the accorded new guidelines.

Tab. 2.2 - Different types of participation in decision making (Beukering *et al*., 2007, pp. 29)

Form of participation	**Characteristics of each type of participation**
Information giving	People participate by answering questions posed by project management using surveys. Information is then fed back to the various groups.
Consultation	Stakeholders are consulted and external agents listen to the views expressed. Solutions may be modified in light of stakeholders responses.
Functional participation	Stakeholder groups are created to meet pre-determined objectives related to the project. This tends to happen after major decisions have been made.
Interactive participation.	People participate in the decision making process, and the development and analysis of different options. Stakeholders and decision makers learn together.
Active participation	People participate by taking initiatives independent of external institutions to change systems

Here lies the normal reason for failure of the common practice of protected areas which is mainly based on prohibition eventually followed by some type of participation with more or less influence in the administration decisions leading to conflicts and a general or partial mismanagement of large stretches of the protected areas compromising their conservation goals.

In order to avoid these risks three combined main approaches must be carried:

- **Contractualization** - establishment of different forms of contracts between different groups of stakeholders involving the definition of responsibilities, compensation, forms of accountability and guaranties that ensure the different contractors the ability to account and control all agreed question. This types of contracts can vary from classical trade contracts: service vs payment to trust contracts: e.g. one guaranties the compliance of given rules, targets or other form of action accepting effective mechanisms of control and sanction without the need of law suits.
- **Accountability** - whenever a given restriction, prohibition or constraint is imposed or proposed, it must not only be soundly based and supported on comprehensible models and simulations, but it must also be subject to mechanisms of follow-up and accountability. It is sadly very common in nature conservation processes that impositions and prohibitions be imposed on citizens, communities or enterprises without a sound justification and without instruments of accountability that ensure that if the basis for that imposition or prohibition proved erroneous it will be changed or removed and the affected people communities and organizations compensated. Only in this way can trust be built up.
- **Valuation** - In order to be able to establish contracts on resources, management practices, decision etc., reproducible methods of valuation must be developed that

allow a clear perspective of the costs, benefits, eventual compensation (e.g. subsidies or payment of NCO), etc.. Normally, when speaking of valuation in the context of integrated management and systematic conservation, the total economic value, comprising use values and non-use values, integrating conservation values (option values and existence values) is the most adopted concept (Fig. 2.4).

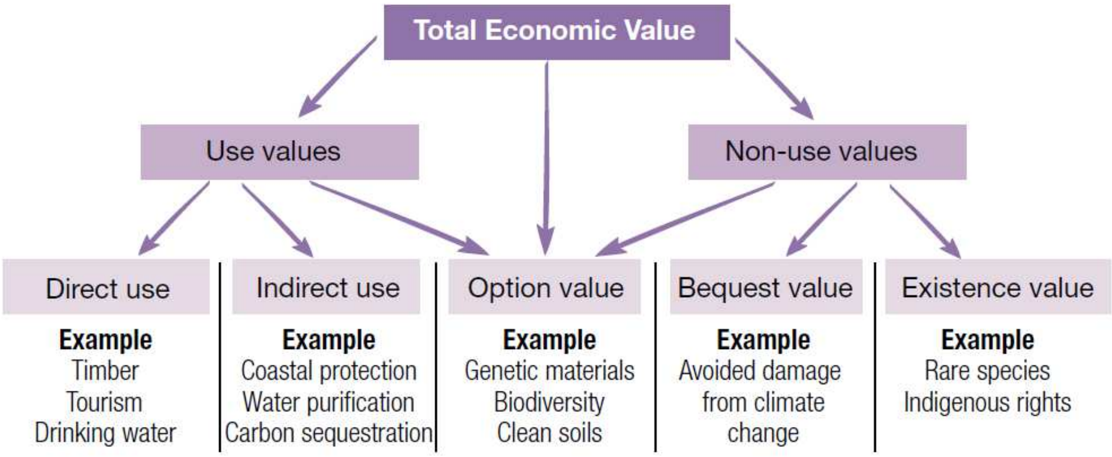


Fig. 2.4 - The composition of total economic value (Beukering *et al*., 2007, pp. 48)

The need for the combination of these approaches derives from the fact that ecological and other services from biodiverse ecosystems do not necessarily prove financially valuable (Marris, 2009) implying the need for aimed subventions to particular cases and ecosystems, together with all other sorts of forms of retribution and efforts of integrated increasing of total value.

This can only be achieved when the territory is considered in its totality as clearly stated by (Davoudi *et al*., 2008, pp. 36):

> *"The recent usage of the concept of 'territorial capital' stems from its inclusion in the OECD (2001) report, Territorial Outlook 2001, which argued that each region has its own specific territorial capital, i.e. path-dependent capital, which could be social, human or physical (Zonneveld and Waterhout, 2005). The factors that can be included in territorial capital range from the purely physical or spatial characteristics of a locality or region, such as its geographical location, its size, its natural resources, to more diverse characteristics, such as the quality of life, local and regional traditions and the quality of governance, to the more intangible factors facilitating creativity and innovation that make up what might be referred to as the 'quality of the milieu'. These factors could also be grouped, though to some extent overlapping, as: natural features, material and immaterial heritage, and fixed assets (Amin, 2000); as infrastructure, facilities and relational goods (Storper, 1997a); and as cognitive, social, cultural and institutional capital (Healey, 1997).*
>
> *Applied particularly to the local or regional level the concept of territorial capital is similar to that of 'endogenous potential'. The presence of distinct territorial capital*

would make investment, for example, more effective in one region than in another. Zonneveld and Waterhout (2005) divide the elements that make up a region's territorial capital into a) structural characteristics, and b) characteristics associated with its spatial position. Dematteis and Governa (2005), meanwhile, identify these elements as:

- *A localized set of common goods, producing non-divisible collective assets that cannot be privately owned;*
- *Immovable goods, that are a constant part of specific places;*
- *Place-specific, that is they are almost impossible to find elsewhere with the same features;*
- *Heritage goods, that is, they are produced and stored over a long period and cannot be produced easily in a short time."*

Building the foundations for the concept of governance as (Davoudi *et al*., 2008, pp. 36) also state:

"Governance, then, is the capacity of public and private actors to:

- *build an organizational consensus involving different actors in order to define common objectives and tasks;*
- *agree on the contribution by each partner to attain the objectives previously defined;*
- *agree on a common vision for the future of their territory.*

These issues are based on an "organizational" concept of the territory in which public and private actors and their relations are the key elements. Therefore, territorial governance is an organizational mode of territorial collective action, based on openness and transparency of the process itself, on cooperation/coordination among actors (horizontally and vertically), and in a framework of a more or less explicit subsidiarity. It implies relationships among actors and interests, agreement between stakeholders and different modalities of definition and implementation of policies. It is oriented towards a commonly defined aim of territorial development at different spatial scales in order to ensure the spatial coherence of the different actions. From this viewpoint, the key challenges for territorial governance are to create horizontal and vertical cooperation/coordination between (i) various levels of government (multilevel governance, vertical relations); (ii) sectoral policies with a territorial impact; and (iii) governmental and non-governmental organizations and citizens (multi-channel governance, horizontal relations between actors and their territories). Vertical and horizontal coordination leads to integration and coherence between disparate responsibilities, competences and visions of territories."

3 - Systematic Conservation in islands - conceptual and practical approaches

3.1 - Systematic Conservation Planning

> *The realization of conservation goals requires strategies for managing whole landscapes including areas allocated to both production and protection. Reserves alone are not adequate for nature conservation but they are the cornerstone on which regional strategies are built. Reserves have two main roles. They should sample or represent the biodiversity of each region and they should separate this biodiversity from processes that threaten its persistence. Existing reserve systems throughout the world contain a biased sample of biodiversity, usually that of remote places and other areas that are unsuitable for commercial activities. A more systematic approach to locating and designing reserves has been evolving and this approach will need to be implemented if a large proportion of today's biodiversity is to exist in a future of increasing numbers of people and their demands on natural resources.*
>
> (Margules *et al*., 2000, pp. 243)

This statement is particular accurate in the case of small islands where the segregation between protected areas and production areas is very complicated if nor totally impossible in populated islands. Non populated islands like the Desertas and Selvagens in the Madeira archipelago are completely preserved from human interaction, because never colonized and permanently occupied, and fulfill with little problems their conservation targets. That is not the case of the large majority of the Islands for example of the Atlantic archipelagos Cap Verde, Canaries, Madeira and Azores, where the population density is generally high and the production activities intense and implying the appropriation and transformation of an important percentage of the islands surface and resources.

Therefore it is necessary to implement conservation policies and praxis that involve all areas and land uses taking into consideration that "*Conservation planning is therefore an activity in which social, economic and political imperatives modify, sometimes drastically, scientific prescriptions*." (Margules *et al*., 2000, pp. 244). The challenge is not how to control the other domains, but to develop methods that founded on sound scientific bases, ensure the different conservation targets (preservation, restoration, etc.) in the frame of an ecosystem based management where the entire islands habitats (natural, semi-natural, productive and strongly disturbed) are all integrated in the planning and management strategy and praxis.

It is in this context that the same authors propose a working framework for the process of systematic conservation planning (Tab. 3.1).

The first thing that this framework as well as all other approaches must take clearly into account is that it is developed and applied in a context of uncertainty because of the knowledge limitations on the ecological processes to be managed and the economical, social and cultural setting within which this management will be performed. This is particularly critical when defining planning and management targets and primarily planning and management criteria and the values on which they must be based.

Tab. 3.1 - Stages in systematic conservation planning (Margules *et al*., 2000, pp. 245)

Systematic conservation planning can be separated into six stages, and some examples of tasks and decisions in each are presented below. Note that the process is not unidirectional; there will be many feedbacks and reasons for altering decisions (see text for examples).

1. Compile data on the biodiversity of the planning region

- *Review existing data and decide on which data sets are sufficiently consistent to serve as surrogates for biodiversity across the planning region.*
- *If time allows, collect new data to augment or replace some existing data sets.*
- *Collect information on the localities of species considered to be rare and/or threatened in the region (these are likely to be missed or under-represented in conservation areas selected only on the basis of land classes such as vegetation types).*

2. Identify conservation goals for the planning region

- *Set quantitative conservation targets for species, vegetation types or other features (for example, at least three occurrences of each species, 1,500 ha of each vegetation type, or specific targets tailored to the conservation needs of individual features). Despite inevitable subjectivity in their formulation, the value of such goals is their explicitness.*
- *Set quantitative targets for minimum size, connectivity or other design criteria.*
- *Identify qualitative targets or preferences (for example, as far as possible, new conservation areas should have minimal previous disturbance from grazing or logging).*

3. Review existing conservation areas

- *Measure the extent to which quantitative targets for representation and design have been achieved by existing conservation areas.*
- *Identify the imminence of threat to under-represented features such as species or vegetation types, and the threats posed to areas that will be important in securing satisfactory design targets.*

4. Select additional conservation areas

- *Regard established conservation areas as 'constraints' or focal points for the design of an expanded system.*
- *Identify preliminary sets of new conservation areas for consideration as additions to established areas. Options for doing this include reserve selection algorithms or decision-support software to allow stakeholders to design expanded systems that achieve regional conservation goals subject to constraints such as existing reserves, acquisition budgets, or limits on feasible opportunity costs for other land uses.*

5. Implement conservation actions

- *Decide on the most appropriate or feasible form of management to be applied to individual areas (some management approaches will be fallbacks from the preferred option).*
- *If one or more selected areas prove to be unexpectedly degraded or difficult to protect, return to stage 4 and look for alternatives.*
- *Decide on the relative timing of conservation management when resources are insufficient to implement the whole system in the short term (usually).*

6. Maintain the required values of conservation areas

- *Set conservation goals at the level of individual conservation areas (for example, maintain seral habitats for one or more species for which the area is important). Ideally, these goals will acknowledge the particular values of the area in the context of the whole system.*
- *Implement management actions and zonings in and around each area to achieve the goals.*
- *Monitor key indicators that will reflect the success of management actions or zonings in achieving goals. Modify management as required.*

3.2 - Ecosystem based management plan

As discussed previously, the ecosystem management approach proposed by the IUCN goes a step further from the systematic conservation planning by enlarging its working focus to the entire ecosystemic structure of the region and their interactions with the social and cultural driving forces.

Therefore it aims primarily at approaching the multifunctional system in a way that ensures the involvement of all the direct and indirect management of that system. Under managers all users are considered (human and non-human), given that they all use, and therefore change the environment, orienting its functions and affecting its resources to their particular interests. (Box 3.1).

Box . 3.1- Key steps in the management planning process (Clarke *et al*., 2010)

1. Identify and involve stakeholders.
2. Identify ecosystem values.
3. Understand management context.
4. Identify key management institutions.
5. Identify goals, targets and threats.
6. Establish management strategies.
7. Implement management actions.
8. Formulate education and communication programs.
9. Set priorities for monitoring and research.
10. Define review and adaptation processes

In this context the UNEP further stresses that:

> *The term governance has become prominent in many settings where a fundamental rethinking of societal goals, structures and mores is seen as necessary. Governance concerns the values, policies, laws and institutions by which issues are addressed (Olsen and Nickerson 2003, Olsen 2003).*
>
> *Governance defines the fundamental goals, the institutional processes and the structures that are the basis for planning and decision-making. Management, in contrast, is the process by which human and material resources are harnessed to achieve a known goal within a known institutional structure. We therefore speak of business management, park management, and personnel management or disaster management. In these instances the goals and mechanisms of administration are well known and widely accepted. Governance sets the stage within which management occurs.*

Ecosystem management would in many instances be better described as ecosystem governance since the changes it requires in values, goals, human behavior and institutions are profound. (Olsen, et al. 2006)

This multifunctional approach allows that all types of uses and their consequences in terms of different indicators can be better assessed and the valuation processes can be carried out on sounder bases including all the factors and agents involved.

Further crucial for the development of any planning process is the identification and clarification of goals. In the context of Ecosystem based management goals focus on maintaining or restoring the natural structure of ecosystems to sustain ecosystem services over time. The goal may also define the geographic scope of the initiative, and refer broadly to the method for achieving the goal. (Clarke *et al*., 2010) in order to ensure that the integrated management of land, water and living sources provides sustainable delivery of ecosystem services in an equitable way (UNEP, 2009).

To achieve these goals a comprehensive set of information must be gathered and processed (Tab. 3.2), taking always into account that the gathering and processing of information as well as management are always ongoing processes (Fig. 3.1).

Tab. 3.2 - Information required for ecosystem management (Pirot *et al*., 2000, pp. 59-60)

a) Description of the main components of the ecosystem, for example:
    - Physical – climate, soils, hydrology, oceanography;
    - Biological – flora and fauna;
    - Social – people and communities living in the area, stakeholder analysis;
    - existing natural resource use; and
    - existing management measures and structures, including protected areas.

b) Analysis of ecosystem functions, linkages and boundaries;

c) Analysis of opportunities and threats, causes and effects;

d) Definition of the ecosystem management objectives, including the need for rehabilitation of soils, vegetation cover, and/or specific ecosystem functions;

e) Description of management measures to be undertaken to address the opportunities and threats, for example:
    - Physical measures – fencing, hydrological management and pollution control, including specific measures for ecosystem restoration;
    - Biological measures – replanting, re-introduction of species, control of pest species, harvesting and weed control;
    - Social measures – social fencing, protection against poaching, alternative energy sources, zoning for multiple use;
    - research – filling information gaps, pilot studies;
    - analysis of the current legal and jurisdictional overlaps or gaps, and whether or not customary laws, bylaws and institutions already exist to strengthen the management regime; and
    - economic measures – incentives, income-generating alternatives, marketing for natural resource products, ecotourism.

f) Expected outcome of key management activities;

g) Description of monitoring measures, including indicators, regularity of measurement and methods of analysis;

h) Requirements for adaptive management;

i) Institutional arrangements and decision-making processes;

j) Involvement of stakeholders – decision-making, implementation and enforcement, monitoring, education;

k) Reporting and communications; and

l) Budget and financing.

Bringing together the two instruments Systematic Conservation Planning (SCP) and Ecosystem Based Management (EBM) we verify areas of overlap, but essentially a complementarity in the practical approaches and a consistent expression of the present paradigm shifts in conservation planning and management (Tab 3.3) where new instruments of characterization evaluation, communication, modelling and multidimensional integration are needed.

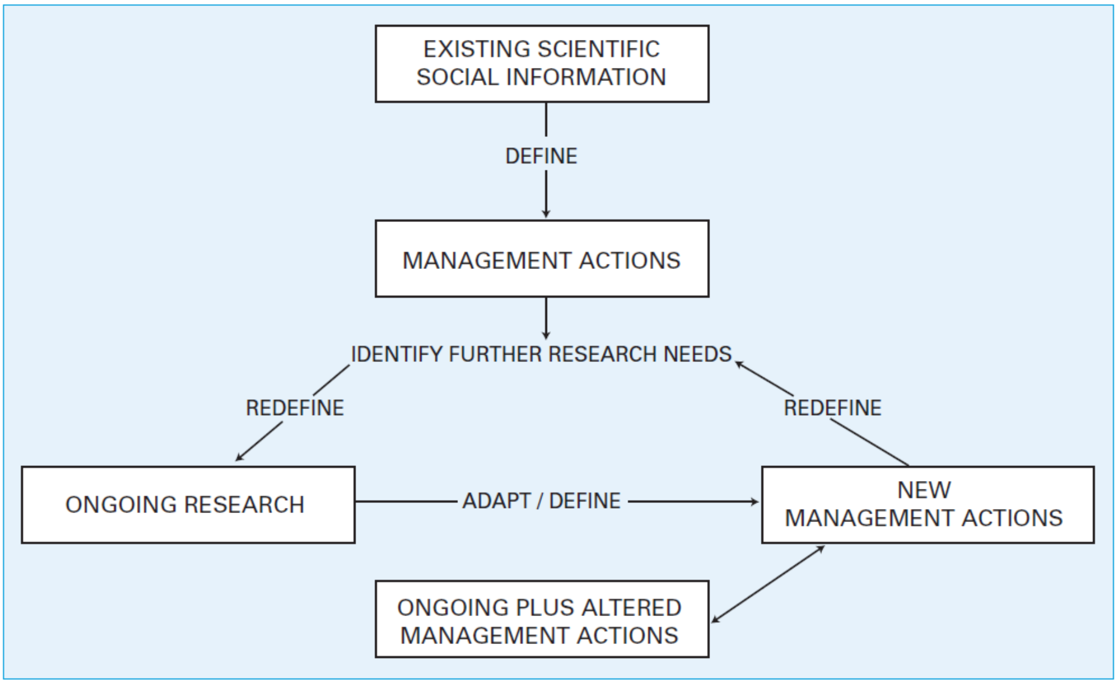


Fig. 3.1 - Interactive relationship between management actions and information requirements. (Pirot *et al*., 2000, pp. 36)

These instruments need to integrate the characterization of each site as a particular entity determined by particular functional relation with neighboring and further apart sites and be able to adopt for each site different and particularly aimed and adapted management measures, conservation goals and management and decision actors.

Tab. 3.3 - Ecosystem-based management as a paradigm shift (Olsen *et al*., 2006; Pikett *et al*., 1992; Hobbs *et al*., 2006)

From	**To**
Individual species	Ecosystems
Small spatial scale	Multiple scales
Short-term perspective	Long-term perspective
Humans independent of ecosystems	Humans as integral parts of ecosystems
Management divorced from research	Adaptive management
Managing commodities	Sustained production potential for ecosystem goods and services
Equilibrium principle	Non equilibrium principle
Closed natural systems	Open natural systems inserted in different contexts
Pristine Ecosystems	Novel ecosystems

3.3 - Valuation and evaluation

3.3.1 - Valuation

To speak of valuation is to speak of the attribution of a value. This value is valid for a given set of conditions, a given time, cultural, paradigmatic context and a given perspective of value determined by the "value" giver or givers. Normally is used in terms of economical value which expresses the degree to which a good or service satisfies individual human preferences in a given moment and context. It can be expressed in terms of number of units of another good or service is necessary to exchange for it or in terms of monetary value (a way of integrating the average balance of those trade values). But it can also be used in reference to other universes like ecological values, which can assume many forms such as rarity, diversity, resilience, naturalness, etc. and are expressed in many different ways (qualitative or quantitative, trough objective or subjective valuation methods).

In the same way that the economical value of a good or service depends from the context and circumstances predominant when attributed, the same thing happens in relation to other values. For example ecological "values" such as diversity, continuity, connectivity, fragmentation are not absolute values but depend very strongly from the perspectives and, paradigms and the prevailing spatial-temporal conditions.

Values are of particular importance because they allow comparisons. But to make comparison it is critical to ensure that the scale of reference used to define the different values, have identical nature and character (whether they are nominal, ordinal or cardinal and expressed in the same units of measure).

Scriven (2007) distinguishes different types of values and tries to systematize their consistence and significance and to highlight the necessary caution it is necessary to work with values and performing valuations (Tab.3.5).

Tab. 3.5 - Types of values (adapted from Scriven, 2007, pp. 12)

Types of values	Characteristics and limitations
Personal preferences (wants).	Although paradigmatically subjective in the purely descriptive sense, these claims are entirely objective in the evaluative sense that they make an intersubjectively testable and hence scientifically respectable claim. The evidence we all use to verify or falsify them is of two main kinds: evidence bearing on the veracity of the claimant, and behavioral evidence of the obvious kind. This type of claim is extremely important in the logic of evaluation because it can provide the main value premise required for support of evaluative conclusions with exactly the same circle of applicability as the premise, namely the person or people said to have the preferences.
Market value	This kind of value has a specific legal status and definition that references the verification procedure, so it is not only objective but quantitative. But the market value is not the most important value; in many cases, an expert adviser will say, “Well, there’s no doubt that the market value of this property is X, but it’s seriously overpriced—we can find you a much better value, in fact a better property for less money.” That is there’s something that we refer to as the ‘real’ value that is sometimes, not always, different from market value. This has other names, e.g., ...
Real, true, essential value	This is a theoretical construct based on abstracting from the properly established criteria of merit for an evaluand. When we talk of a change as ‘really significant’ or a doctoral thesis as ‘truly excellent,’ we are stressing that a truly careful evaluation will reveal the result we are claiming. This sense of value is the one that professional evaluation seeks to uncover, and it is the one that evaluation as a discipline is all about, just as the ‘real truth’ is what the professional journalist or scientist seeks. To reach it, we usually have to assemble a number of values and a number of facts, and integrate (synthesize) them in a way that calls on a couple more types of value. The first of these is:
Public value	Public values are the kind to which we appeal when we are trying to establish the m/w/s of some evaluand (a program, product, or person) in a way that will be intersubjectively acceptable, as for example when it is to be paid for with public money, or is intended to receive public acknowledgment for its m/w/s. There are many species of these, including legal, ethical, cultural, logical, scientific, educational, historical, professional, and expert values, and the context determines which one(s) it will be relevant to consider. (The name for these is intended to suggest the contrast with private values a.k.a. personal preferences.) However, public values are general in nature, and in order to pin down an evaluative conclusion of the required specificity, we often—although not always—need a refinement of them, as follows:
Standards and requirements	Standards are specific levels or amounts of public values that are set for certain evaluative or practical purposes. Some public values are so essentially tied to action that they are themselves referred to and formulated as standards—a good example is safety standards, which are normally expressed in exact terms, e.g., “A fire extinguisher of type X must be located and visible in standard working conditions within five feet of each machine operator’s normal location.” But in many cases, the standards will be context dependent, and stated for specific evaluative tasks or contexts, for example: “An A on this test will require a mark of 85%.” (The formulation of a set of standards like this one, covering all grades, is called a rubric.)... The preceding five categories are the main types of value, but there are a couple more that should be mentioned to avoid confusion.
Contextual values	There are many contexts in which a statement of bare empirical fact has evaluative significance. (This is one reason why the facts vs. values dichotomy is misleading.) It is a ‘mere’ statement of fact that someone has just broken the world record for the hundred meter dash, but of course it’s also a statement about the m/w/s of the event and the sprinter. Hence, in an argument, it may be entirely appropriate to address the evaluative component of the statement rather than the factual one, e.g., by pointing out that the track was an exceptionally favorable one and the new record was only a hundredth of a second better than the previous one, set on an ancient track.
Illustrative and exemplary value	When someone talks of the ‘perfect crime’ or the ‘perfect storm’ they are not suggesting that the crime or the storm are ideal events in themselves, but only that they are ideal examples of their kind;

In this context another important aspect that have to be taken into account is the difference between value and quality. Value is only the expression of a given characteristic (like the amount of money somebody is prepare to spend for a given good or service) while quality expresses an inner characteristic of the valued object, independent from its expression in terms of the measuring scale.

For example, one of the characteristics of islands ecosystems is a comparatively lower biodiversity due to their isolation and limited space and resources. A situation of colonization by invasive species can determine an important increase in the value of biodiversity without signifying, well on the contrary, an increase on the ecological quality of that island.

Finally, we have to take into account that in the frame of environmental planning and management a complete reevaluation of the decision-making process and of the way the environmental and the economical, social and cultural constraints are evaluated must be conducted. This purpose can only be achieved, if a common base of dialogue between the different disciplines and values can be build up. In what concerns the environmental information several difficulties arise when fulfilling this objective:

- How to differentiate the intrinsic (environmental potential and sensitivity for example) from the extrinsic values (economical, political, cultural, social) of each environmental variable?
- How to differentiate the circumstantial from the stable determinants of each environmental variable or constraint?
- How to integrate the intrinsic dynamic of the environmental systems in the evaluation procedures?
- How to differentiate the individual value of each environmental object from its value within a given context?
- How to compare different environmental objects on an objective base?
- How to differentiate the inductive or circumstantial evaluation criteria (such as appearance), from the effective environmental determinants?
- How to integrate a subjective environmental evaluation in a desired near-to-objective decision-making process determined by subjective and circumstantial values like the dominant cultural patterns, the economical and social constraints and the decision makers inability to operate complex systems?
- How to differentiate, within the evaluation process, the influence of the planners or the political objectives, from the mere technical evaluation procedures?
- How to determine what is an absolute conservation site or value from a circumstantial one?
- How to make compatible the different semantic characteristics of the classification languages and procedures allowing to surpass the individual disciplinary paradigms?

This set of difficulties express the dilemma faced by many environmental scientists, when producing information to be used in decision support systems or to determine any kind of environmental indicators (Alberti and Parker, 1991): on the limited knowledge base and available data and models, how to balance the pressure on the natural resources and processes, without clearly knowing the environmental thresholds of decline or degradation?

In the context of the present research it is necessary to analyze more closely the processes of economic and ecological valuation.

3.3.1.1 - Economical valuation

As previously stated, the process of economical valuation in the context of landscape planning, environmental management and systematic conservation and in the global frame of the sustainability concept is developed around the concept of Total Economical Value. This concept, initially proposed by Pearce *et al*. (1989) allows a broader consideration of the value of a good or a service as expanding from the original "willingness to pay (WTP)" and "willingness to accept (WTA)" (offer/demand curves) incorporating in the value equation use values (direct use - commodity outputs and indirect uses - non commodity outputs) and non use-values expressing general services that are not directly perceived by each individual, but affect a large or a global number of individuals. All the components of the Total Economic Value are susceptible of an economic valuation, although it depends in many factors from indirect and in many cases conjunctural factors - such as willingness to pay for the non-use value component. Beukering *et al*. (2007) tries to systematize the main economical valuation methods available (Tab. 3.6).

Tab. 3.6 - Valuation methods, typical applications, examples and limitations (Beukering *et al*., 2007, pp. 51)

Valuation Method	Approach	Application	Examples	Limitations
Market prices	Observe prices directly in markets	Environmental goods and services that are traded in markets	Timber and fuel wood from forests clean water from wetlands	Market prices can be distorted e.g. by subsidies Environmental services often not traded in markets
Replaceme nt cost	Estimate cost of replacing environmental service with man-made service	Ecosystem services that have a man-made equivalent that could be used and provides similar benefits to the environmental service	Coastal protection by mangroves water storage and filtration by wetlands	Over-estimates value if society is not prepared to pay for man-made replacement. Under-estimates value if man-made replacement does not provide all of the benefits of the environmental service
Damage cost avoided	Estimate damage avoided due to ecosystem service	Ecosystems that provide protection to houses or other assets	Coastal protection by mangroves/ reefs; river flow control by wetlands	Difficult to relate damage levels to ecosystem quality
Net factor income	Revenue from sales of environment-related good minus cost of other inputs	Ecosystems that provide an input in the production of a marketed good	Filtration of water by wetlands; commercial fisheries supported by coral reef	Over-estimates ecosystem values
Production function	Estimate value of ecosystem service as input in production of marketed good	Ecosystems that provide an input in the production of a marketed good	Filtration of water by wetlands; commercial fisheries supported by coral reef	Technically difficult. High data requirements
Hedonic pricing	Estimate influence of environmental characteristics on price of marketed goods	Environmental characteristics that vary across goods (usually houses)	National parks, air pollution, proximity to waste dumps	Technically difficult. High data requirements
Travel cost	Travel costs to access a resource indicate its value	Recreation sites	National parks, marine protected areas	Technically difficult. High data requirements
Contingent valuation	Ask survey respondents directly for WTP for environmental service	Any environmental good or service	Species loss, natural areas, air pollution	Expensive to implement

Choice modelling	Ask survey respondents to trade-off environmental and other goods to elicit WTP	Any environmental good or service	Species loss, natural areas, air pollution	Expensive to implement Technically difficult
Value transfer	Use values estimated at other locations	Any environmental good or service	Species loss, natural areas, air pollution	Possible transfer errors. Can be as technically difficult as primary valuation

The use of these methods applies to different goods or services. Considering, for example ecosystem services the same authors illustrate the growing difficulty in valuing non use components of value (Tab 3.7). These difficulties can only be overcome trough an integrated multifunctional and inter-responsible approach.

Tab. 3.7 - Ecosystem services and commonly applied valuation methods

Ecosystem service	**Valuation method**
Food, timber, fuel wood	Market prices
Water filtration	Replacement cost , net factor income, production function
Water storage	Replacement cost , net factor income, production function
River flow control	Replacement cost , damage cost avoided, production function, net factor income
Coastal protection	Replacement cost , damage cost avoided, production function, net factor income
Support to fisheries	Net factor income , production function
Recreation site	Market prices , contingent valuation, travel cost, hedonic pricing, choice modelling
Visual aesthetics	Contingent valuation , hedonic pricing, choice modelling
Biodiversity	Contingent valuation , choice modelling
Non-use/existence values	Contingent valuation , choice modelling

Effectively, methods like replacement costs, damage cost avoided, net factor income, production function and hedonic price can only be successfully implemented when involving the entire affected population and stakeholders. This implies that planning and management evolve to a more integrated, open, participated and mainly, involved praxis.

Only if a reciprocal system of evaluation of the different services provided and received (and by whom) can allow an autonomous management involving all the acting parts. Any attempt of administrative imposition or of disintegrated organization will be counterproductive.

Also of particular importance is to ensure that the valuation process is, simultaneously geographically referred - each value depends from the particular location and geographical context, and fair in terms of the individuals and groups associated with each valuation process

For example, water regulation is a good example of a management object that has to involve in reciprocated, accountable and responsible ways all involved, from the owners and managers of the forests and other areas above in the catchment area, to the energy producers that benefit from the flow regulation or the farmers and urban populations that benefit from the global flow regulation, the flow retention and the reduction of erosion (and sedimentation).

3.3.1.2 - Ecological valuation

When speaking of valuing nature two mainly perspectives arise immediately: it can only be performed from the economical perspective either in the strict sense of utilitarism (use values) or integrating utilitarian with not directly utilitarian criteria (building the concept of Total Economic Value integrating use and non-use values) or it correspond to an absolute value focused mainly in concepts like existence value. There is a third perspective focused on the "risk of nature" that adjust the existence value according to the perceived risk that the valued object is subject to.

The need to value the environment arose in economical theory with the concept of meta-economics proposed by Schumacher (1974) in is work "*Small is beautiful*" in the sense of the way in which a given context, direction and point affects the process of production and distribution of goods and services. "*This includes both the nature of the world in which these processes are set and from which they draw their resources, and the significance of the fairly extensive subset of human ends to which they conduce*" (Foster, 1997, pp. 4).

This concept of meta-economics must also be applied to the environment in the frame of its management (and valuation) in the sense that we cannot understand and manage an environmental system independently from its geographical and historical (and obviously socio-economical and cultural) context.

Another important aspect associated with these concepts is the ethical component of value, aspect that assumes a particular relevance when speaking of ecological valuation because of the perceived relation between the risk endured by a certain environmental object process or factor and human activity leading to an affection of the valuing process by the antinomy natural vs. humanized.

The existence value initially defined as "the value of *an object in the natural world apart from any use of it by humans*" (Aldred, 1997, pp. 155) showed important problems in its application leading the same author to propose a different definition: "*the value of some environmental good is defined as the value assigned by the agent to the good in addition to any expected changes in the welfare of the agent contingent upon the goods continued existence"* (Aldred, 1997, pp. 162). This second definition allows a better comprehension of the "meta" character of this concept by referring it to a given agent in a given context. A good example of this relativity is photosynthesis when it appeared in the course of evolution it determined by producing the residue oxygen, the extinction of nearly all live in the planet. Today it is the basis of the existence and autonomy of life in the planet.

Therefore **value cannot be neutral** and its determination must always include a clear presentation of the valuing context and criteria.

Consequently, attributing value and performing evaluations using those values must always be a multi-criteria process expressing the above mentioned multifunctionality and multidimensionality of the social and environmental context of every planning and management process.

It is in this context that Kaule (1991) tries to systematize the problem of ecological valuation referring that the attribution of a value to a natural good or service because of its critical importance for the planning and management processes must not be a process of building a price catalog of environmental goods and services but of developing criteria for comparing alternatives and the null hypothesis in a framework of well-defined priorities and constraints (Box 3.2).

Box 3.2 - Valuating the degree of threat of a given species (adapted from Kaule, 1991)

The first step is the definition of the geographical reference to which the attribution of the value is performed (a rare species in a given area can be common in another area).Next it is necessary to define the temporal reference for the value attribution (in Germany 1850 was adopted as the reference for the attribution of the value for rarity in the red lists).

The relativity of the value according to the surrounding land use is also critical: what is damaging in a given context can be positive in another.

The main factors to take into consideration when determining the rarity of one species in a given context are (in a not mutually exclusive form):

1- *Intrinsically rare species*
    a. *due to the specificity of their habitat (ex. bogs in Portugal)*
    b. *due to their high degree of environmental demands (e.g. inland salt meadows)*
    c. *due to the marginal character of those particular ecosystems (on the limit of their geographical dispersion)*
    d. *due to the migratory character and specialized dependence on given habitats*
    e. *due to the need of ample homogeneous undisturbed areas (e.g. linx, wolf, mink)*
2- *Endangered species due to the action of Man*
    a. *species of oligotrophic areas (growing eutrophication of the landscape)*
    b. *species from extreme habitats (moist or dry)*
    c. *species demanding un-fragmented habitats*
    d. *species adapted and dependent on receding cultural landscapes*
    e. *species adapted to receding agricultural practices or cultures (e.g. flax in the Iberian Peninsula)*
    f. *species that are particularly sensitive to pesticides, biocides and contaminants*
    g. *species adapted to flood/drought or similar cycles*
    h. *species whose main nourishment source disappears due to the use or biocides or other human caused factors of extinction*

In the valuation process it is critical always to give a central focus to the relativity of the criteria: "worthy" in the nature conservation domain is different (sometimes even opposed) to "worthy" in the domain of water resource protection or even environmental quality (type of energy production system). Its relative value depends on the dominant priorities at each moment: "*it is impossible to compare in the same scale the pleasure of going to a cinema and having a good meal*"

Therefore, in order to conduct a sound valuation process the first step is the clear definition of targets as, for ex:

- Definition of priority areas for conservation and protection

- Definition of development goals
- Comparison of land use alternatives
- Definition of compensation measures
- Definition of management priorities and strategies

The definition of a system of targets must be made in the frame of the regional nature of ecological systems implying the need for a clear definition and distinction of local regional national and global value frames. Another important aspect to be taken into consideration is the need not to restrict the geographical frame to the specific site or region, but to take into consideration the entire "watershed" affecting and determining the nature and dynamics of that site or region.

3.3.2 - Evaluation

Evaluation is the systematic determination of merit, worth and significance of something or somebody, using comparable criteria in the frame of a set of norms, standards or reference systems. Evaluation is essentially a process of measurement meaning that it must always be referred to a comprehensive and reproducible system or scale of reference. It corresponds, in the practice to the determination of the merit and worth of programs, entities, ideas, etc., in terms of how effectively and efficiently they are serving or fulfilling the expectations of those affected (adapted from Scriven, 1993). It constitute a fundamental element of any practical activity - where it is used to differentiate between the most favorable or adequate attitudes to be taken from those less adequate or favorable and in any discipline where it distinguishes between god and bad procedures, research targets, interpretation or theories, and compares the relative value of objects within predefined reproducible evaluation criteria (adapted from Scriven, 1997).

Evaluation is, therefore an essential component of any decision process by allowing to rank different alternatives, perspectives, objects according to objectives or other criteria defined as building the base of the decision concerned. Therefore its development must obey to methods previously assessed for their correspondence to the aims and circumstances of that particular process, but remaining valid for any similar process and evaluated objects.

Therefore any evaluation process has to meet the following conditions (Scriven, 1993):

1) It must be an objective approach which implies:
    a) To explicitly define and defend a logic of evaluative conclusions inferred from factual premises and resulting from explicit definitions;
    b) To refuse the fallacies of arguments in favor of bias-free doctrines.
2) Must be consumer-oriented and not user-oriented. This implies the refusal to be a "decision support" but only an contribution to the construction of one in an independent perspective. An evaluation result is not an end in itself but an instrument

to be further used in independent frameworks and methodologies whose informational (but not operative) component it will be part of.

3) Must correspond to a generalized perspective - not a general perspective, but a generalization of the evaluation concepts throughout all domains of human knowledge and activity.

4) Must build a technical vision what implies a deep knowledge of other disciplines, methodologies and the development of its own technical methodology. These methodologies must be reproducible and understandable as any other scientific methodology.

To evaluate is, therefore, a complex process that must obey the very strict and well defined rules and methodological and epistemological demands. But it is essentially an objective and reproducible technical process incompatible with biased and improvised approaches. Its methods must be sound, well substantiated and permanently subject to revision, correction and assessed in order to prevent or reduce normal sources of error like dominant paradigms, contextual factors and methodological defaults.

When conducting any environmental evaluation process it is mandatory to ensure that the reference system is clearly and comprehensibly defined (e.g. the choice of the year 1850 as a temporal reference for the determination of rarity of a species in Germany).

This implies the consideration of at least two working domains defined and characterized in such a way that they can be compared using the same criteria and variables:

- The reference domain, expressing the stable un-circumstantial characteristics of the area to evaluate expressing the resources available in the area.
- One or more circumstantial domain (corresponding, for example, to the present land use and to different alternative scenarios), expressing the circumstantial resource affectation in the area.

Every evaluation procedure, as already referred, is directly dependent first from a clear definition of the objectives and objects of that evaluation, then, of the development of the evaluation procedure and the definition of the system of reference and the valuation criteria.

In the present case where the objective is the development of a framework for the development of processes of systematic conservation planning and ecosystem based management in small islands, particular attention must be given to fulfillment of the requirements displayed in Tab. 3.1, 3.2 and 3.3 because they clearly define what should the reference data and objects be.

But it is not only necessary to gather data, it is also of primary importance to characterize the way in which that data and the corresponding systems are organized and interact, because, from these relations, comes the expression of the multifunctionality of the system in analysis and the ability to understand how different evaluation criteria expressing different perspectives of the reality, can be built (Fig. 3.2).

In small islands some of these relations have little significance while others assume particular importance.

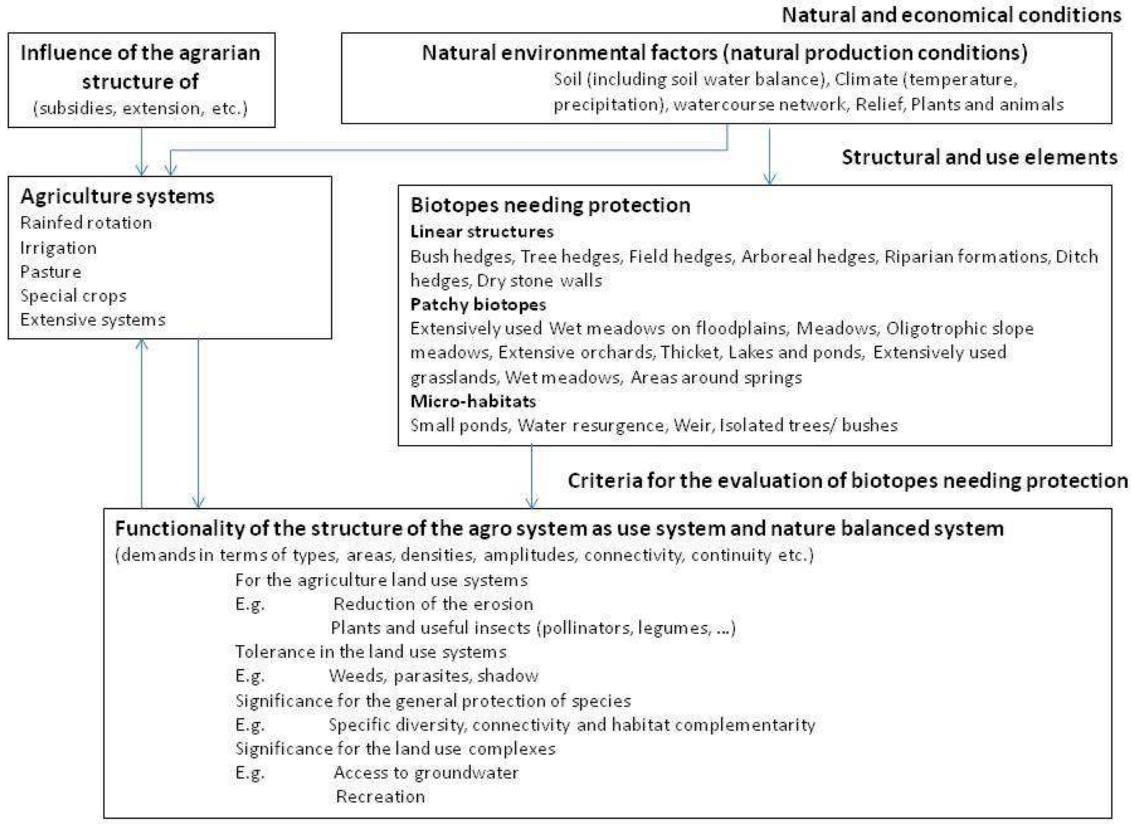


Fig. 3.2 - Functional relations and structural elements in an agro system to determine evaluation criteria (Kaule, 1991, pp. 283)

For example continuity loses some of its importance, while complementarity assumes a critical importance in order to ensure that all sub-habitats necessary for a given species remain present.

3.4 - Applying to small Islands

According to Davis *et al*. (2003), conservation planning over large regions requires answers to a series of interrelated questions:

- What resources (ecological features and processes) do we seek to conserve in the planning region? [Conservation Goals]
- What is the current extent and condition of those resources? [Resource Assessment]
- What are the key environmental and social drivers affecting resource extent and condition? [Process Models]
- How are resource extent and condition likely to change in the future? [Scenarios of threatening processes]

- What conservation tactics are available for different places and conservation concerns and how do they compare in terms of cost and likelihood of success? [Conservation Alternatives]
- What are the highest priority areas for investing today's limited conservation funds? [Conservation system design]
- Are ongoing conservation projects effective? [Monitoring and Evaluation]

This questions when applied to the small island context must be considered, as previously developed, in a particular perspective. The first question to be considered is that each island is a case and there cannot be a general framework applicable to all types of small islands. Nevertheless there are some common issues that must be taken into account in building such a framework.

What resources (ecological features and processes) do we seek to conserve in the planning region? [Conservation Goals]

Islands, particularly those of the macaronesian region where the study case is included have normally a more or less longer history of colonization (in the Macaronesia 500 to ca. 1000 years), that lead to profound changes in the ecology (in some cases involving the almost total destruction of the previous vegetation and the introduction of new species and new ecological processes (particularly large scale herbivory). On the other side, islands are ecologically isolated (or almost completely isolated, determining that if there is no human intervention in the recolonization with original species, there is little chance of natural recolonization. Finally, islands are more or less densely occupied by human activities, indispensable for the well-being of the inhabitants and visitors and for the economical viability of the island society. This determines that there is little chance of recovering human used areas for conservation or restoration purposes.

So this question can only be answered taking into consideration what values remain and what new values appeared. Only then can the second question be answered:

What is the current extent and condition of those resources? [Resource Assessment]

The extent of the resources in an island must be determined with particular attention trying to evaluate clearly what is the real potential extension (derived from the existent stable environmental factors) of the environmental factors necessary to that species or community and pin point areas where that species survives in non-optimal conditions. Also important is the identification of microelements and habitats, as well as possible or existent interactions with other islands (in an archipelago or other source of propagules).

What are the key environmental and social drivers affecting resource extent and condition? [Process Models]

The pressure on the values doesn't correspond to a stable process throughout history. Many resources and values where strongly affected (or even locally compromised) by actions or land uses that are no more performed, determining that ecosystems and values endangered by those types of disturbances present completely different management questions as objects and systems affected by present land uses. So, in the first case it is necessary to determine how are those objects and systems evolving, if there is a lack of recolonizers, if they can be imported, and if there are still sources of disturbance that can be removed without land use conflicts. In the second case it must be determined, for land use, habitat type and biotope what are the factors of disturbance and how their reduction or exclusion would cause social-economical losses that could not be compensated in a sustainable and acceptable way. Intermediary solutions must also be evaluated together with the minimal conditions necessary for the sustainable maintenance of the value or ecosystem. (one example are situations where agriculture uses extreme conditions with very low or no profit and impedes, therefore the restoration of those areas and the possibility of compensation the real or apparent production from those areas with measures promoting production in more adequate areas).

How are resource extent and condition likely to change in the future? [Scenarios of threatening processes]

The elaboration of these scenarios must take into account the evolution of the different sources of disturbance (predominantly human population increase, tourism and real estate, industry and infrastructures, agriculture and forestry and spreading of alien species). The characterization of these scenarios must be geographically located in order to hierarchize the different intensities and character of the disturbances. It must also be related with the previous inventory of existing and potential resources and values and their relative resilience or degree of threat.

What conservation tactics are available for different places and conservation concerns and how do they compare in terms of cost and likelihood of success? [Conservation Alternatives]

This is a critical area because it implies a balance between the conservation targets the available or potential values and the ability to build a societal involvement on the conservation process trough adequate mechanisms of compensation, contractualization, development of NCO, creation of alternative sources of income associated with the conservation praxis, etc. This issue implies an effective and global involvement of all the stakeholders and a particular attention to the particular socio-cultural factors characteristic of islands.

What are the highest priority areas for investing today's limited conservation funds? [Conservation system design]

It depends: areas degraded but without disturbance can be les prioritary than areas with low value, but high disturbance and good recovery potential (like some areas invaded by alien species). A balance must be made between short medium and long term feasible targets, ensuring, at the same time that emblematic values receive the necessary attention. In this way one can, with limited resources develop successively areas that presenting no interest today can be emblematic in a medium turn, without losing from sight the main values that, when not directly threatened can be object only of a maintenance management or a low intensive restoration or improvement. Many islands are of volcanic nature and that characteristic allows for an immediate showcase capable of attracting tourists with limited investment and maintenance costs, allowing the use of available funds to the progressive recovery of vegetation formations and protection and recovery of animal habitats (perhaps with a priority on birds due to their larger attractivity and potential source of income or founding).

Are ongoing conservation projects effective? [Monitoring and Evaluation]

This is a critical issue in any conservation and management policy. But particular attention must be given to the need to predefine very clearly already in the planning and execution phases what are the monitoring objects and the evaluation variables (namely intermediary targets in order to allow timely readjustments). The involvement of all stakeholders in these processes is so indispensable like in any other stage of the process.

4 - Building an information framework for systematic conservation planning in an island context

4.1 - Conceptual framework

Landscape characterization in the frame of planning and management processes considers the need to differentiate the different domains or information layers (Fig. 4.1) which, integrated build the representation of the character of a landscape at a given moment.

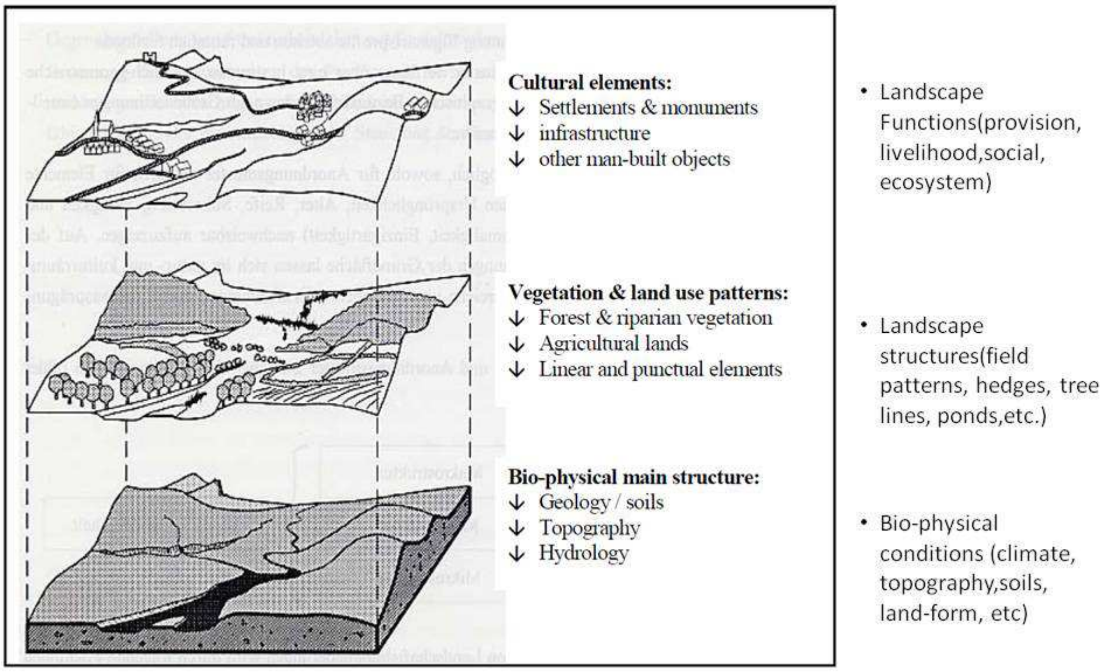


Fig. 4.1 - Landscape character consisting of three main layers: biophysical main structure, vegetation and land-use patterns and cultural elements (Wascher, 2004, pp. 244)

This approach presents nevertheless important constraints because it doesn't integrate the processes and interactions that occur in the different layers and between them. Additionally it does not take into consideration the time dimension and the evolutionary processes intrinsic to the nature itself of the landscape.

It is therefore necessary to complement and develop this characterization model in order to include those processes as well as being able to represent and operate the temporal evolution processes.

Such characterization model has to consider in its basic assumptions that one must distinguish between the layer of the stable resources and the layer(s) of the resource allocation by the different uses (human or natural) or planning alternatives and scenarios. This distinction derives from the fact that the stable resource and structural processes corresponds to the intrinsic framework of each landscape including not only the availability of resources but also temporal factors like release rates (e.g. natural geological weathering and nutrient and soil elements release rate). This resource layer interacts with the circumstantial layers by conditioning their characteristics and dynamic patterns as well as levels of resource availability.

It is based on these questions and on the consideration that different disturbances determine distinct hierarchical types of influences and perturbations on the different landscape elements, in terms of nature, space and time and showing a more stable or labile behaviour that the Integrated Landscape Assessment approach (ILA) was developed.

The ILA approach is based on the assumption that, in order to be able to characterise and evaluate this circumstantial landscape state, one as to characterise it by combining two different conceptual and practical information layers: a tendentially stable reference layer and the present or proposed land use layer (and eventually other conceptual layers corresponding to different land use scenarios). This allows a homogeneous process of analysis of the present situation or eventual scenarios in relation to the reference layer.

Therefore, the ILA model includes at least two conceptual working layers:

- A circumstantial layer corresponding to the present conjunctural "state" of the landscape depicting the present factors of resource allocation.
- A stable "potential" layer depicting the stable characteristics of each site allowing the identification of use constraints or potentials (e.g. available resources, their availability rates or spatial process paths and patterns).

These two layers correspond, conceptually, to the resource baseline and its evolution trend and to a given land use situation (present or planning scenario of resource allocation) allowing the evaluation of the resulting evolution trends, in the classical sense of impact evaluation (Fig. 4.2).

ILA is, in this context, a framework for data retrieval and evaluation processing. The only requirement of the method is the availability of a stable geographical reference base that can be qualified with the same set of indicators or descriptors as the system to be evaluated. This implies that every geographical land use/habitat or ecological/biological structural arrangement can be described by a set of indicators or other evaluation tools that can be applied, both to a given stable geographical/ecological system of reference as to the present landscape structure, in order to determine the variation of those indicators or evaluations descriptors. The advantage of the ILA framework is the consideration of a stable system of reference, to which the present land use or the proposed land use alternatives can be compared and evaluated. This is the only way in which we are able to consistently compare different situations and scenarios as well as different economical and ecological sets of conditions or hypothesis.

Each layer will display the structural arrangement of land /landscape units and associated ecotopes. We obtain, therefore, an information system where every geographical land use/habitat or ecological/biological can be described by a set of indicators or other evaluation tools that can be applied both to the present landscape as to the stable geographical/ecological system of reference in order to determine the variation of those indicators or evaluations descriptors (Fernandes *et al*., 2006).

We can, therefore, evaluate the reversibility or irreversibility of given disturbances and the positive or negative sustainability of each land use in each landscape unit. We can also identify the nature (resource or disturbance) of landscape corridors or other connectivity paths, the effective degree of complementarity between land units and the real variation on the degree of fragmentation.

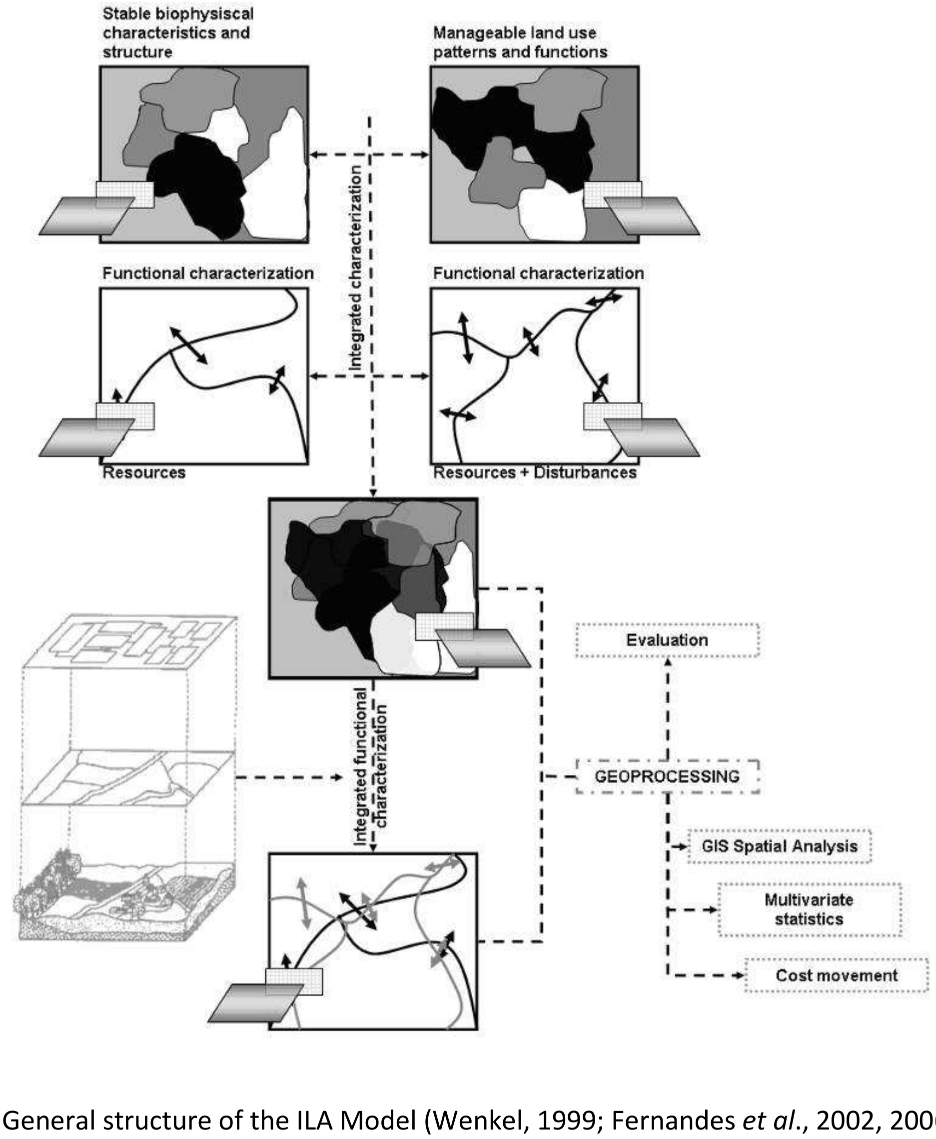


Fig. 4.2. General structure of the ILA Model (Wenkel, 1999; Fernandes *et al*., 2002, 2006)

When analysing nature conservation issues, this approach of a sinecological character, must be complemented by an autoecological characterisation of target species, groups of species and habitats. This characterisation will include, for example, the habitat demands of those species and can be associated with the optimum curves for each species/groups of species or habitats allowing the identification of the degree of fulfilment of the ecological optimum by the prevailing condition in each land unit. Such information or models will allow, for example, the evaluation of the degree of stress that a given target species is supporting in its present habitat and, therefore the evaluation of its resilience relative to external disturbance such as land use changes or natural environmental oscillations.

The use of the ILA model at the structural and functional level allows the use of a large variety of tools like:

- Comparison of landscape metrics between the reference and the circumstantial characterisation layers.
- Qualitative evaluation of the stable or circumstantial character of landscape elements like (matrix, patches, corridors) or characteristics like fragmentation or connectivity.
- Modelation of landscape or habitat connectivity as well as target animal movements (using for example percolation or cost-distance models).
- Evaluation of management scenarios according to different sets of valuation criteria.

4.2 - Application to the universe of small islands

The development of the characterization models able to support ecosystem oriented management processes in small islands face several difficulties related not only with data availability but also with the particularities of small islands environments.

The main differences between small islands and mainland ecosystems are, as already referred the fact that while in continental systems the pedological and bioclimatic factors are dominantly the main factor determining the ecological zoning, in islands systems those factors appear conditioned in particular ways due to the restricted geographic space of the islands, what makes particularly complex the development of a reference models for these systems.

Let's consider, as an example the case of two atlantic islands (Santiago (Cape Verde Archipelago), and Madeira) (Fig. 4.3, 4.4 and 4.5).

One can verify that the master lines of the ecological zoning are referred primarily to morphological factors (position, local morphology and aspect) that will influence the critical climatic factors (water and temperature) in terms of direct exposure or of shelter, in terms of altimetric zoning or in the exposure to the different types of winds with different moisture content (influencing rainfall and evapotranspiration) as well as to the indirect precipitation associated with the formation of stable cloud belts at given altitudes (e.g. Madeira).

Only marginally and detectable at detailed scales are the influence of the soil and other forms of subtract noticeable (the main types of such features in the case of the Santiago island are water courses and drainage lines, open valleys, beaches, arid areas, wetlands, etc.). In the case of Madeira there are important areas of not zonal vegetation associated with riparian areas, rocky substrates, subject to salt influence and sandy subtract.

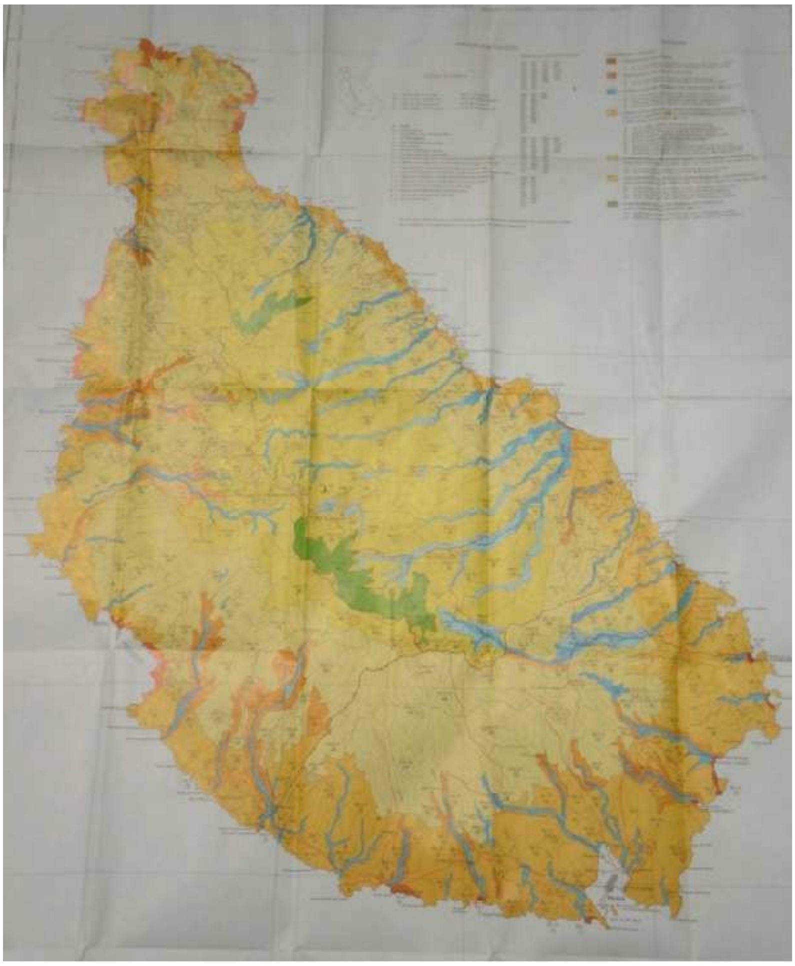


Fig. 4.3 - Agro ecological and vegetation map of the Santiago Island (Cap Verde Archipelago) (Diniz and Matos, 1986)

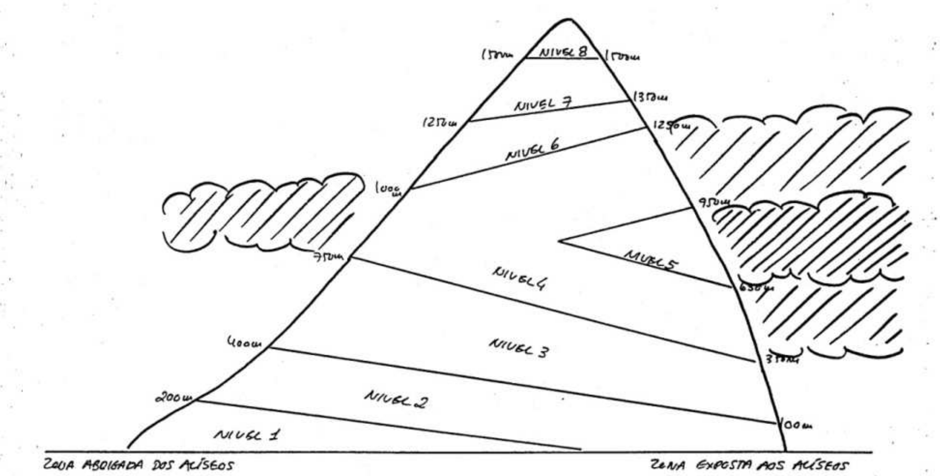


Fig. 4.4 – Vegetation belts in the island of Madeira (Cruz, 1994)

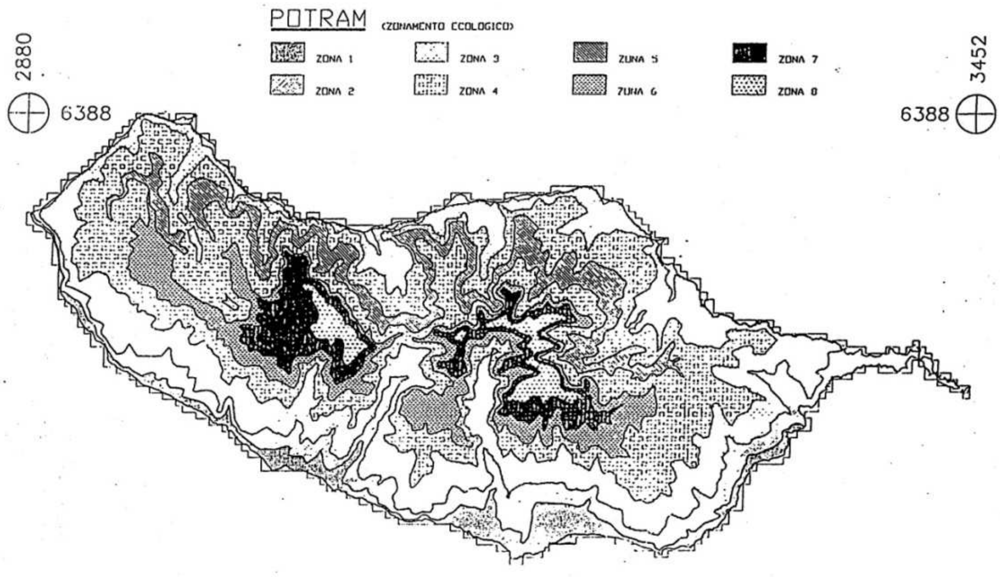


Fig. 4.5 – Vegetation belts and ecological zoning of the island of Madeira (Lopes, 1990)

These examples, although not exhaustive and systematic illustrate quite well what must be the main guiding lines for the construction of a biophysical system of reference for insular environments

Those lines will, therefore, be:

1. Main determinant ecological (phytogeographic) factors:
2. Local factors

All these factors (resources) must be considered in their present (and not potential) form because the purpose of these characterization approach is that it must express the present reality of the resources and not their hypothetical evolution in a time frame much longer than that of the planning and management process.

This approach correspond, therefore in its essence to the conceptual matrix developed by Diniz and Matos (1986) that allowed them to perform for the Island of Santiago (as well as for the entire Archipelagos of Cape Verde and São Tomé e Príncipe and vast areas in Angola) a vast set of evaluation procedures for the planning and management of agriculture, but that can directly be also used for nature conservation purposes.

ILA is of particular utility in this context, because it allows the consistent consideration, comparison and evaluation of the same geographical object in different forms (e.g. land use or natural habitats spatial allocation) or according to different evaluation criteria (naturalness, adaptation to given target species or habitats, etc.). These consistency derives from the definition of an independent object of reference (e.g. ecological reference units) that can be characterized with the same set of indicators as all scenarios or land use alternatives and support evaluation algorithms adapted to the different selected evaluation criteria.

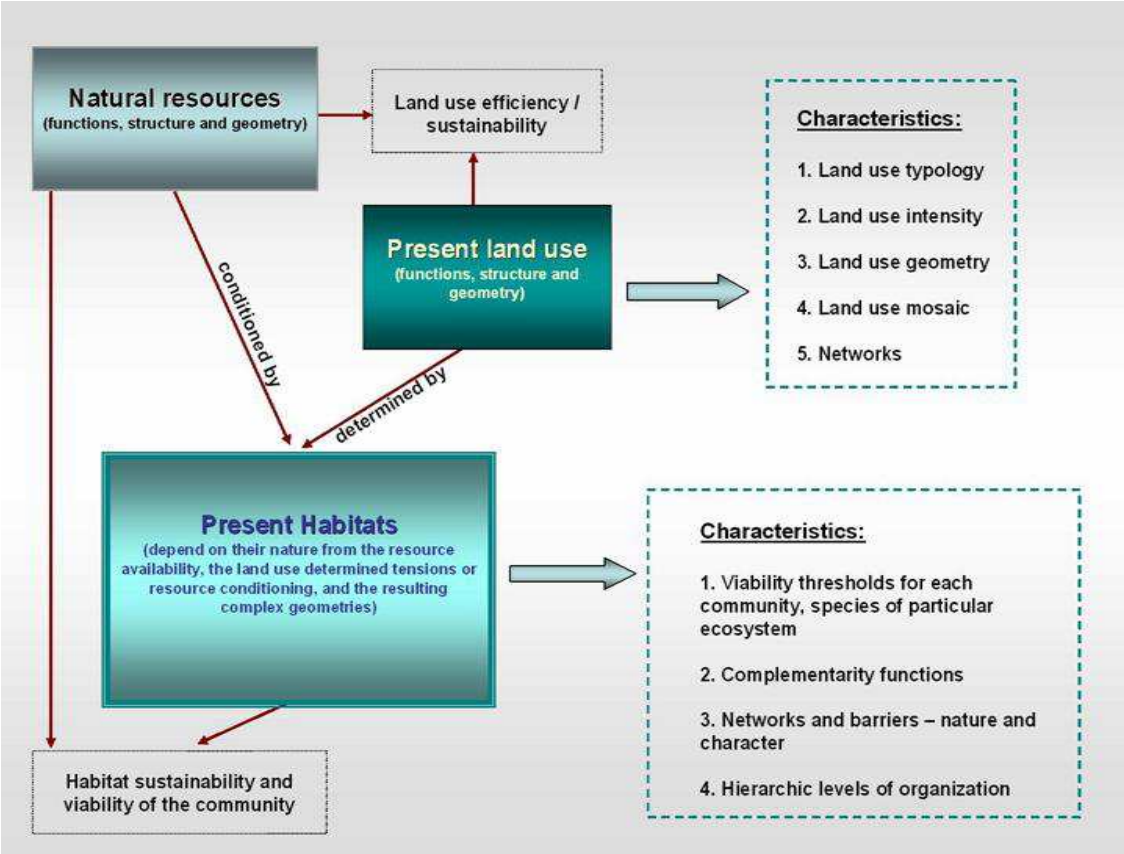


Fig. 4.6 - Interactions between present land uses, present habitats and natural resources

Critical for the development of all the algorithms based in target habitat or target species criteria is the availability of detailed data of the autoecology of those particular species or the synecology of those habitats.

Particularly important is the determination of criteria for the definition of Minimal Viable Populations (MVP) and the identification of critical factors affecting those criteria (habitat area, fragmentation, patchiness, edge/core relation, etc.

The second set of data (Fig. 4.6): interaction between land uses and natural values, implies the creation of a detailed data base on each type of patch (be it subject to any form of land use, be it natural (pristine, remnant, recovering, etc.)) where at least the associated natural values be identified together with the historical and present factors determining their characteristics and conditioning the existence of those values.

Of particular importance is the clear identification of the autochthon or imported nature of those values, and, in this last case their type of interactions (positive or negative) with autochthon values (e.g. vine as a contribute to an increase on the availability of food for some species (need to clarify eventual negative interactions due to competition by these favored species).

The third set of data is critical for the future conduction of the management processes. This is mainly due to the fact that it must bring together economical and ecological factors within their social context (Fig. 4.7).

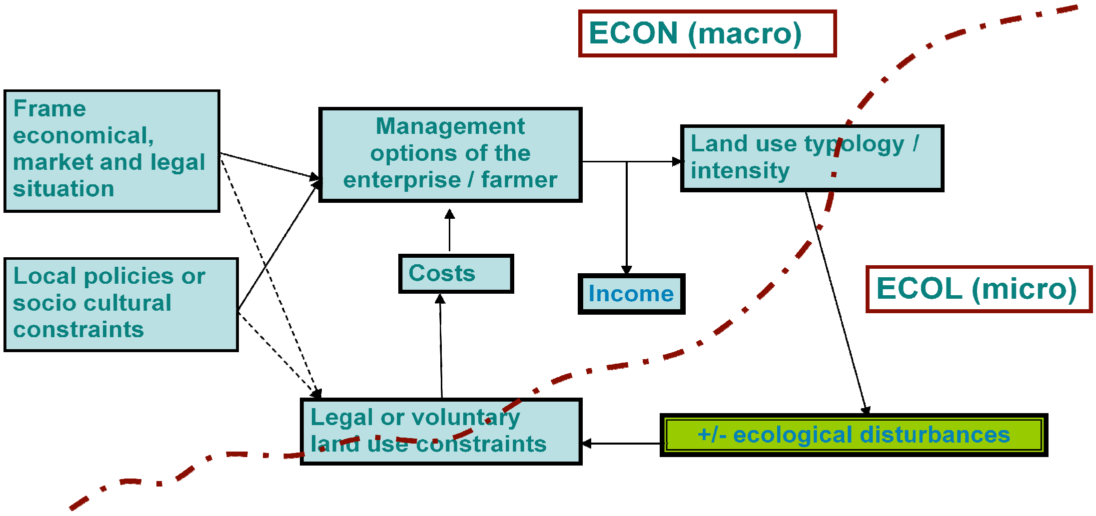


Fig. 4.7 - Interaction hedge between ecology and economy in landscape management

Development of management models - The first question that must be assessed is the way in which the different stakeholders (e.g. farmers) make their management decisions, in order to search for factors that potentiate a positive involvement instead of the classical limitation (prohibition) approach of many conservation policies (Fig, 4.8).

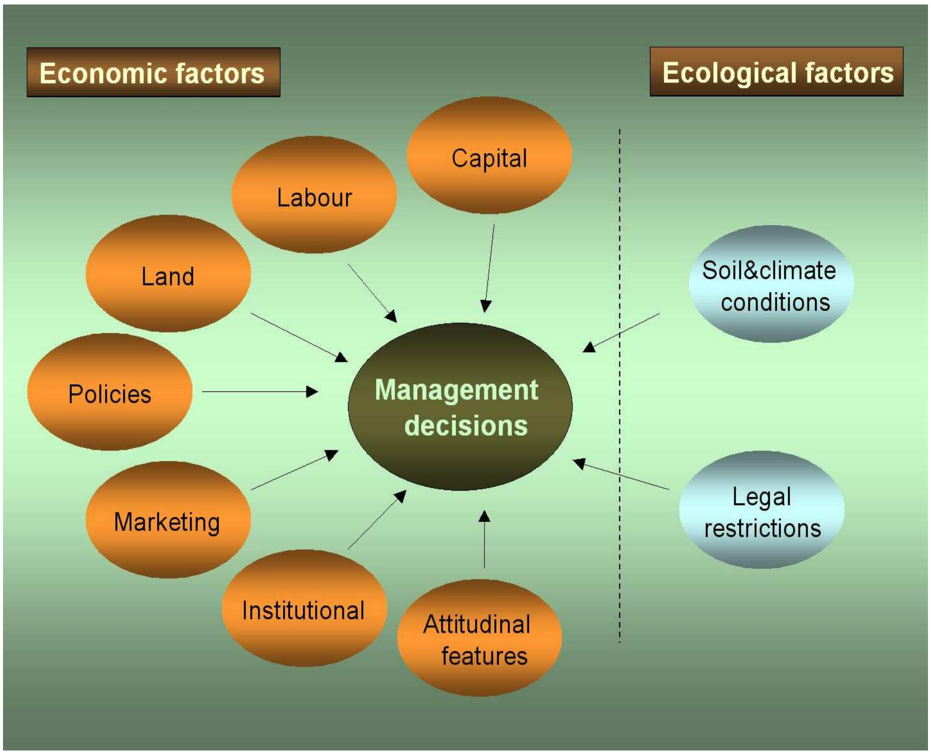


Fig. 4.8 - Factors affecting management decision for example of farmers

There are domains where it was possible to find a replacement for former damaging practices like all the industry around whale watching and diving that built an alternative to the former activity of whale hunting.

But at the level of much of the stakeholders (farmers and fishers) the alternative is not so easy, because of the difficulty in identifying and developing Non commodity outputs (NCOs) that compensate certain restriction derived from the needs for a systematic conservation and ecosystem based management.

This is exactly the level where the ability to evaluate and simulate in a single integrated tool alternative management approaches will be able not only to define policies, but mainly to allow the involvement of all stakeholders in the definition of those alternatives, and particularly in their implementation.

One has, therefore, to implement multifunctional management systems integrating all factors in a clearly defined geographical framework.

The only way to ensure the sustainability of the process of sound and assumed involvement involves strong and reliable forms of contractualization, ensuring a comprehensive clarification of all the responsibilities involved and the accountability processes.

In an Island environment, with strictly limited resources, consensual management approaches are of critical importance. Therefore, the ability to sample all information in a coherent framework where all evaluation procedures can be lead in a reproducible way with a comprehensive system of reference, allows an active involvement of all stakeholders in the development of the best solutions for each site and moment and the permanent reevaluation of those solutions.

4.3 - Building the characterization system

As previously stated when describing the ILA model, the first step for its implementation is the characterization of the reference layer. This layer must be defined in such a way that it represents with the best possible detail the stable biophysical characteristics of the area. Therefore, its quality, precision and amount of information integrated depends from the available information and its quality and detail.

The geographical object that will build the basic structure of this layer can be designated as "ecological reference unit" (ERU) in the sense that it integrates all determinant stable ecological factors occurring in the study area.

As previously stated these factors correspond basically to the following list:

1. Main determinant ecological (phitogeographic) factors:
    a. Bioclimatology (normally associated to altitude and exposition)
    b. Macro-morphology (conditioning exposition but also the predominant dynamic processes (mass movements on slopes, land, ocean, valley breezes, "foehn" effects, hydrologic retention, evapotranspiration, indirect precipitation (fog or clouds)
    c. Substrate (determining, between many other factors nutrient, water and thermal balances)
2. Local factors

a. Micro-morphology
b. Soils and substrates
c. Local factors of water availability or unavailability
d. Local chemical limiting on constraint factors (nutrients, salts, toxicity, etc.)

Its selection derives from the fact that the ERUs are primarily focused of areal characteristics and express mainly ecological factors determinant for the development of vegetation and the differentiation of vegetation communities.

Particular factors relevant for the fauna and independent from the present vegetation must also be taken into consideration (e.g. cliffs, presence of water, rockiness).

Associated with this layer of geographical elements, other layers must be built characterizing the dynamic processes occurring in that area: hydrology, macro and microclimatology, erosion and sedimentation patterns, rates, variations, etc.

Of particular importance is the need to ensure that all these characterization layers / data bases have common descriptors as if applied to the present landscape. Only in this way can they be compared, and evaluation procedures conducted using this reference layer as the reference for all evaluation processes.

It proved useful, in some circumstances, to include in the data describing each ERU, whenever possible, the most probable vegetation communities susceptible of naturally occurring in those units. The reason for this usefulness derives from the fact that many valuation variables are easily applied to vegetation communities (and equivalent land uses) allowing therefore a wider set of evaluation procedures and modeling possibilities.

The second domain of characterization is the present land use.

The first thing that must be given particular attention is the selection or construction of Land use classification legends (Box 4.1)

Box 4.1 - Building a land use classification system (adapted from Guiomar et al., 2009)

Land use mapping is a critical instrument for landscape assessment and planning. Nevertheless the utility of land cover maps is directly dependent from the adopted classification legend. On one side this legend must be widely accepted in order to allow interregional or even international comparisons. On the other side it must be able to be efficiently implemented with a reasonable cost- and time-efficiency. Simultaneously it must be able to represent suitable to serve the wider number of potential user as possible.

Examples of this variety of possible uses are: [1] dominant land use type; [2] land cover typologies (must include dominant vegetation type); and [3] dominant vegetation layers.

The Housing and Home Finance Agency of Urban Renewal Administration and the Department of Commerce of Bureau of Public Roads, developed in 1965 (URA-HHF and BPR-DC, 1965) a standard land use coding manual, for identifying and coding land use activities. Instead of combining into one category several characteristics that can describe a piece of land, the study concluded that each separate dimension or characteristic be defined by a separate classification system. These characteristics, as illustrated in Fig. 4.9, could then be grouped. The different characteristics that describe either a landscape unit, a structure on the parcel or the landscape activities are maintained separately, and they are put together in the combinations that will best fit the needs of a particular study. This, of course, does not mean that a variety of information cannot be collected in the same field survey.

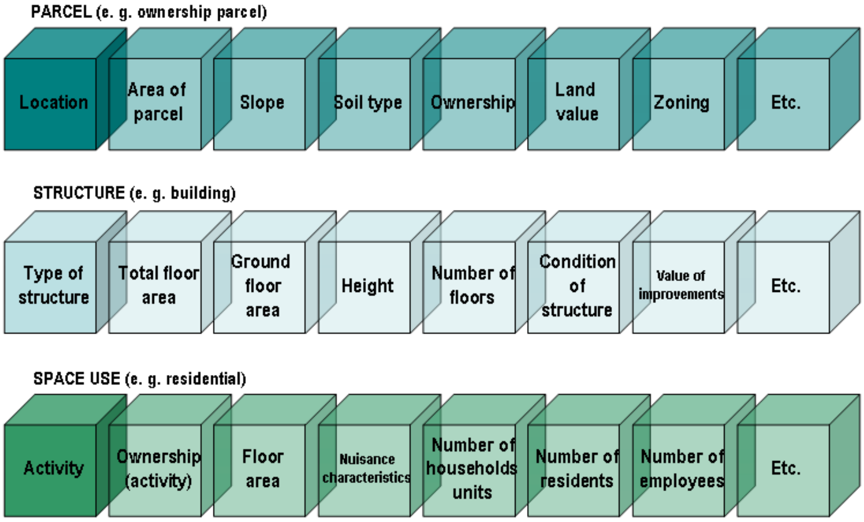


Fig. 4.9 - An example of characteristics commonly used to describe a parcel of land (URA-HHF and BPR-DC, 1965)

The land use and land cover classification system presented by Anderson et al. (1976) includes only the more generalized first and second levels. For land use and land cover data needed for planning and management purposes, the accuracy of interpretation at the generalized first and second levels is satisfactory. The types of land use and land cover categorization developed by can be related to systems for classifying land capability, vulnerability to certain management practices, and potential for any particular activity or land value, either intrinsic or speculative.

The land use, vegetation cover and land form classification system developed in the State of Florida Department of Transportation (SFDT, 1999) is arranged in hierarchical levels with each level containing land information of increasing specificity:

1. Level I would normally be used for very large areas, state-wide or larger, mapped typically at a scale of 1:1000000 or 1:500000;
2. Level II mapping typically might be at a scale of 1:100000;
3. Level III mapping scale typically is 1:24000;
4. Level IV typically might be mapped at a scale of 1:6000.

Two common limitations of current databases are either [1] the original data are highly discipline-related, making them difficult to understand by users from other disciplines, or [2] the original data are assembled in classes that are too general to be used by specialists (Di Gregorio and Jansen, 1998).

Many other classifications have been developed with different purposes and it is not generally accepted that habitat classifications (such as EUNIS) can be compared with land use classifications (such as CLC) (Tab. 4.1). Nevertheless if we consider the perspective of the users, an integrated classification combining both land use and dominant vegetation information is much more cost- and time-efficient.

All these classifications, because they are focused on a single descriptor (land cover in terms of land use or vegetation/habitats) have only a limited ability to describe the main character of a given landscape. Cruz (2002) proposed a classification model for the portuguese phytogeocenosis structured according to a 15 digit alphanumeric classification code, where the first 5 digits represent the geocenosis (geographical context), the next 5 digits the phytocenosis (vegetation association) and the last 5 digits the anthropogenic influence. Other classifications systems combining different descriptors where proposed, maintaining, nevertheless, a single classification code:

AAAAA11111XXXXX

(GEOSYSTEM – PHYTOSYSTEM $_{(habitat)}$ – ARTIFICIALIZATION DEGREE)

West et al. (2005) relate a similar approach, the National Hierarchy of Ecological Units, a hierarchical approach classification with 8 levels, focused on climatic, geologic, geomorphic, edaphic, and vegetational characteristics.

Tab. 4.1 Examples of classification legends with different informational contents (all referred to a 3 level hierarchy)

Dominant Land Use type (Extracted from Di Gregorio and Jansen, 2005)	Land Cover typologies (include dominant vegetation type) (CORINE Land Cover classification - CLC)	Dominant vegetation typologies – Habitats (EUNIS 2004)
A11. Cultivated and Managed Terrestrial Areas A12. Natural and Semi-Natural Vegetation A23. Cultivated Aquatic or Regularly Flooded Areas A24. Natural and Semi-Natural Aquatic or Regularly Flooded Vegetation B15. Artificial Surfaces and Associated Areas B16. Bare Areas B27. Artificial Water bodies, Snow and Ice B28. Natural Water bodies, Snow and Ice	**Class 1: Built up area** • 111 Continuous urban fabric • 112 Discontinuous urban fabric • 121 Industrial or commercial units • 122 Road and rail networks and associated land • 123 Port areas … **Class 2: Agricultural area** • 211 Non-irrigated arable land • 212 Permanently irrigated land • 213 Rice fields • 221 Vineyards • 222 Fruit trees and berry plantations … **Class 3: Forest and natural area** • 311 Broad-leaved forest • 312 Coniferous forest • 313 Mixed forest • 321 Natural grassland • 322 Moors and heathland …	**G Woodland, forest and other wooded land** **G1 Broadleaved deciduous woodland** G1.1 Riparian and gallery woodland, with dominant *Alnus*, *Betula*, *Populus* or *Salix* G1.2 Mixed riparian floodplain and gallery woodland G1.3 Mediterranean riparian woodland G1.4 Broadleaved swamp woodland not on acid peat G1.5 Broadleaved swamp woodland on acid peat G1.6 *Fagus* woodland G1.7 Thermophilous deciduous woodland G1.8 Acidophilous *Quercus*-dominated woodland G1.9 Non-riverine woodland with *Betula*, *Populus tremula* or *Sorbus aucuparia* G1.A Meso- and eutrophic *Quercus*, *Carpinus*, *Fraxinus*, *Acer*, *Tilia*, *Ulmus* and related woodland G1.B Non-riverine *Alnus* woodland G1.C Highly artificial broadleaved deciduous forestry plantations G1.D Fruit and nut tree orchards

Adopted the more adequate classification system it is necessary to proceed with the biotope/land use cartography in order to ensure an adequate inventory of their nature, value(s), stress factors, conflicts, etc.

Of particular importance in this cartographic and data sampling process, is the need to identify and map all particular elements with ecological, socio-cultural or other significance, in order to have a complete sampling not only of the macro habitat structure but also from microhabitats, particular elements of special cultural significance, etc.

As stated before this process is simultaneously a cartographic process and a data sampling procedure.

Examples of relevant data at the level of environmental and ecological variables are (Box 4.2).

Box 4.2 - Relevant data at the level of environmental and ecological variables (adapted from Kaule, 1991)

Characterisation of critical environmental factors:

- Light
- Temperature
- Continentality (or "Oceanitality") summer fresh and inter moderate, or the reverse, for example
- Moisture
- Reaction (acidic or not)
- Nutrient availability (N, P, micronutrients, etc.)
- Toxicity

Many of these factors can be characterized when data is available, by using the Ellenberg Indicative values for plants.

Regenerative capacity or replacement possibility

- Nature of the ecosystems (primary, secondary or associated with some type of land use)
- Factors of origin (e.g. geological) and their reproducibility.
- Presence of species in the area
- Age of the ecosystem
- Nature of the determinant and affecting factors

Local and regional particular characteristics and features

- Water courses - rivers, submerged shoreline, reed, riparian formations, floodplain, meanders and oxbow lakes, terraces and their vegetation
- Lakes - Water surface, shore, accumulation series, circulation
- Torrents - erosion cone, accumulation cone, middle drainage line
- Escarpments - Escarpments, slope base deposits
- Surrounding type of influences
- Inter-influence basis
- Non traceable disperse influences
- Susceptibility

Characterization of areas with particular conservationist value

1) Threat
    a) Threatened formation according to the Red Lists
        i) grouped by ecological factors
        ii) grouped by threatens to the flora
        iii) grouped by threatens to the fauna
    b) Analysis of the formation: statistic of the number and area of each remaining biotope type

c) Evaluation of the rate of loss
   i) comparison of the present formations with the potential of passed distribution
2) Hierarchization of the protection systems
   i) World, european, national, regional, local
3) Risk factors and necessary correcting measures
   i) Analysis of the threats on the
      (1) species
      (2) physical environmental factors
      (3) Ecosystems.

Characterization of biotopes in use-ecosystems

The criteria must include:

1. General information
   a. Type (for ex. bush hedges, tree hedges, dry stone walls, trees, thickets, pounds, etc.
   b. Dimension (width, height, area, volume, etc.)
   c. Age
2. Vegetation
   a. Herbaceous strata
   b. Bush strata
   c. Tree strata
   d. Strata associated with wetlands
   e. Riparian vegetation
   f. Aquatic vegetation
   g. Rocky vegetation
   h. ...
3. Animal habitats and particular structures
   a. Microstructures, niches
   b. Gradient formations
   c. Woody plants with particular significance for insects
4. Economical significance (ecological services)
   a. reduction of water erosion
   b. reduction of wind erosion
   c. protection against eutrophication
   d. shoreline protection
   e. increase of the biodegradation capacity
   f. ...
5. Aesthetical significance

Other characteristics of particular importance are the ecological structures and their interrelations as well as its nature (Tab 4.2).

Aspects like connectivity and connectedness have to be evaluated for ex. trough clusters analysis and complementarity referred to particular species or groups of species.

One particular aspect of primary importance are the patches (normally resource-patches) that are associated with particular habitats (normally of high faunal significance because they present unique conditions that favors the presence of exclusive specialized species (animals and plants). Examples of such patches are springs, small volcanic formations or processes (fumaroles), areas of extreme morphological conditions (slope, exposure to wind or radiation), wet patches (associated with the micromorphology or with micro variations in the soil profiles determining accumulation layers in the profile.

Table 4.2 - Structural-functional classification system (adapted from Forman and Godron, 1986)

Landscape components	**Structural characteristics**	**Nature** (types)	**Functions**	**Dynamic** (changes)
Matrix	Microheterogeneity Macroheterogeneity Connectivity Connectedness Continuity Porosity	Resource Disturbance (chronicle) Endurance Consistence	Habitat Complementarity Control of the spatial dynamics	Stability Resilience Seasonality
Patch	Size Shape Number Biotype Configuration Vertical structure Internal heterogeneity (gradient character)	Resource Disturbance (chronicle) Reminiscent Regenerated Introduced Ephemerous	Habitat Complementarity Polarity Permeability Source (productivity) Absorption/ Accumulation	Meta-stability Resilience
Corridor (Border/ Ecotone)	Width Connectivity (continuity) Biotype Ecotone convolution Gradient character	Resource Disturbance (chronicle) Remnant Regenerated Introduced Ephemerous Contrast-Similitude	Habitat Conductivity Filter/Barrier Source Absorption/Accumulation Hygroscopy Permeability Complementarity	Seasonality Type of border

5 - The Pico island context

5.1 - The Macaronesian region (extracted with light adaptations from Condé *et al*. 2009)

5.1.1 - Introduction

The Macaronesian biogeographical region is comprised by volcanic islands in the Atlantic Ocean and includes the archipelagos of the Azores, Madeira and the Canary Islands:

- The archipelago of the Azores consists of nine islands halfway between the American and European continents, located on both sides of the mid Atlantic ridge and covers around 2 300 km^2;
- Madeira, Porto Santo, and the Desertas cover 800 km^2 of land located 750 km west of Morocco,
- The Salvage Island, only covering 4 km^2 are located between Madeira and the Canary Islands,
- The Canary Islands comprise seven main islands 100 km off the coast of Africa. With its 7 200 km^2 it constitutes 75 % of the region.

The volcanic islands of Macaronesia cover an array of landscapes ranging from deserts and xerophytic scrubs in arid and rocky areas in the eastern Canary Islands to humid mountain evergreen broadleaf forests and sand dunes in Madeira and the Azores.

A distinguishing feature of the region is the historic and present importance of the volcanic activity, with resulting special landscape components such as steep mountain sides and lava flows. The area is geologically young and still active, and volcanic eruptions have occurred in the region also in recent times. The ongoing seismic activity and recent eruptions, together with high-reaching mountain peaks creates an extremely complex and varied landscape and determine important land use constraints and environmental risks.

A typical Mediterranean climate dominates in the subtropical islands of Madeira and the Canary Islands, with key features as low seasonal variation in temperatures and low amounts of precipitation (rarely more than 250 mm concentrated in November-December) and generally dry conditions. Wind exposure and mountain peaks are prominent factors allowing the development of climax communities of native species and evergreen forests by creating a cloud layer at ca. 1000 m altitude by a combination of high dry winds and lower humid sea breezes. At higher altitudes, both frost and snow may occur.

The Azores, strongly influenced by its oceanic location, are climatologically different from Madeira and Canary Islands with high precipitation and high humidity. Precipitation shows a prominent east-west gradient with substantially higher annual rainfall in the westerly islands.

5.1.2 - Human historical influence

The Canary Islands have a relatively long history of human occupation. The Guanches brought domesticated animals (goats, pigs, dogs and possibly sheep) and culture plants (barley, beans, peas) from the mainland to the islands about 4 000 years ago, while Madeira and the Azores were uninhabited until the early 15th century.

The rich volcanic soils and a favorable climate allowed a rapid expansion of areas used for agriculture production for export. By the end of the 15th century, Madeira was the worlds' leading producer and exporter of sugar. Other products included wheat, wine, maize and sweet potatoes. The expanding agricultural industry had a major impact on topography and original biodiversity. Large native areas, including forests, were transformed into cultivation (at places to monocultures of sugar cane) and extensive irrigation systems were constructed to bring water from mountainous areas to dry lowlands.

The introduction of grazing animals, especially rabbits, had a particularly devastating effect on the ecosystems of the islands. Fragile forest ecosystems have been irreversibly degraded. The original vegetation of low-lying islands composed by *Phoenica juniper*, *Dracaena draco* and *Appolonias barbujana* is no longer present.

Agricultural activities also developed on the Azores, first producing cereals for the ships sailing the Atlantic, then the blue dye "pastel" plant (*Isatis tinctoria L)* and presently with an intensive production of cattle and dairy products.

5.1.3 - Ecosystems and habitat types

The habitats found in the Macaronesian region can be grouped into three main vegetation types: coastal habitats, evergreen forest and uplands. In the Canary Islands and Madeira, natural habitats are closely linked with altitude, with many key species occurring in narrow belts.

5.1.3.1 - Coasts and islets

The coastline of the Macaronesian region is varied with cliffs falling to the sea, ravines and outlets. Gran Canaria and Tenerife have sand dunes in the south while Madeira has the 630 m high Cabo Girão – one of the highest sea cliffs in the world. Smaller islands, like La Graciosa, are mountainous and heavily influenced by wind and hosts seasonal vegetation.

The herb and shrub vegetation of Madeira is fully developed at altitudes above 300 m. It is broken by urban development areas and land used for agriculture purposes. The shrub area is not always present and introduced species like cactus (*Opuntia tuna*), gorse (*Ulex europaeus*) have replaced in large areas indigenous species like globe daisy (*Globularia salicina*) and spurge (*Euphorbia piscatoria*).

Shallow bays, reefs and marine caves are found in the archipelago of the Desertas. Here a rich and important endemic flora can be found as well as the monk seal (*Monachus monachus*), marine birds and tarantulas.

Flat fertile areas ('fajãs'), with a plant community dominated by grasses, mainly the endemic *Festuca petraea*, are found around the Azorean coastline. The fajãs are influenced by wave actions, lava streams and depositions of volcanic ash. The numerous introduced species in the area mainly occur in the coastal zone and in connection with human settlements.

Coastal cliffs and islets are important as breeding habitats for pelagic birds. Cliffs in the Macaronesian region offer breeding grounds for among others Cory's shearwater (*Calonectris diomedea boralis*), Manx shearwater (*Puffinus puffinus*) and little shearwater (*P. assimilis*). Islets also serve as staging areas for a number of migrating birds. Birds stopping over during migration are a natural food source for breeding raptors (e.g. Eleonora's falcon, *Falco eleonorae*).

5.1.3.2 - Desert ecosystems

The arid regions of Europe have mainly arisen due to human activities. Original vegetation has been cleared, leaving the light soil exposed to wind and sunlight. In the Canary Islands, the desertification was enhanced by a lowered water table due to water extraction or tapping springs. The resulting halophytic vegetation has been overgrazed by livestock (especially goats) leaving the soil bare.

In desert ecosystems, a high proportion of the biomass of the system occurs in soil organisms and to extensive root systems of shrubs. Vegetation of desert systems in the Macaronesian region is dominated by the plant families *Euphorbiaceae, Asteraceae, Caryophyllaceae, Crassulaceae* and *Fabaceae*. In the region we find these systems in parts of the Canary Islands. The Canarian deserts represent an outpost of an arid vegetation zone extending from India to Mauretania. The area in Macaronesia hosts several endemic species or subspecies among them Purpurian lizard (*Lacerta atlantica*) and the Canary Islands chat (*Saxicola dacotiae*). The most threatened bird species in this arid zone is the Houbara bustard (*Chlamydotis undulata*), with a race endemic to Fuerteventura and Lanzarote.

5.1.3.3 - The evergreen forests

The humid evergreen laurel forest and the dry evergreen forest – now confined to the Canary Islands – are characteristic for the Macaronesian region. The most ancient elements, including ancient endemics, are found in the laurel forest.

The evergreen humid forests – the Laurisilva

The Laurisilva forest develops in areas with reduced solar radiation, moderate temperatures, high precipitation (500–1 200 mm) and presence of fog and is especially rich in deep, extensive ravines. Tree trunks are generally covered by a thick carpet of mosses and lichens and are usually colonized by ferns. The dominant trees are Canary laurel (*Laurus azorica*), Madeira mahogany - "Vinhático" (*Persea indica*) Acotea - "Til" (*Ocotea foetens*). In Madeira, the forest is also characterised by the presence of the endemic lily of the valley tree (*Oxydendrum arboreum*). The laurel forest in the Azores also has a presence of juniper (*Juniperus brevifolia*) and Azorean heath (*Erica azorica*). The islands Sao Miguel, Pico and Terceira have the largest remnants of this unique laurel-juniper forest. On other islands, remnants are mostly found in *caldeiras* and deep ravines.

The unique humid evergreen forests in the Macaronesian region are today degraded. Human activities have decreased their coverage from an original 60 % in Madeira to the present ca. 20% (15000 hectares). The same reduction in area of this type of forest has also been recorded in other islands. In Tenerife, the humid forest today covers less than 20 %, in Gran Canaria 1 % and in the Azores 2%.

The dry evergreen forest

The combination of high solar radiation, high temperatures, low precipitation and sporadic sea fogs are pre-requisites for the development of the dry evergreen forest of Macaronesia, today exclusive to the Canary Islands. A number of endemics are found in this habitat: holly (*Ilex canariensis*), Azorean candleberry (*Myrica faya*) and willow (*Salix pedicellata*) although this last one is restricted to water courses.

At lower altitude the forest hosts species of both Mediterranean and North African origin, such as *Pistacia atlantica* and *Juniperus phoenicia*, or endemic species like the Canary palm (*Phoenix canariensis*) and *Dracaena draco*. At levels over 400 m above the sea level forests are harbouring species like azorean heath (*Erica scoparia* ssp. *platycodon*), Canary pine (*Pinus canariensis*), with an undergrowth of *Cistus montpeliensis, Cistus symphytifolius* and *Chamaecystus proliferus.*

5.1.3.4 - Uplands

At dryer places and altitudinally above the Laurisilva forest a pine forest belt is found. Here the endemic Canary pine (*Pinus canariensis*) grows together with tree heath (*Erica arborea*), *Cistus*-species and the endemic escabon (*Chamaecystus proliferus*). The higher part of this belt hosts the endemic *Juniperus cedrus*.

At even higher altitudes (above 2600 m), one finds a unique xerophytic and cold-resistant vegetation with the endemic Teide violet (*Viola cheiranthifolia*).

In Madeira, the upland vegetation occurs above the limit for the evergreen forest. It is characterized by high differences in temperature, intense winds, high precipitation and even snow. Most plant species are in danger of extinction. This ecosystem hosts several endemics: Madeira heath (*Erica maderensis*), a violet (*Viola paradoxa*) and Madeira trift (*Armeria maderensis*).

5.1.3.5 - Mires

The humid climate at high altitudes of the Azores allows the development of several types of mires. Bogs, fens and forested peat bogs – covering an area of 2100 hectares – are found on Sao Miguel, Terceira, Pico, Faial, Sao Jorge and other islands. Mires hosts several endangered species, among them juniper (*Juniperus brevifolia*), Azorean heath (*Erica azorica*) and fern species (e.g. *Culcita macrocarpa*).

Data are not available for assessing earlier extensions of mires, but recent human activity, including forestry and agriculture, has decreased the area of mire habitats. However, certain areas are still not influenced beyond repair and restoration is still an option.

5.1.3.6 - Inland waters

The Canary Islands have no permanent rivers, but Madeira has a large number of small rivers, streams and springs. Rivers and streams in the north of Madeira flow permanently, while southern rivers normally become dry in summer. In addition to natural water courses, a network of conduits and tunnels – the levadas – collect and transfer rainwater to farms and gardens. The levadas on Madeira is estimated to have length of 700 km on an island that is 60 km long.

5.1.4 - General species richness and endemism

A diverse landscape and lack of direct effects of glaciation makes the Macaronesian archipelago a hotspot for biodiversity in Europe. Further, the volcanic origin of the islands and the fact that they have never been directly connected to any mainland are reasons why the region also hosts a large number of endemic plant and animal species. A considerable number of the endemics are ancient relict endemics, with a great affinity with Tertiary flora and fauna. For some species groups the level of endemism is remarkably high, for plant species the highest in Europe. The isolated location of the islands and the moderating effect the ocean has on the climate further strengthen the development of a unique flora and fauna. This taken together has allowed the biological diversity to escape significant alterations.

Recorded differences in flora and fauna among islands can be attributed to trade winds, distances to source areas for dispersal from the mainland and differences in human history and settlements for the islands in the region.

Tab. 5.1: The Macaronesian Sites of Community Importance (SCI)

	Macaronesian Region		Sites of community importance adopted by the EC in Dec 2001				
	Area (km^2)	% of the region	Number of sites	Total area (km^2)	Marine areas (km^2)	Terrestrial areas (km^2)	% of terrestrial area
Canary Islands	7 242	70	174	4 573	1 760	2 813	39
Madeira	797	8	11	431	Ca 200	231	29
Azores	2 333	22	23	336	88	248	10
Total	10 372	100	208	5 340	2 048	3 292	32

Table 5.2: Endemic species in the Macaronesian biogeographic region as listed in Annex II of the Habitats Directive

Region	Plants	Plants priority	Animals	Animals priority
Canary Islands	66	35	6	2
Madeira	46	10	18	2
Azores	26	6	2	1

5.1.5 - Main pressures on biodiversity

The main pressures on biodiversity in the Macaronesian region are:

- Human population increase;
- Tourism;
- Agriculture;
- Forestry;
- Alien species.

5.1.5.1 - Human population increase

In line with other areas of Europe, the Macaronesian region has experienced a significant increase in human population since the beginning of the 20th century. Simultaneously, inhabitants of the islands of the region began to move to the capitals and other centers of the islands. The need for better infrastructures (e.g. roads) implies the occupation and destruction of important areas, structures and ecological functions (continuity, fragmentation, minimal dimension, disturbance, etc.).

5.1.5.2 - Tourism

There is a great seasonal fluctuation in the human population of the region due to the large number of visitors. Tourism started in the mid-19th century and has increased to high levels. In 1998, 11 million visitors arrived to the Canary Islands, mainly from UK, Germany and Spain. Today tourism represents up to 80 % of the GDP (gross domestic product) in the Canary Islands.

The growing tourism industry of the region, and especially that of the Canary Islands and Madeira, has caused dramatic changes to coastal areas. The establishment of hotels and other tourism facilities partly use rich agriculture lands and has pronounced negative impact on natural coastal habitats. Further, the increasing number of visitors to the islands poses threats to, among others, nesting areas of sea birds.

5.1.5.3 - Agriculture

Agriculture is an important feature of the Macaronesian region, 14 % of the land in the region is cultivated habitats. More than 50% of the Canary Islands' area has over time been used for agriculture purposes. The prime agricultural products are tomatoes, maize, potatoes and bananas. Vast areas of indigenous forest have been transformed to managed forest due to the use of young timber in banana plantations and by the plantation of California pine (*Pinus radiata*).

Fruit producing trees were first introduced by early settlers. Figs (*Ficus carica*) and date palm (*Phoenix dactylifera*) were introduced more than 2 000 years ago in the Canary Islands, while the major part of fruit producing trees was introduced much later. Avocado, mango and apples have been commercially cultivated for less than 40 years. Of special importance in this respect is the cultivation of olive trees (*Olea* europaea) which form open woodlands on high south-facing slopes.

The production of sugar, wine and bananas is the backbone of the agricultural economy of Madeira, together with numerous common European vegetables. Further, temperate fruits like oranges, lemons, guavas and mango together with pineapple and figs are cultivated for export.

Agricultural production in the Azores differs substantially from the Canary Islands and Madeira. Here livestock and dairy production is the main trade using more than 100000 ha of the total farmland. Most of the farms are relatively small, hosting between 5 and 20 heads.

5.1.5.4 - Forestry

Most of the forest of Madeira has been destroyed during the last 500 years through exploitation for agricultural purposes and ship-building. Today felling is strictly controlled and the main threat to forest today is forest fires. Fires are commonly deliberately started to improve grazing for livestock. In the Azores forests have been cleared for pastures but have also been replanted with alien tree species (*Acacia* spp. and *Cryptomeria japonica*).

5.1.5.5 - Alien species – introduced fauna and flora threaten biodiversity

Fauna

In the Macaronesian region rats (*Rattus* spp.) are a special problem when they impose a predation pressure on birds, which are the main vectors for dispersal of seeds in the laurel forest. The introduction of rabbit (*Oryctolagus cuniculus*) to Porto Santo in the Madeira archipelago caused a degradation of the natural vegetation, a situation that has remained due to continued grazing by both rabbits and livestock. Overgrazing by rabbits and livestock has lead to severe regression of the endemic flora on Desertas and Salvagens, which in turn has caused erosion of the coastline.

Seabirds and indigenous predators evolve a natural coexistence with indigenous predators, but introduced predators can cause severe reduction and even extinction of seabird populations.

Flora

Two thirds of the vascular flora of the Canary Islands is not native. Ca. 700 species of the islands' flora are introduced and an additional 1 300 species are cultivated plants. A majority of species have a Mediterranean origin. The share of alien tree species is remarkably high. 300 tree species have been introduced, compared with the 40 indigenous species.

Introduced species represent an array of life-forms from herbs, succulents and shrubs to trees. Few, however, can be regarded as pests although a number of them have become rather common. An aggressive invader is sedge (*Cyperus rotundus*) which has invaded fields and gardens. It spreads through seeds, bulbs and runners and is in banana plantations fought with special herbicides. The wild tobacco (*Nicotiana glauca*), introduced from South America has established well and is now being found even in the driest parts in the Canary Islands.

In Madeira a number of ornamental plants have been introduced and have naturalized over centuries. Some of these species (e.g. *Acacia* spp., *Papaver* spp. and *Pittosporum undulatum*) are most common in the lowlands, while others (*Ageratina* sp. and *Erigeron* sp.) also have penetrated into higher regions.

The native vegetation of the Azores has been severely altered and half of the species are non-native. Some of the species are very competitive and invasive like the mock orange (*Pittosporum undulatum*), Kahili ginger (*Hedychium gardnerianum*) and lily of the valley tree (*Oxydendrum arboreum)*.

5.2 - The Pico Island

5.2.1 - Study area

The Azores is an isolated Northern Atlantic archipelago (Fig. 5.1), formed by nine main islands and several small islets and seamounts located along the Mid-Atlantic Ridge (Feraud *et al*., 1980), approximately between the coordinates 37° to 40° N latitude and 25° to 31° W longitude and distributed from West-Northwest (WNW) to East-Southeast (ESE). Over 1600 km from Portuguese mainland (and 1900 km from Newfoundland), the Azorean islands extend for about 615 km and are divided into three groups (Fig. 1b): the western group (Flores and Corvo); the central group (Faial, Pico, S. Jorge, Terceira and Graciosa); and the eastern group (S. Miguel and S. Maria, plus the Formigas islets). All islands are fully oceanic (volcanic islands of recent origin), having arisen along ocean-floor fracture zones where the North American, Eurasian, and African tectonic plates meet at a triple-junction (Ferreira, 2005; Azevedo and Ferreira, 2006). According to Azevedo and Ferreira (2006) the western group is situated entirely on the North American Plate and the other two groups are within a transition zone named Azorean micro-plate between the Eurasian and African Plates.

The Azores are the youngest archipelago in the Macaronesian region (Fernández-Palacios *et al*., 2011). The oldest rocks in the archipelago are found on Santa Maria island (8.12 Myr B.P.) while Pico is the youngest island of the archipelago (0.25 Myr B.P.) (Abdel-Monem *et al*. 1975;

Feraud *et al*. 1980, 1981, 1984; Chovelon, 1982; Azevedo *et al*., 1991; Nunes 1999; Azevedo *et al*., 2003; Azevedo & Ferreira, 2006).

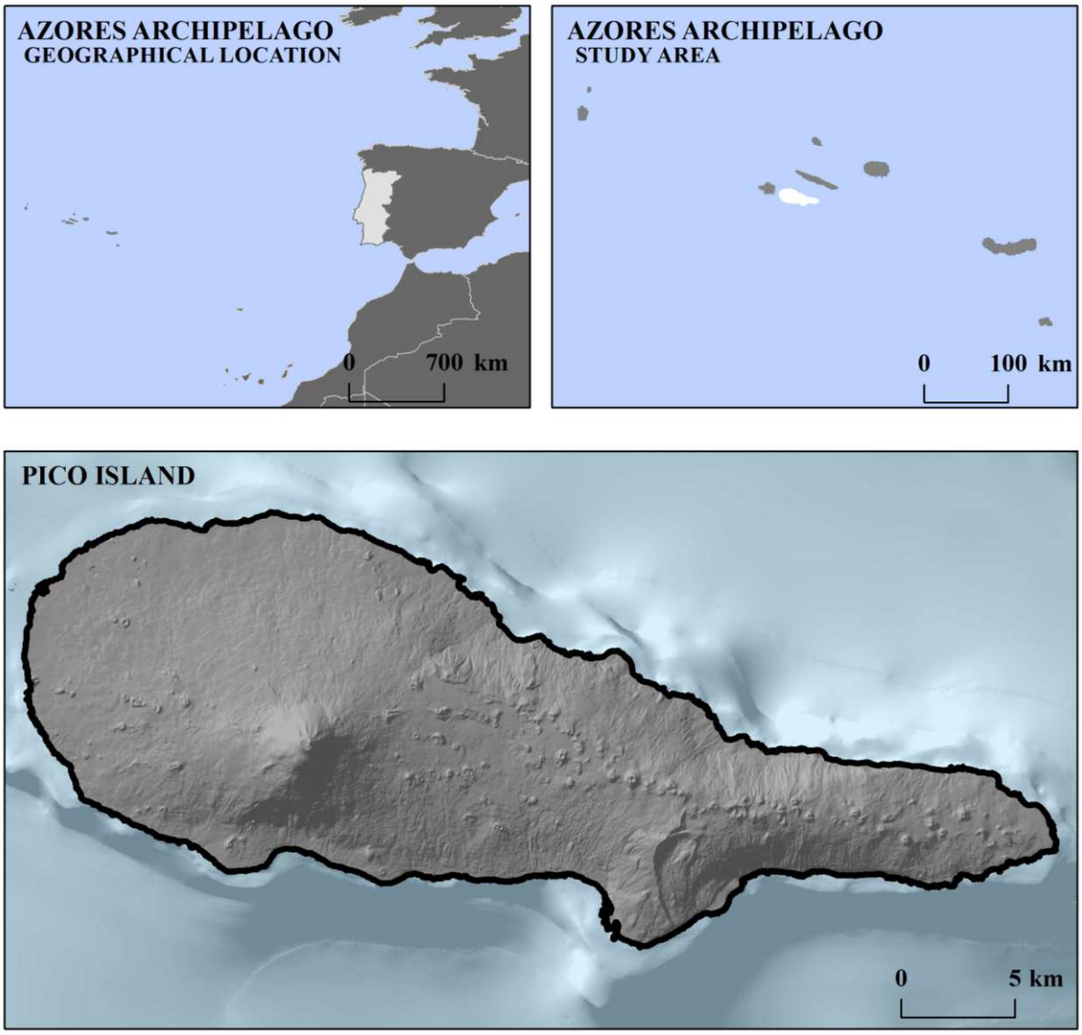


Fig. 5.1 - Study area

This study was conducted in the Pico island (Fig. 1c) which is the second largest island of the archipelago with 447.74 km^2. Presents an oval shape, elongated in the E-W trending along ~42 km long and ~15.2 km wide (maximum values) (Cancela d'Abreu *et al*., 2005). The island of Pico, through its morphology, expresses remarkably the effects of volcano-tectonic structures that are in its origin (Nunes, 1999; Madeira and Brum da Silveira, 2003; Cruz *et al*., 2006; França *et al*., 2006; Dias *et al*., 2007). Three different areas can be distinguished on the island (Madeira, 1998; Nunes, 1999; Madeira and Brum da Silveira, 2003; França *et al*., 2006; Dias *et al*., 2007): the older volcano (Topo volcano; Chovelon, 1982), a central type shield volcano located in the middle-south of the island, is composed of ankaramitic and basaltic lava flows and is partially dismantled by landslides, displaced by faulting and covered by younger volcanism; an intermediate volcanostratigraphic unit, which comprises several alignments of basaltic spatter cones and related lava flows along WNW-ESE fault; and finally the youngest unit of the island is the Madalena Volcanic Complex, which can be structurally divided into two sub-units, the East fissural zone which is composed of several alignments of cinder and spatter cones and related lava flows, and the strato-volcano of Pico displaying a pit crater on its summit and straddling the fissural structure at its western end.

5.2.2 - The present conservation policy - the concept of “Park Island”

The Regional Government of Azores (Portugal) approved a new concept for the Regional Protected Areas Network, where every protected or classified area in each island where aggregated in a single management entity: the "Natural Island Park".

This type of park correspond to the UICN concept of "Natural Park" and integrates all previous protected and classified areas in a single management instrument without implying their fusion as a single entity but preserving instead their individuality.

- This concept was based on the need to build and ensure a coherent ecological network against the classical sum of individual management units, allowing a better integration of all values natural, esthetical, cultural or even economic.
- The Natural Island Park is build trough the aggregation of all classified areas in each island together with maritime areas of particular value, richness or contribution to natural resources.

The Natural Island Park integrates tree distinct levels of planning and management with different administrative and legal frameworks:

- Protected areas;
- Other elements of the national fundamental nature conservation network;
- Every other area of the island and surrounding sea.

This last item represents the great innovation as it integrates the targets of nature conservation with the development of the entire island in economic, social and cultural terms.

Implicit to this concept is the need to clarify hierarchies of value of importance among the different natural and cultural values within a given socio-economic framework. Therefore, the preservation of target species and animals must be balanced with the human factors that historically or presently promote those values or endanger them, without compromising the global viability of both natural systems and assets and the economic viability of the island society.

This integrated approach allows a clear comprehension and evaluation of the relative values of natural habitats, men related habitats and other cultural values and, therefore a clarification of the evaluation criteria to be applied to each situation and to the global context.

The main challenge of this new concept is the development of multi-dimensional evaluation and decision making processes in an environment with strong propensity for being closed, and very little ability to modify the available resources and biological assets.

The Pico Natural Island Park was created in 2008 and integrated all former protected or classified areas (Fig. 5.2):

- Natural reserves - area of land or sea containing one or more exceptional ecosystems or that are representative of biological singularities:
    - Natural reserve of Pico Mountain (PIC001);
    - Natural reserve of Caveiro (PIC002);
    - Natural reserve of Mistério da Prainha (PIC003);
    - Natural reserve of Furnas de Santo António (PIC004).
- Nature 2000 Network
- Natural Monument - area specially devoted to the preservation of specific natural conditions, namely due to their singularity or rarity or the representativity of its aesthetical qualities:
    - Natural Monument of Torres Caves (PIC005).
- Protected areas for species and habitat management - areas whose management is particularly oriented towards an active intervention in certain habitats or as function of certain species:
    - Protected area for species and habitat management of the Lagoa do Caiado (PIC006);
    - Protected area for species and habitat management of the Lajes do Pico (PIC007);
    - Protected area for species and habitat management of the Furnas de Santo António (PIC008);
    - Protected area for species and habitat management of the Silveira (PIC009);
    - Protected area for species and habitat management of the Mistério de São João (PIC010);
    - Protected area for species and habitat management of the Terra Alta (PIC011);
    - Protected area for species and habitat management of the Ribeiras (PIC012);
    - Protected area for species and habitat management of the Zona do Morro;
- Landscape protected areas - areas where the man-nature interaction determined the existence of a landscape with distinct characteristics expressed in aesthetical, ecological and cultural values:
    - Landscape protected area of the Vine Culture – Ponta da Ilha (PIC013);
    - Landscape protected area of the Vine Culture – Ponta do Mistério (PIC014);
    - Landscape protected area of the Vine Culture – Northern area (PIC015);
    - Landscape protected area of the Vine Culture – São Mateus/São Caetano (PIC016);
    - Landscape protected area of the Vine Culture – Western area (PIC017);
    - Landscape protected area of the Central Area (PIC018).
- Protected areas for resources management - terrestrial or maritime areas whose management is oriented to the preservation of certain species and habitats safeguarding the sustainable use of the natural ecosystems:

- Protected areas for resources management of the Porto das Lajes (PIC019);
- Protected areas for resources management of the Ponta da Ilha (PIC020);
- Protected areas for resources management of the canal Faial-Pico Chanel / Pico sector (PIC021).

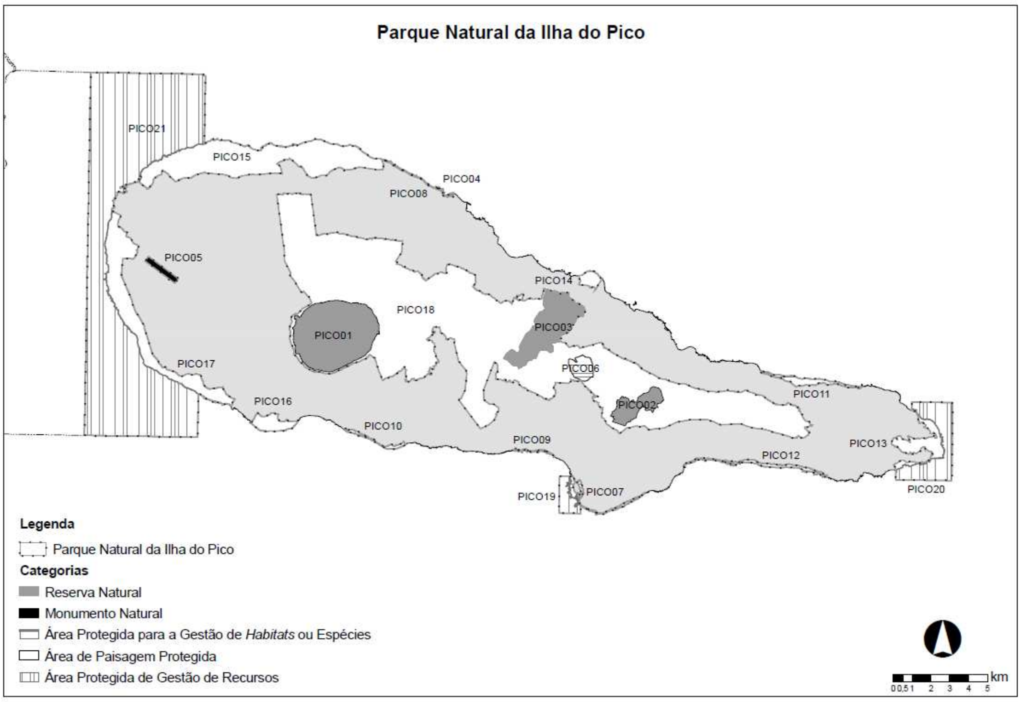


Fig. 5.2 – Pico Natural Park

The main values integrated in this protected areas network include biological (mainly avifauna and vegetation, as well as cultural values of world relevance: the Vine Culture areas are classified as World Heritage.

In addition to the Island Natural Park there are further conservation restrictions included in the regional landscape Plan (PROTA) that identifies further areas of ecological interest where land use restrictions are implemented (Fig. 5.3).

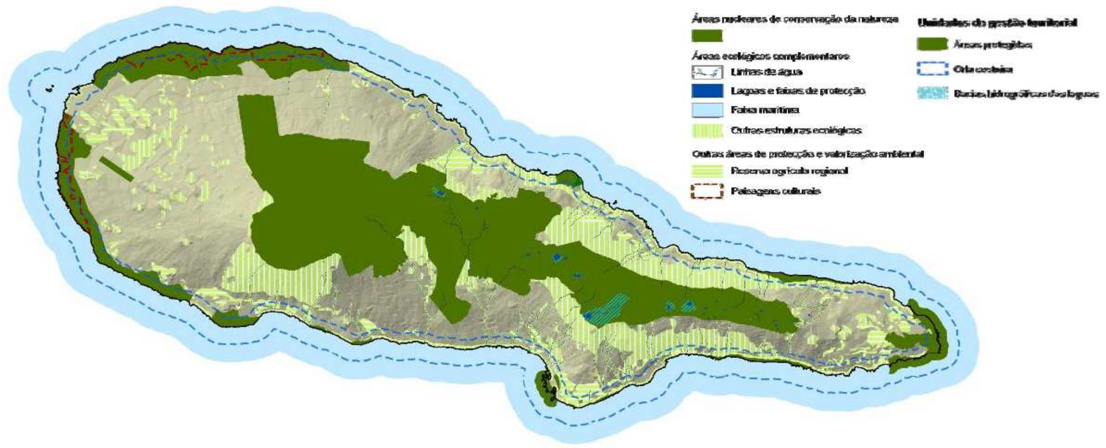


Fig. 5.3 - Environmental promotion and protection system (Regional Plan)

This combined approach based mainly in land use restrictions, although building a very important contribution to a better management of all the natural, social economic and cultural values of the island, poses a series of technical and practical challenges that imply new approaches in the characterization and evaluation of the existing and potential values, as well as to the convergence of the different expectation of the varied involved stakeholders (given, for example the important economical activities (mainly livestock production in most of the protected and classified areas (Fig. 5.4).

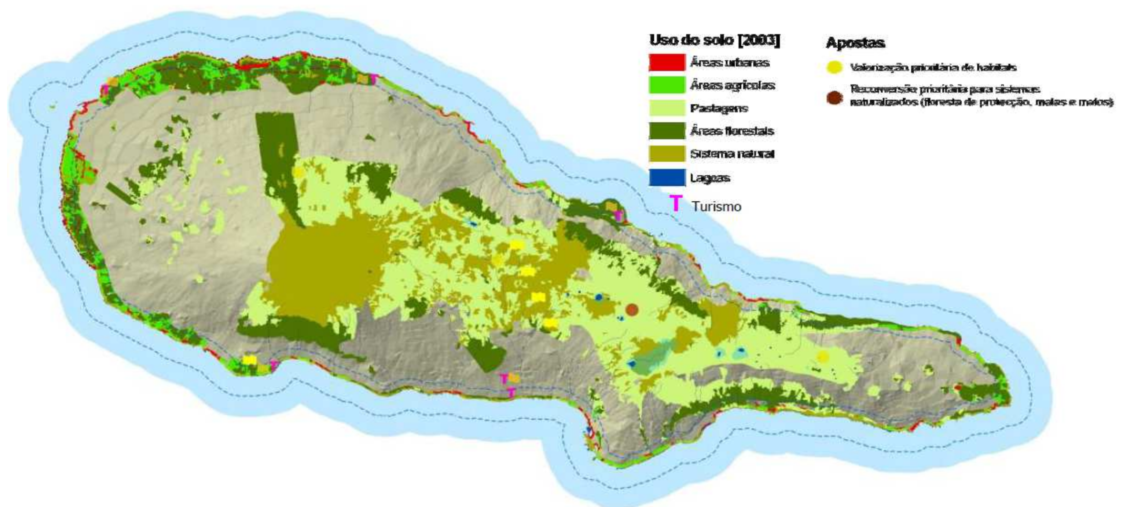


Fig. 5.4 - Present land use in the protected and classified areas of the Pico Island

5.3 - The characterization framework (following the ILA methodological approach)

As stated above (Chapter 4) the any characterization and evaluation process needs to have a stable comprehensive reference system with which any item can be compared and to which any evaluation can be referred. (Fig. 5.5)

In the case of geographic and land use systems the concept of land unit is used referred to the stable biophysical variables (e.g. geology, soil, climate, morphology, position) and expressed in different ways namely using the natural vegetation corresponding to those stable ecological characteristics. This approach presents several advantages:

- The use of a stable system of reference allows the comparative simulation of different land use scenarios, but also the permanent availability of the same reference system independently from the intensity of land use changes throughout the years.
- It allows the use of different evaluation algorithms according to different evaluation contexts, without having to repeat or adapt the characterization process.
- Trough the independent consideration of the land use scenarios, it allows those scenarios to be the object of economical comparative analysis or evaluations, without any interference with the nature or quality of the environmental information.
- It allows the consideration of different evaluation criteria for the same area or sets of landscape objects (e.g. naturalness vs. promotion of a disturbed habitat essential to the survival of a given endangered species –great bustard in the Iberian Peninsula).
- It allows the comparison of different sets of scenarios and conservation targets.
- The use of the model at the structural and functional level allows the use of a large variety of tools like:
    - Comparison of landscape metrics between the reference and the circumstantial characterisation layers;
    - Qualitative evaluation of the stable or circumstantial character of landscape elements like (matrix, patches, corridors) or characteristics like fragmentation or connectivity;
    - Modelation of landscape or habitat connectivity as well as target animal movements (using for example percolation or cost-distance models).

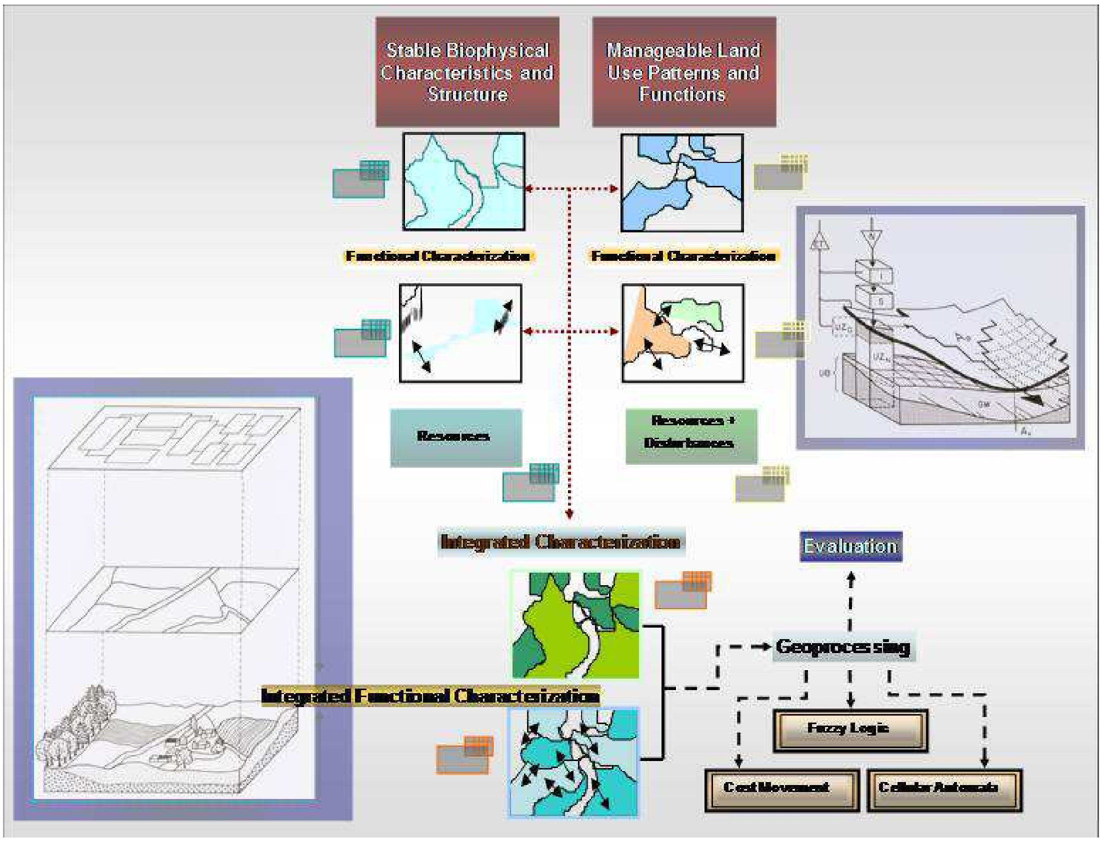


Fig. 5.5 - The ILA characterization Model

For its implementation the framework demands:

- A stable geographical reference base that can be qualified with the same set of indicators or descriptors as the system to be evaluated.
- Every geographical land use/habitat or ecological/biological structural arrangement can be described by a set of indicators or other evaluation tools that can be applied, at the same time to a given stable geographical/ecological system of reference in order to determine the variation (+/-) of those indicators or evaluations descriptors.
- The evaluation process be carried out through the comparison of the "conceptual situation" – the reference system, with the present situation, according to the system of values chosen.

The scale, evaluation framework (value structure), variables considered, depend only on data availability.

It is therefore in this context that two different information layers where characterized.

5.3.1 - The resource information layer

The sources of information for Pico are very diversified but present important lacks in critical variables like soil and vegetation maps.

Simultaneously, there is a high degree of lack of homogeneity in the cartographic quality of the maps (not only Datum and scale differences, but also distortions and displacements). The precision of the available cartography is also very variable. Some problems were detected with some descriptors that, if not corrected would generate important mistakes.

It was, therefore necessary to ensure the compatibility of the geographic information, assess it for errors - same digital data layers presented serious errors and incongruence, stressing clearly the need for the development of an integrated information system for the islands of Azores ensuring the quality and accessibility of the biophysical, economic and social information.

5.3.1.1 - Biophysical Information

Geology

Pico Island is built from the geomorphological perspective by three units corresponding to three vulcanos: Montanha Volcanic Complex,, S. Roque - Piedade Volcanic Complex (Achada Plateau) and Topo - Lajes Volcanic Complex (Fig. 5.6).

According to Nunes (1999), the Mountain volcanic complex includes the Pico Mountain volcano that is a strato-volcano with mostly recent secondary eruptions in its flanks. The Achada Plateau corresponds to a fissural volcanic system building a linear structure of volvanic activity along tectonic fissures oriented WNW-ESE to W-E. It includes about 100 small volcanic cones of debris, from *spatter* or eruptive fissures and lavic flows in both north and south directions. Its stratigraphy is very diverse including old to very recent volcanic events. The Topo - Lajes volcanic complex includes a central volcano of the shield type (the Topo volcano) and associated secondary eruptions. In this area the oldest geological formations of the island can be found with ages up to 300 000 years (Nunes, 1999)

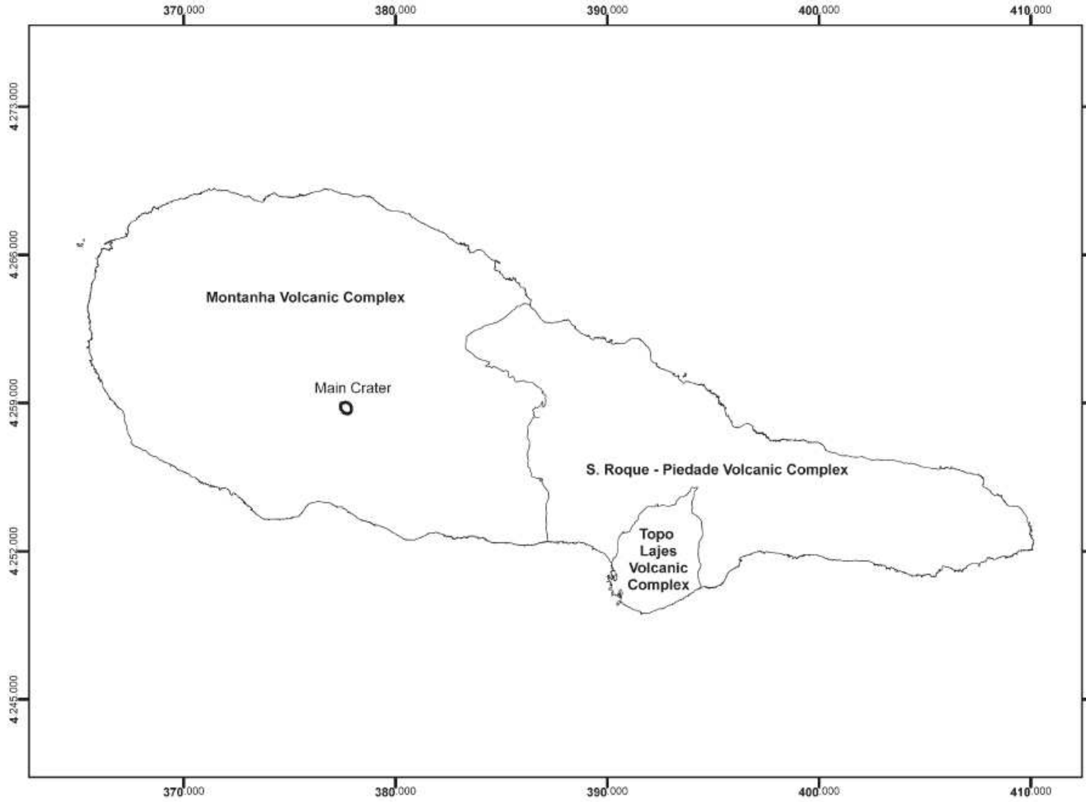


Fig. 5.6 - Volcanic complexes from Pico Island (modified from Nunes *et al*., 1999 *cit in* França *et al*., 2006)

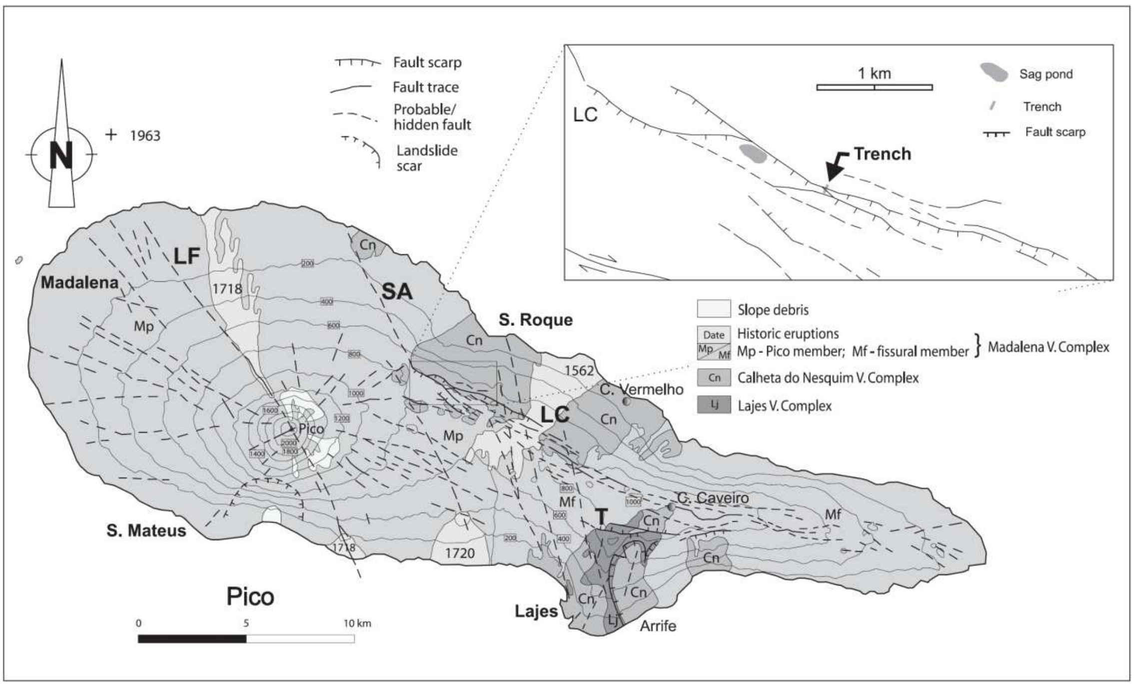


Fig. 5.7 Simplified topography and geology of Pico Island (adapted from Madeira, 1998 *cit in* Madeira & Brum da Silveira, 2003). Volcano stratigraphic units: Lj - Lajes Volcanic Complex; Cn - Calheta do Nesquim Volcanic Complex; Madalena Volcanic Complex: Mp - Pico Volcano member; Mf - East Fissural Zone member; dates indicate historic eruptions. Identification of

main faults: LC - Lagoa do Capitão; T - Topo; LF - Lomba de Fogo-S. João; SA - Santo António. Curved structures are ancient landslide scars at S. Mateus and Arrife. Dashed lines represent hidden faults and radial fractures of Pico volcano. Inset shows detail of Lagoa do Capitão fault zone and location of trench. Contour lines every 200 m

Over these three units one can observe still same historical volvanic occurrences (historical because all occurred after the colonization of the island: 1562-64, 1718 and 1720) that correspond to the different "Mistérios" formations (Fig. 5.7).

Geologically the island is mainly built of Basalt and Peridotic Andesits.

Soils

Soils are generally young andisols, developed from pyroclastic materials under humid and mesic conditions (Pinheiro *et al*., 1998; Auxtero and Madeira, 2009). Soils differ essentially on the P sorption and adsorption capacity (Auxtero *et al*., 2005) due to the presence of colloidal constituents which have been observed in soil observed in soils with andic properties (Madeira *et al*, 2007; Pinheiro *et al*., 2001).

In the absence of a soil map of the Pico Island it was used the Pico Island Soil Quality Map: *Carta de Capacidade de Uso do Solo* (Pinheiro *et al*., 1987) (Fig. 5.8) whose legend is as follows (Tab. 5.3).

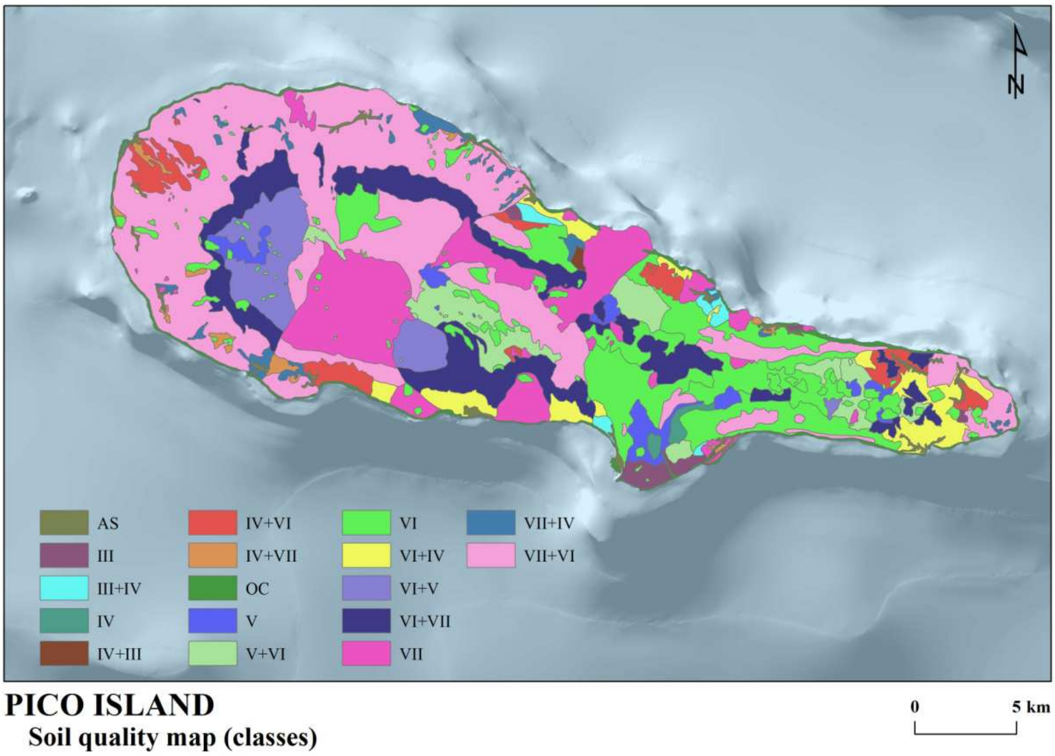


Fig. 5.8 - Pico island soil quality map

Tab. 5.3 Factors represented in the Pico Island Soil Quality Map: *Carta de Capacidade de Uso do Solo* (Pinheiro *et al*., 1987)

Factors	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**
Slope (%)	<3	<10	<20	<20	<30	<50	Any
Depth (cm)	>90	>60	>30	>30	>30	Any	Any
Texture	Balanced	Balanced	Balanced	Any	Any	Any	Any
Rockiness (%) (Ø <)	null	<10	<20	<50	Any	Any	Any
Rockiness (%) (Ø >)	null	null	<3	<10	<25	Any	Any
Rock formations (%)	null	<2	<10	<25	<50	Any	Any
Drenching	null	null	Short periods	Short periods	Short periods	Any	Any
Micro morphology	null	null	weak	Moderate	Moderate	Strong	Strong

To this legend one must add the subclasses:

e – erosion and runoff - soils with high susceptibility to erosion;
s – soil limitation at the level of the roots - limitations like effective depth, low fertility or weak response to fertilizers, salinity or alkalinity, stoniness, rock formations, etc.;
w – drenching - soil with excess water;
m – micro morphology - very irregular morphology.

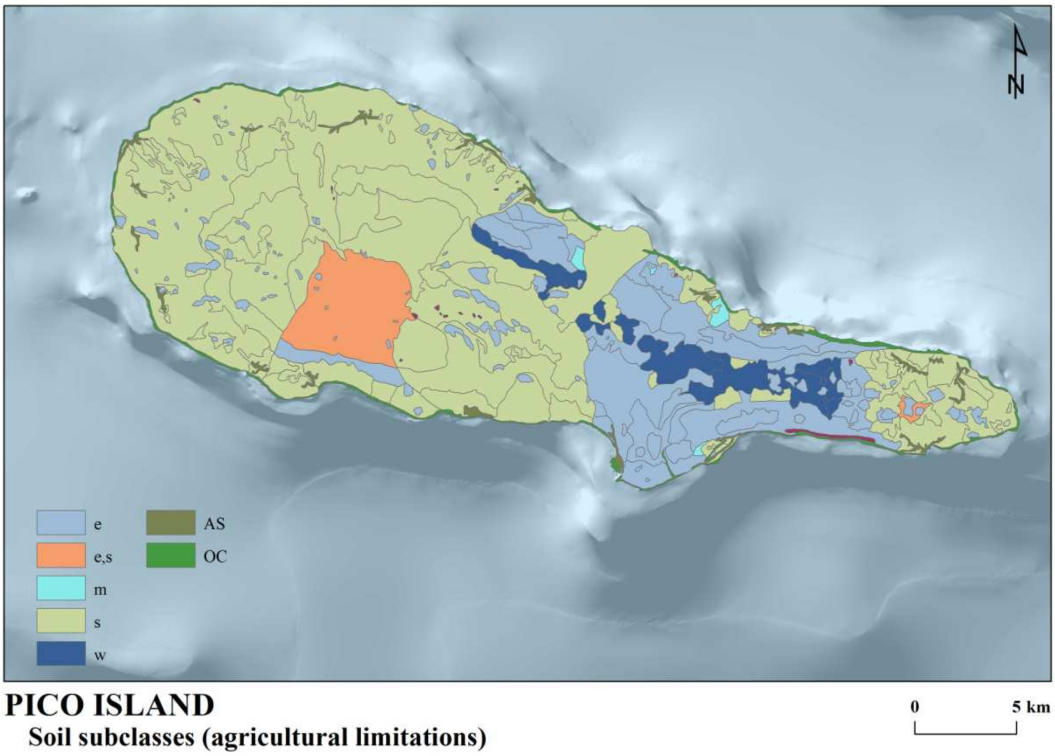


Fig. 5.9 - Soil subclasses (agricultural limitations)

One can observe that there are no soils of class I and II - arable soil apt for permanent use and only limited areas of classes III, IV and III+IV (arable soils with occasional use). Analyzing the maps from Fig. 5.8 and Fig. 5.9, as well as Tab 5.4 it is possible to verify the extreme poverty of the soils of the Pico island (only 2.2% are arable soil without limitations) and the overwhelming percentage of soils with extreme limitations and aptitude only for natural pastures or forest or that should be preserved as natural reserve because they cannot sustain any economical use (56.6 %). Considering the subclasses displaying the soil limitations it is possible to verify 64 % present limitations for the good development of roots and 27% present erosion risks.

Tab. 5.4 - Soil quality classes and subclasses in Pico Island with the corresponding area and percentage of the total area of the island

CLASSES	Total area (ha)	%	SUBCLASSES	Total area (ha)	%
AS	565,7	1,3		102	0,2
III	443,9	1,0	AS	566	1,3
III+IV	335,3	0,7	e	9509	21,2
IV	223,9	0,5	e,s	2585	5,8
IV+III	54,1	0,1	m	171	0,4
IV+VI	1567,4	3,5	OC	990	2,2
IV+VII	338,6	0,8	s	28586	63,9
OC	989,8	2,2	w	2254	5,0
V	1054,6	2,4			
V+VI	2217,9	5,0			
VI	6896,1	15,4			
VI+IV	1741,5	3,9			
VI+V	2284,2	5,1			
VI+VII	5226,2	11,7			
VII	5520,4	12,3			
VII+IV	708,1	1,6			
VII+VI	14594,6	32,6			

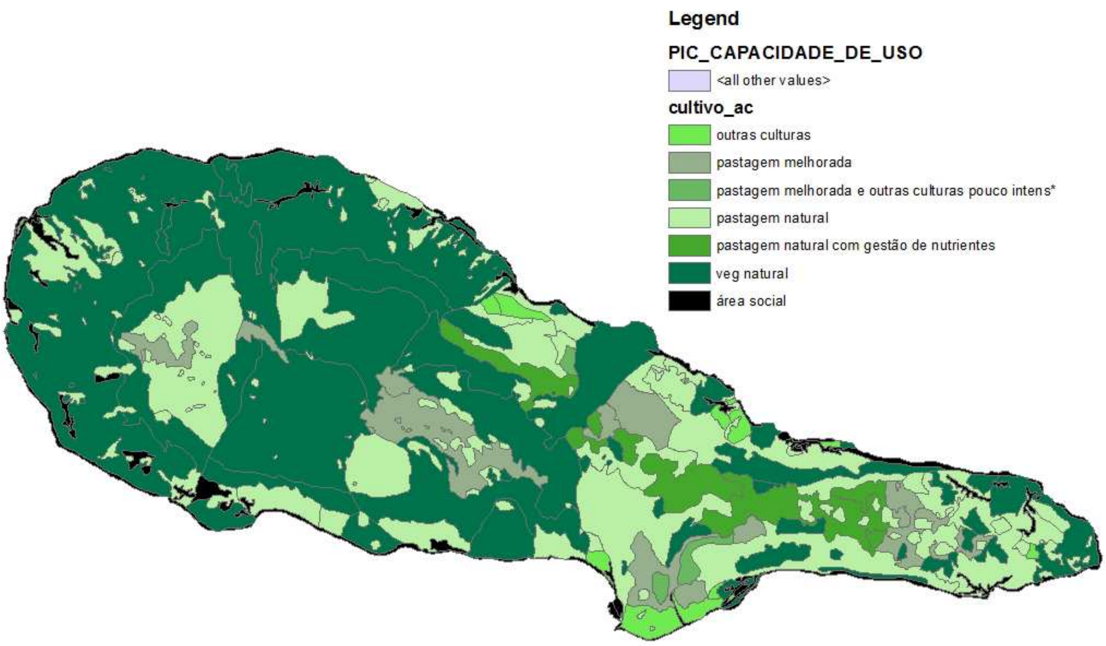


Fig. 5.10 - Potential for agricultural use according to the soil quality map

These results show an island with very limited potential for agriculture and only with a limited potential for pastures (Fig. 5.10)

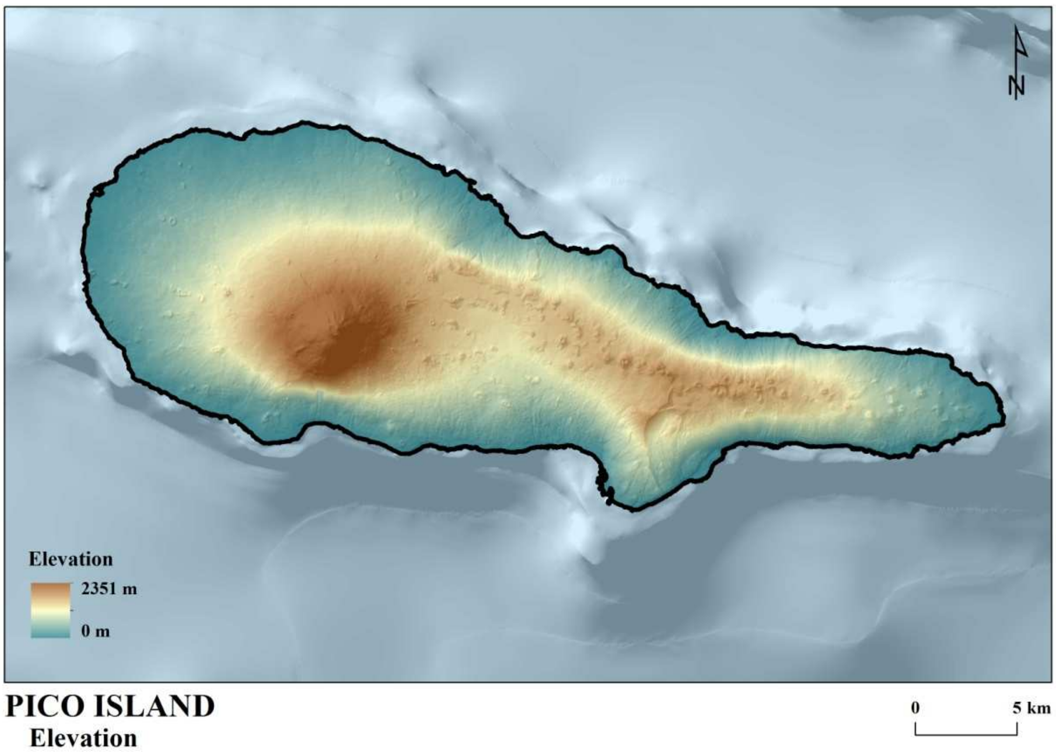
Even for pastures, considering all the limitations, the large majority of the island should be preferably reserved for natural vegetation (aggregation of classes VI and VII and their combinations).

Morphology - Digital Elevation Model and derived information

The data on altimetry supplied to the project and the resulting Digital Elevation Model (DEM) showed several anomalies in the derived variables. This situation is common and usually is due to the previous use of a method for watershed delimitation where the watercourses are sinked into the DEM, giving origin to a deformed surface.

On the other side, the provided digital altimetry data contained only lines, representing in the same theme not only contour lines, but also elevation points (represented as circles) and geodesic marks (represented as triangles). This lead to the impossibility of using the data right away because the GIS would interpret all the information as if they were contour lines.

Thus, all the altimetry was corrected trough the separation of the different data types in new themes, allowing then the elaboration of a correct DEM (Fig. 5.11).



5.11 - Digital elevation model

Topo to Raster module (ArcGIS 10^{TM}) was used to compute a hydrologically correct Digital Elevation Model with a resolution of 10 m. This procedure is based on the algorithm developed by Hutchinson (1989). This approach uses an iterative finite difference interpolation technique and it is a discretized version of thin plate splines (Wahba, 1990). Slopes (Fig. 5.12) were computed according to the Horn's method (Horn, 1981). Pico volcano is the highest altitude in the Azores (2351 m).

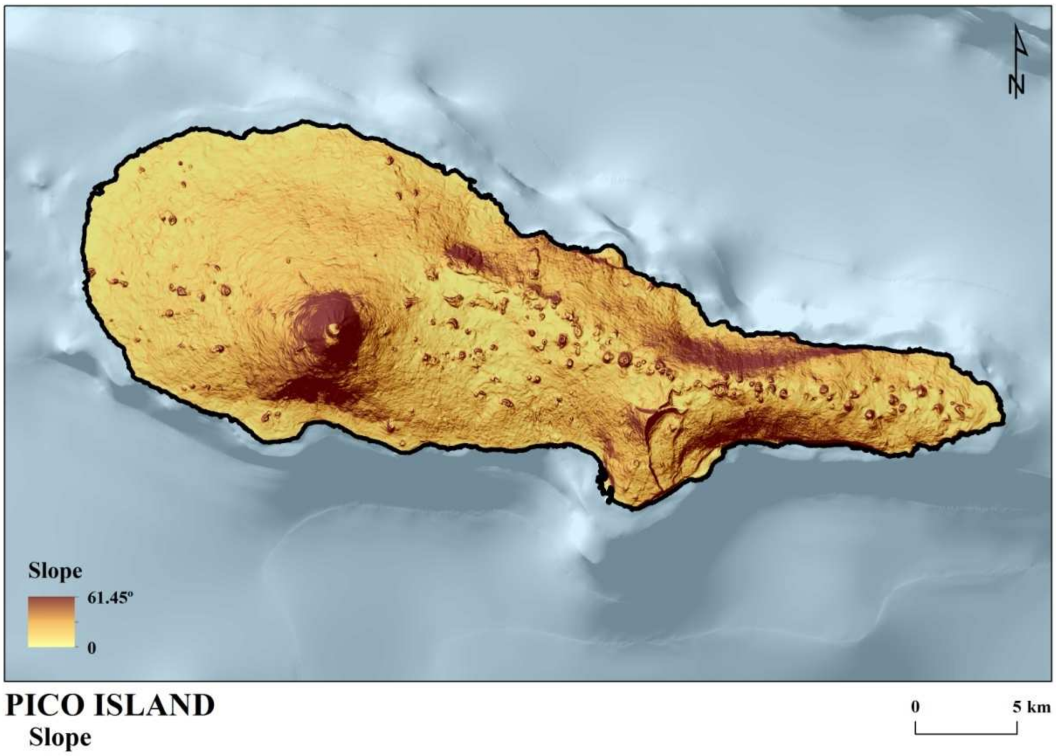


Fig. 5.12 - Slopes

Drainage system

The characterization of the drainage system is of critical importance for management, in particular when considering that this are the paths followed by contamination and also the watersheds that ensure the existence and evolution of lakes, ponds, wetlands and mires, as well as their possible contamination or eutrophication.

Due to the insufficient cartographic information on the drainage system, the DEM was used to determine the drainage network (Fig. 5.13) and corresponding drainage basins, through spatial analysis with the GIS software ArcGIS 10^{TM}.

The initial premise guiding the process is that the flow across a surface will always follow the steepest downslope direction. In a raster environment, once the direction of flow out of each cell is known, it is possible to determine which and how many cells flow into any given cell. This information is then used to define watershed boundaries and stream networks.

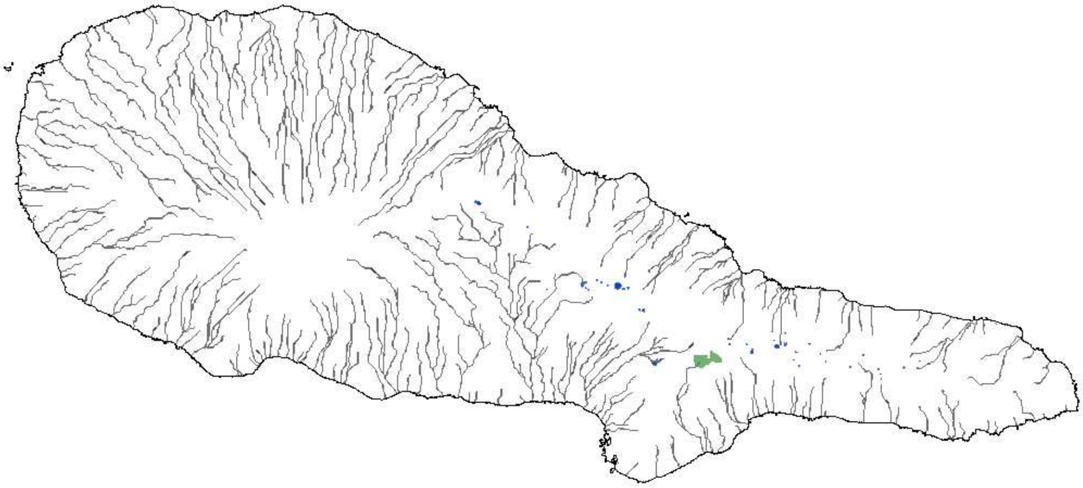


Fig. 5.13 - Hydrography

Considering the eight-direction (D8) flow model, presented by Jenson and Domingue (1988), there are eight valid output directions relating to the eight adjacent cells into which flow could travel. However, there may be some cells that are lower than the surrounding cells so, all water traveling into the cell will not travel out. These depressions or areas of internal drainage are called sinks, which can be the result of an incorrect value or just represent real local depressions. Is this study the sinks were identified and filled, resulting in a depressionless DEM.

After the determination of the flow direction on this depressionless elevation model, it was calculated how many cells flow into another cell, the flow accumulation. When enough water flows through a cell, the location is considered to have a stream passing through it. This last determination requires a threshold, in this case it was considered 35 ha as the minimal drainage area for a given cell be considered a stream. Continuing the process of hydrological analysis, the watersheds were delineated (Fig. 5.14) using the Hydrology toolset from the Spatial Analyst Toolbox in ArcGIS 10^{TM}.

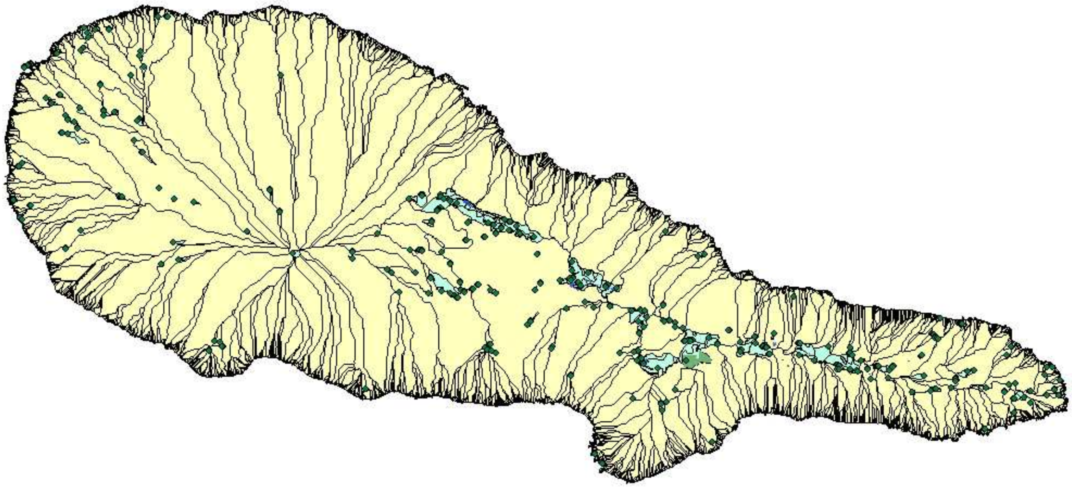


Fig. 5.14 - Watershed, areas of internal drainage (sinks) and watersheds of the existing wetlands, ponds and mires

Additionally the Pico Island soil quality map was used to identify the wet or flooded soils which were combined with the previous map in order to assess its correction. It also allowed the identification of other areas with interest in terms of preservation, improvement and restoration of wetlands and habitats associated with wet or drenched (temporarily or permanently) soils (Fig. 5.15).

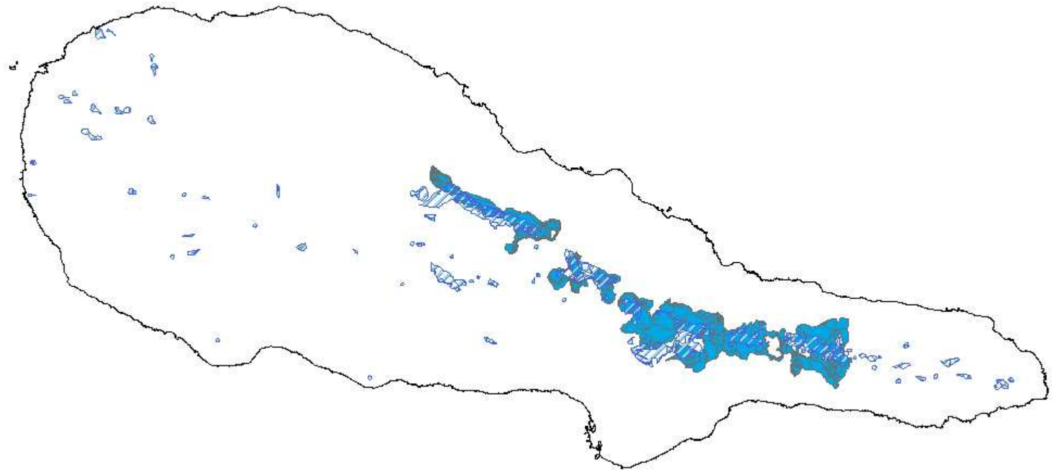


Fig. 5.15 - Drenched soils (Pico Island Soil Quality map) and sinks with their related watersheds

A good correspondence can be found in the center plateau (where all the lakes and mires are located, but additional research must be conducted in the areas outside those drenched areas (with the exception, of course, of the watershed that flow into those areas).

Climate

The climate of the island is temperate oceanic with low annual temperature amplitudes, a regular rainfall distribution along the year high relative humidity temperatures. Rainfall varies strongly with altitude (Fig 5.16) from 1000 - 1900 on the lower 100m to more than 4000 mm above 700 m. The geographic distribution of the rainfall shows a small deviation to the North. Despite its regular distribution during the year, still has some monthly variation, with maximum values in January-February and a minimum in July.

The indirect precipitation associated with fog and clouds is very important particularly between 700 and 180 m. There is also snowfall mainly above 2000m.

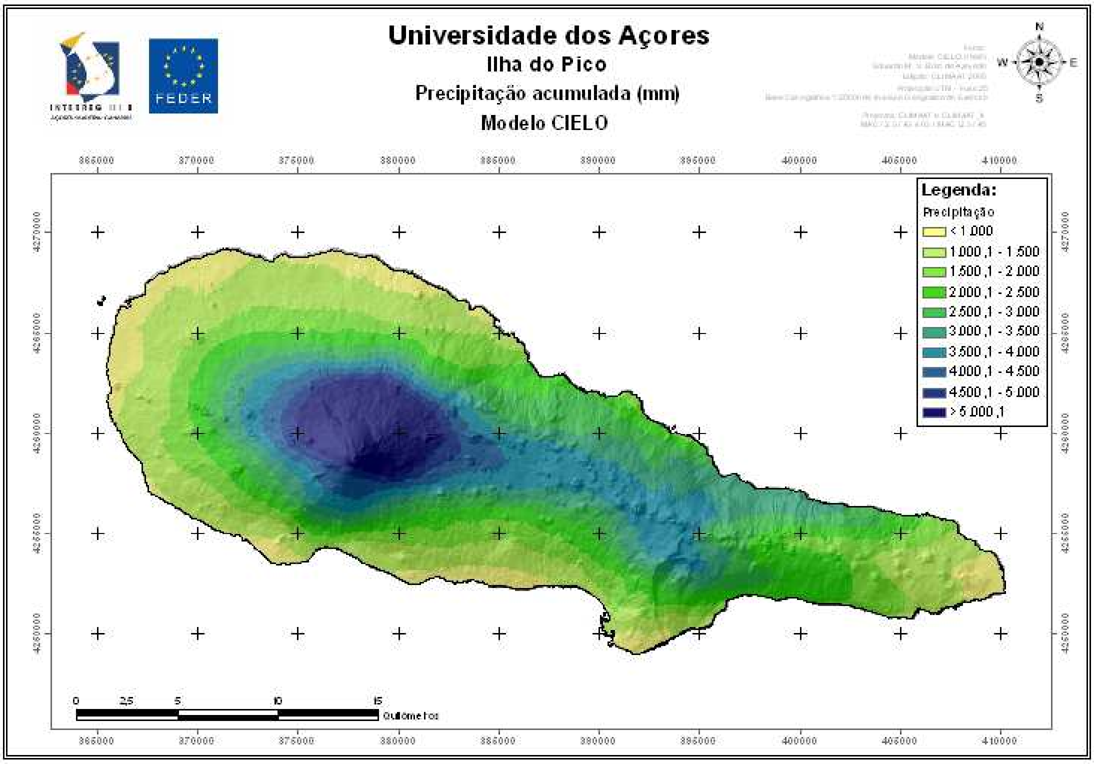


Fig - 5.16 Rainfall distribution

Its monthly distribution (Fig 5.17 shows that the winter months are the ones with more rainfall.

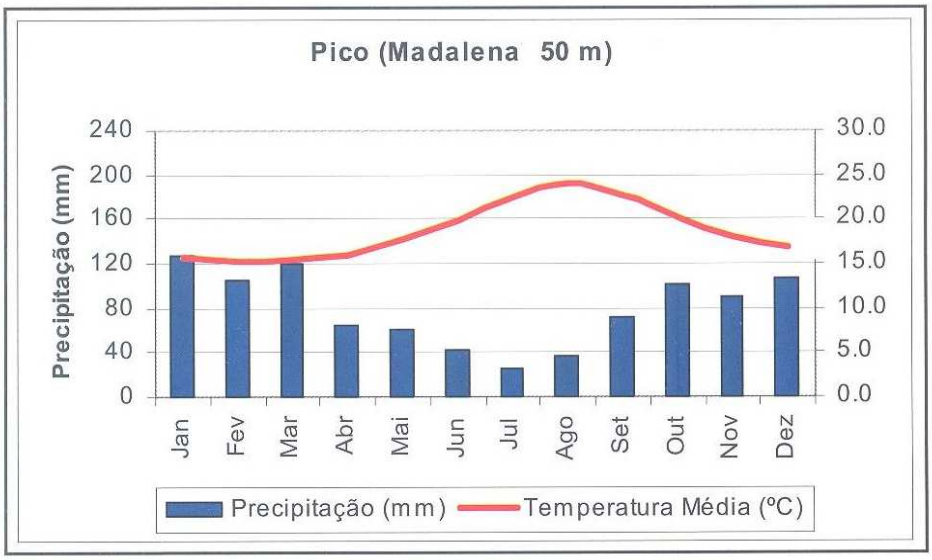


Fig. 5.17 - Thermo-pluviometry in Madalena (Forjaz *et al*., 2004)

Moisture is also an important characteristic averaging around 80% along the year. It tends to augment with altitude and presents a clear influence from the morphology, which can be associated with fog and mainly with the stationary clouds between 700 and 180 m (Fig. 5.18).

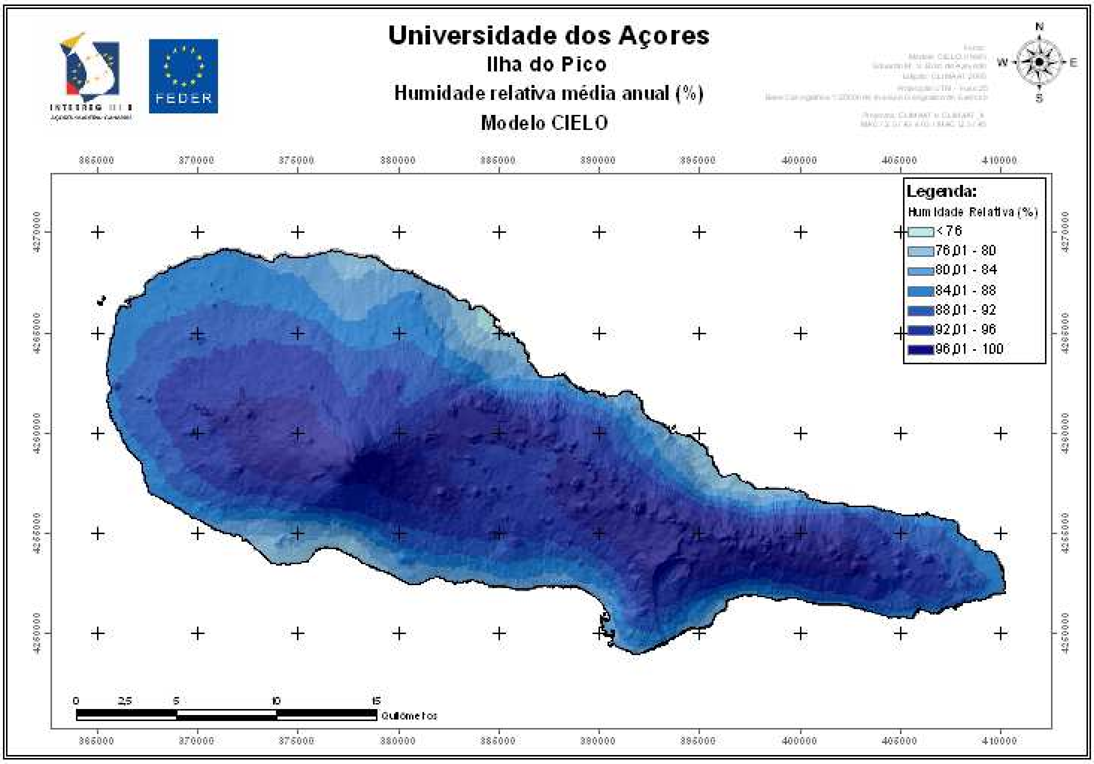


Fig. 5.18 - Relative humidity

The temperature amplitude is very small varying in Madalena from around 13ºC-14ºC in January and February to 22ºC-23ºC in July and August, for an average year temperature of 17,4ºC. (Fig. 5.17)

The winds blow predominantly from SW.

Flora and vegetation

From a chorological perspective the Azores archipelago is included in the Macaronesian region which includes very characteristic vegetation structures with a high number of endemic *taxa* (superior to the expected for insular regions with their characteristics). It is also relevant because this is an area of refuge of wet subtropical vegetation formation *(Laurisilvae*) that built the Mediterranean basin vegetation during the Tertiary period. From a chorological perspective the Azores archipelago is included in the Macaronesian region which includes very characteristic vegetation structures with a high number of endemic *taxa* (superior to the expected for insular regions with their characteristics). It is also relevant because this is an area of refuge of wet subtropical vegetation formation *(Laurisilvae*) that built the Mediterranean basin vegetation during the Tertiary period (fact that, according to some authors is proved by the existence of remnants of the *Laurisilvae* (like the presence of *Laurus azorica* e some areas of the littoral of Marrrocos and in the Monchique Mountain (SW Portugal)).

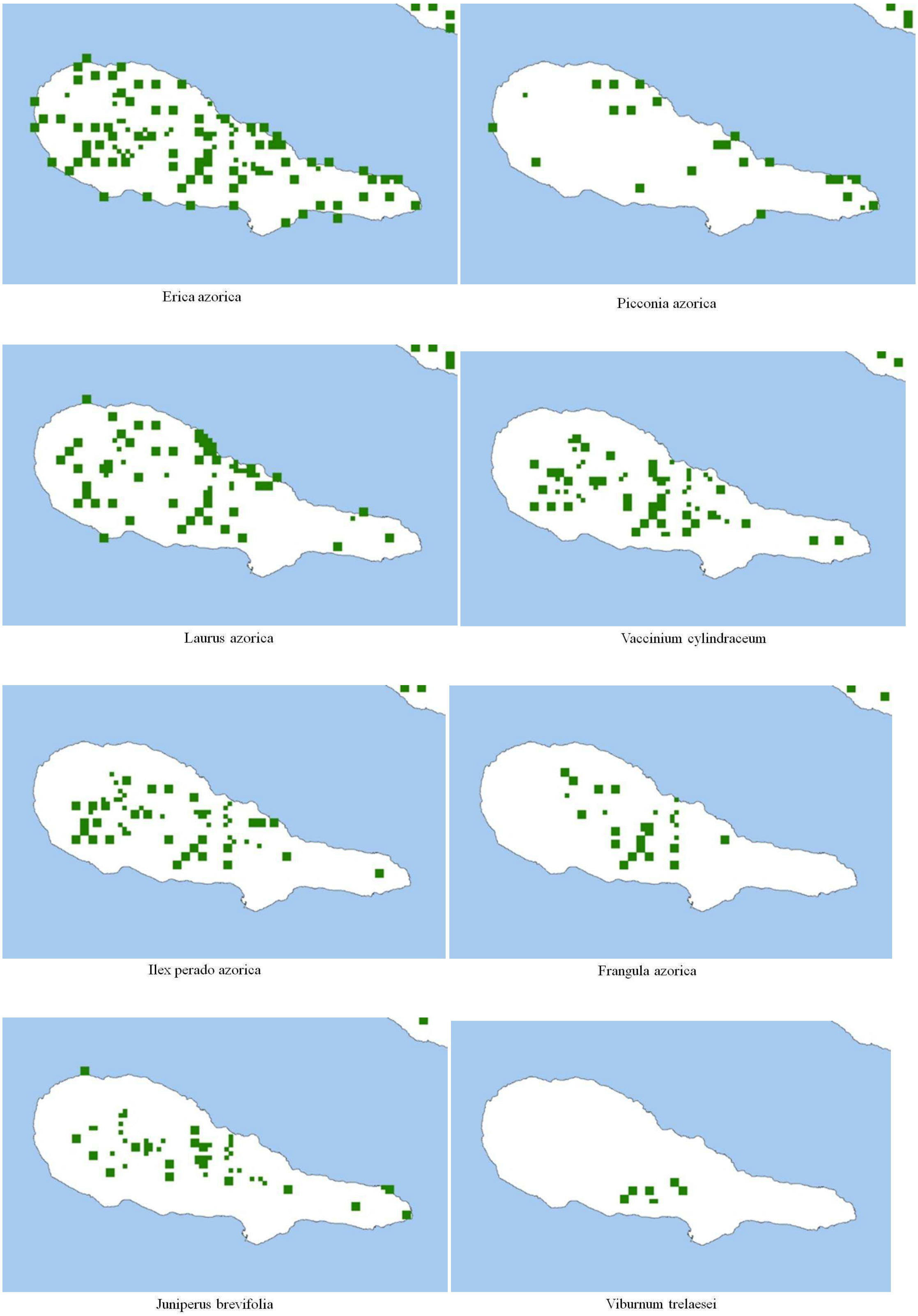


Fig. 5.19 - Illustration of the occurrence of same endemic species in the island of Pico according to http://www.azoresbioportal.angra.uac.pt/ (viewed 23.9.2013)

In Azores, 947 vascular plant species are registered from which only 7.2 % are endemic *taxa* (Borges *et al*., 2005) (Fig. 5.19), and a large number correspond to exotic species resulting from accidental or voluntary introduction after the colonization of the islands.

As particular important species one can list the following (Box 5.1)

BOX 5.1 - Particular important vascular plant species according to 92/43/CEE Directive
Myosotis azorica H.C. Watson
Myosotis maritima Hochst.
Azorina vidalii (H.C. Watson) Feer
Spergularia azorica (Kindb.) Lebel
Lactuca watsoniana Trelease
Scabiosa nitens Roemer & J.A.Schultes
Erica scoparia L. subsp. azorica (Hochst) D.A. Webb
Trichomanes speciosum Willd.
Isoetes azorica Durieu ex Milde
Lotus azoricus P.W.Ball
Vicia dennesiana H.C.Watson
Arceuthobium azoricum Wiens & Hawksw.
Marsilea azorica Durieu ex-Milde
Picconia azorica (Tutin) Knobl.
Rumex azoricus Rech.f.
Frangula azorica Tutin
Prunus lusitanica L. subsp. azorica (Mouillef.) Franco
Euphrasia azorica H.C.Watson
Euphrasia grandiflora Hochst. ex Seub
Ammi trifoliatum (H.C.Watson) trelease
Chaerophyllum azoricum Trelease
Melanoselinum decipiens (Schrader & Wendl.) Hoff.
Sanicula azorica Guthnick ex Seub.

The Pico Island, from a phytocenotic perspective presents in the context of the Azores archipelago the highest plant diversity due to its altitude (2345 m) and the small population of the island determining a relative low disturbance intensity. Its main vegetation types are the following (Fig. 5.20).

In the costal are structures with *Euphorbia azorica, Crithmum maritimum, Juncus acutus, Festuca petreae, Cynodon dactylon, Plantago coronopus, Lotus subbiflorus. Solidago sempervirens, Campanula vidalii, Daucus carota* subsp. *maritimus, , Spergularia azorica, Polypogon monspeliensis, Frankenia pulverulenta,* etc. can be found.

In the lower altitudes up to 600-700m forest or bush formations dominated by *Myrica faya, Erica azorica, Laurus azorica, Frangula azorica, Ilex perado* subsp. *azorica, Viburnum tinus* subsp. *subcordatum, Picconia azorica, Myrsine africana, Rubus ulmifolius, Hedera helix* subsp. *canariensis, Smilax divaricata* can be cound.

At altitudes between 500 and 1800m forest of *Laurus azorica. Persea indica (?), Juniperus brevifolia, Frangula azorica, Daphne laureola, Euphorbia stygiana, Prunus lusitanica* subsp. *azorica, Rubus hochstetterotum, Hedera helix* subsp. *canariensis, Vaccinium cylindraceum* occur.

Above 1700m predominate shrublands with *Calluna vulgaris, Daboecia azorica* and *Thymus caespititius*.

In the water courses one can find essentialy *Laurus azorica, Persea indica* (?), *Hedera helix* subsp. *canariensis,*

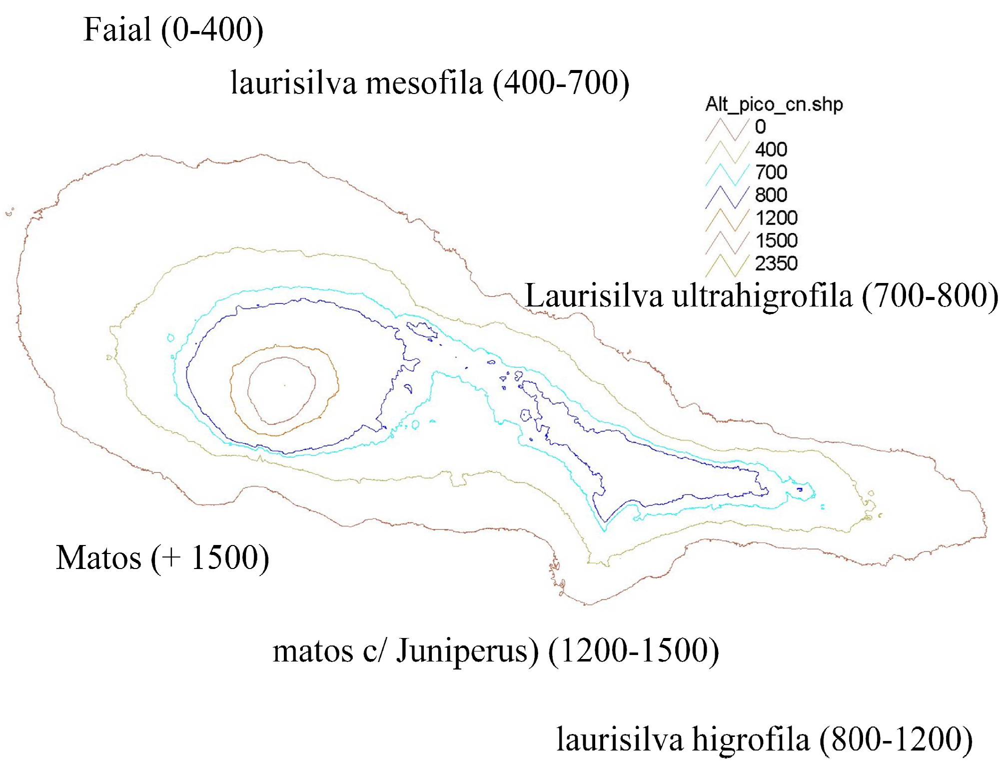


Fig. 5.20 - Main altitudinal belts and associated natural vegetation in Pico

Landscape dynamics

Landscape dynamic in a small island like Pico must be considered at two levels:

- The natural dynamic associated with physical processes (mainly superficial and sub superficial runoff and accumulation, infiltration, erosion and sedimentation) and, eventually, in volcanic islands like Pico, physico-chemical processes associated with earthquakes (large and small), landslides (large and small) and emissions of chemicals from volcanic outlets, springs etc.
- The biological dynamic associated mainly to animals, colonizing habitats, using complementary habitats and eventually, when possible, moving between neighboring islands or even larger distances. Additionally along with these animals

movements both also trough wind movements and ocean currents, plant and small invertebrates propagation.

The first type of processes is generally easy to characterize (e.g. Fig. 5.21 displaying the basis, water courses (permanent or temporary and the land uses), allowing, together with the rainfall data to model the runoff in different situations and also the runoff of nutrients and contaminants associated with agriculture or other activities.

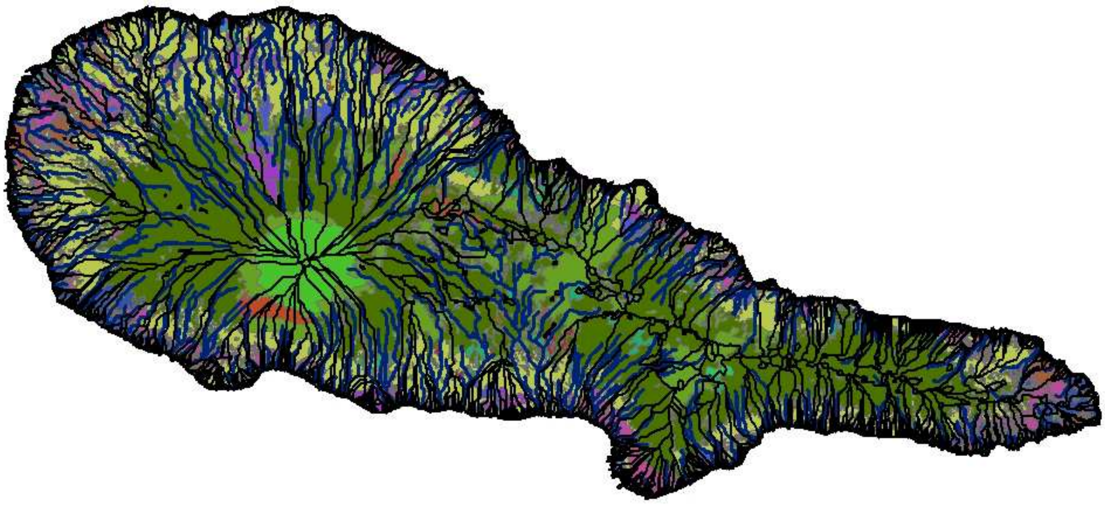


Fig. 5.21 - Land use, basins and water courses

This modeling process is of particular importance when sensitive areas of habitats lay downstream from possible sources of contaminants (e.g. nutrients associated whit livestock production). Let's consider, for example the endorheic basins, mires and the drenching soils that are presently or potentially proprietary habitats. Most of their basins are occupied with pasture and there is an increased risk of eutrophication of ponds and lakes and of a change in the nature of the vegetation community and succession in the wet areas (Fig. 5.22). This knowledge is of the utmost importance for a more ecosystem direct management of the grazing intensity in these areas in order to preserve and promote these habitats and all their functions (including varied NCOs).

The modeling of erosion is more difficult because of the lack of data on soils, but the morphological and the land cover component can be evaluated without problem.

Mass movements are also critical issues in terms of risk evaluation and must be analyzed trough a specific geotechnical study. Nevertheless the type of geology and the tectonics of the island (Nunes, 1999; Forjaz, 2004) allow a previous evaluation of these risks. The same can be said in relation to volcanic activity, springs and other sites of volcanic emissions.

The characterization of the biological dynamic in much more difficult due to the lack of integration of the existing data and the lack of aimed data, only possible to gather in the frame of specialized interdisciplinary research projects.

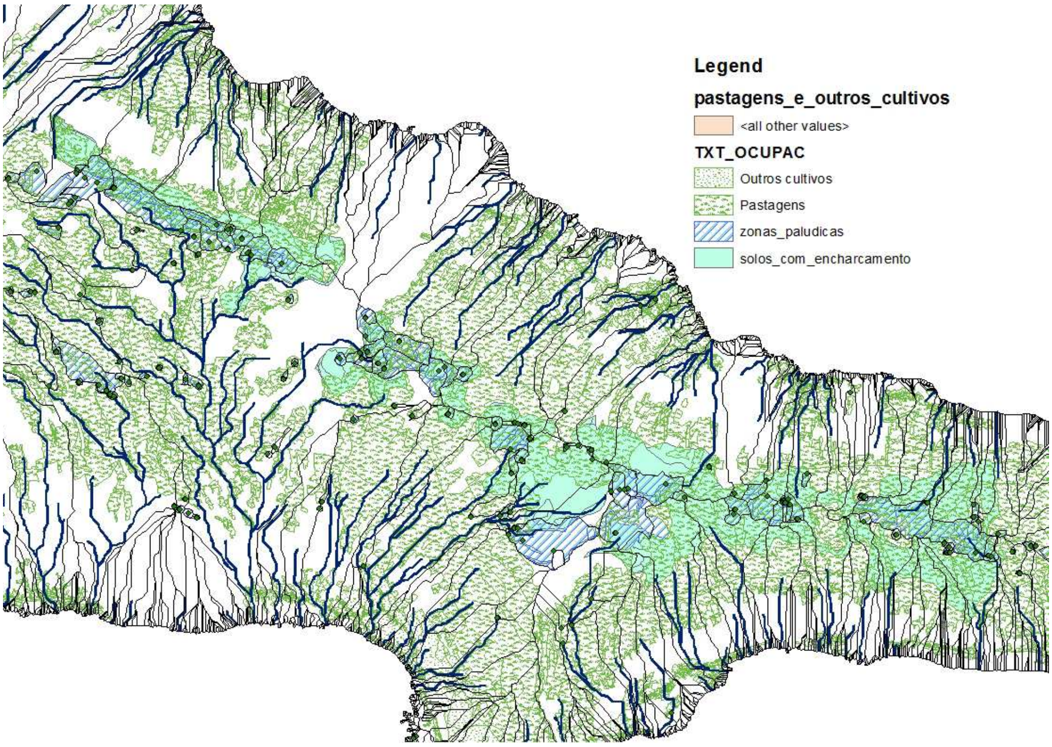


Fig. 5.22 - Wet and drenched areas and the distribution of pastures and other agricultural cultures

5.3.1.2 - The land use information

The information of the Land Use of the Pico Island was performed using the COS 2007 Map produced by the regional government (fig. 5.23 with the legend presented on Tab. 5.5.

Tab. 5.5 - Legend of the Land Use Map of Pico

Code	Land cover	Code	Land use	Observations
1	Urban area	a	Residential	
		b	Primary sector	Agro-livestock
		c	Secondary sector	Industry, wood processing, etc.
		d	Tertiary sector	Facilities, port areas, schools, bathing areas, etc
2	Road network	e	General systems	
3	Vineyards	b	Primary sector	Active or abandoned, vegetation cover less than 50%.
5	Other crops	b	Primary sector	
6	Pastures	b	Primary sector	
7	*Erica azorica*	f	Natural vegetation	
8	–Shrubs and herbaceous vegetation mosaics	f	Natural vegetation?	
9	*Cryptomeria japonica*	g	Woodlands	
10	*Acacia melanoxylon*	g	Alien species	
11	*Pittosporum undulatum*	g	Alien species	
12	*Myrica faia*	f	Natural vegetation	
13	Other spaces with little or	h	Abandoned lands	Eroded or unused areas

	no vegetation	b	Primary sector	Recently logged forests
		c	Secondary sector	Extraction of sand
		d	Tertiary sector - facilities	Areas with bare soil corresponding to 1d category
14	Bare rock	i	Natural áreas without vegetation	Rocky coastal areas
15	Water bodies	j	Water bodies	
16	*Pinus sp.*	g	Woodlands	
17	*Eucalyptus globulus*	g	Woodlands	
18	Peatbogs	f	Natural vegetation	

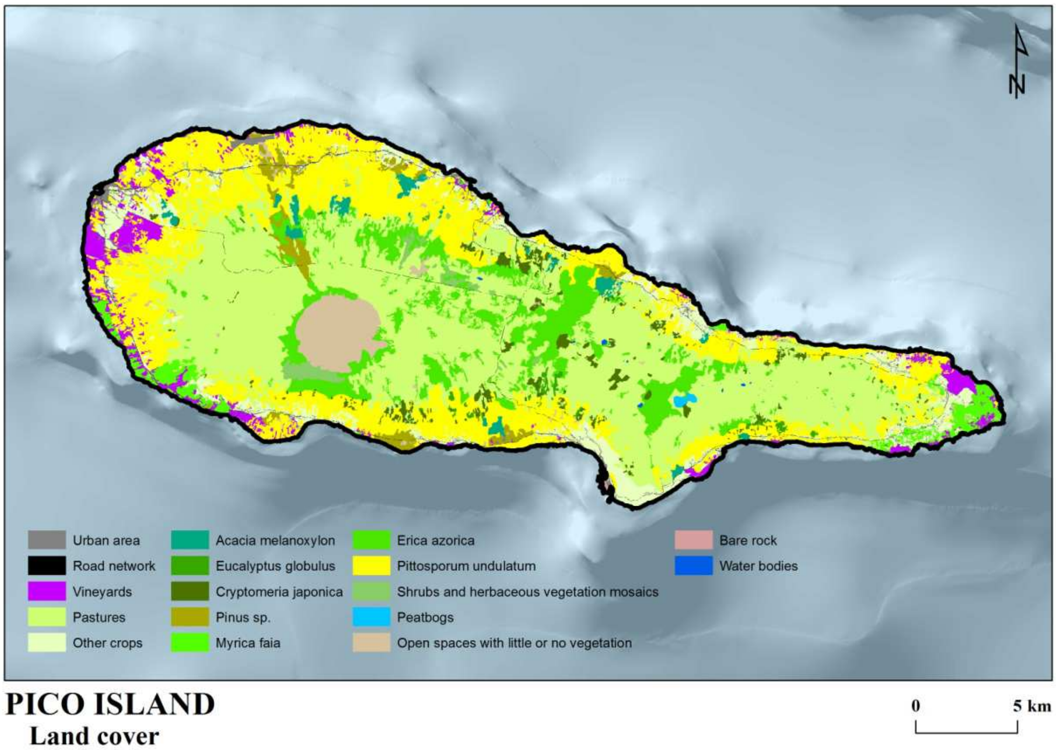


Fig. 5.23 - Land Use Map of Pico (2007)

It is easy to observe that the island has a very limited urban occupation (almost only the heads of the municipalities (Madalena, Lajes do Pico and São Roque) (Fig. 5.24)

Analyzing the present land uses it is possible to verify the dominance of pasture and the importance of the areas invaded by *Pittosporum undulatum* and also the important remains of *Erica azorica* and also some important patches of *Myrica faya*, indicating a good potential evolution towards natural vegetation communities. It is also possible to identify to important areas of vineyards that build the World Heritage cultural *Landscape of the Pico Island Vineyard Culture*.

Most of the island presents low levels of disturbance and use intensity, except along the peripheral littoral road where there is an intense urban pressure for building 2nd residence houses and progressively also touristic infra-structures.

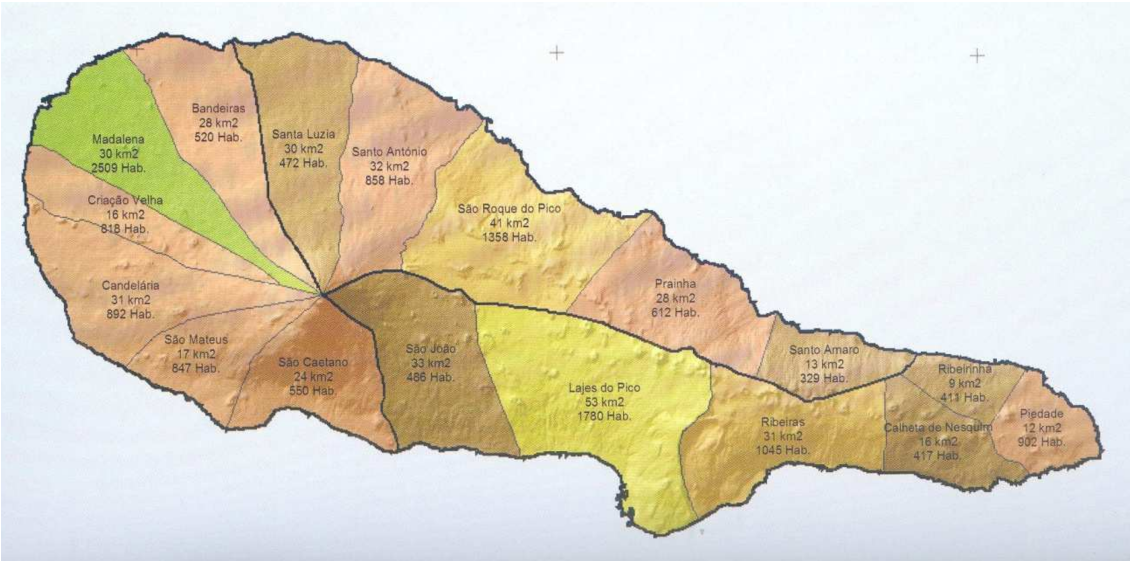


Fig. 5.24 - Population in each commune in Pico (Forjaz et al. 2004)

The 2007 land use map uses a very limited legend (Tab. 5.5) mainly focused in economical activities and providing poor information on natural formations, leading, inclusively to some misinterpretation or even errors. One example is the classification of most of the Pico Mountain as "naked soil". The class "other herbaceous and bush vegetation) is also very general and imprecise. This lack of precision derives, not only from the fact that these maps are aimed primarily at the economic land use mapping and have a working scale that doesn't allow more detailed classifications and the display of elements occupying small areas or situations of combined uses (for example, there are large areas classified as "*Pittosporum*" that still have important percentages of occupation by *Myrica faya*) and present therefore a different significance for example for the identification of priority management areas (in this case for the control of invasive species and the recovery of the "Faial Forest").

When considering Fig. 5.25 it is possible to verify that a large percentage of the agricultural activities are located in soils with no or almost none potential for that kind of land use.

Further analyzing Fig. 5.26 the scarce agricultural resources of the island and the need of a very careful management of the apparent areas of conflict (areas with extreme limitations and potential only for natural vegetation occupied with pastures) become very clear. This can be acceptable (even in areas of high erosion risks, if the pastures and mainly the grazing intensity is managed in the sense of the protection of the soil and the development of a more diverse mosaic with, for example the inclusion of natural thickets in the most endangered or fragile areas.

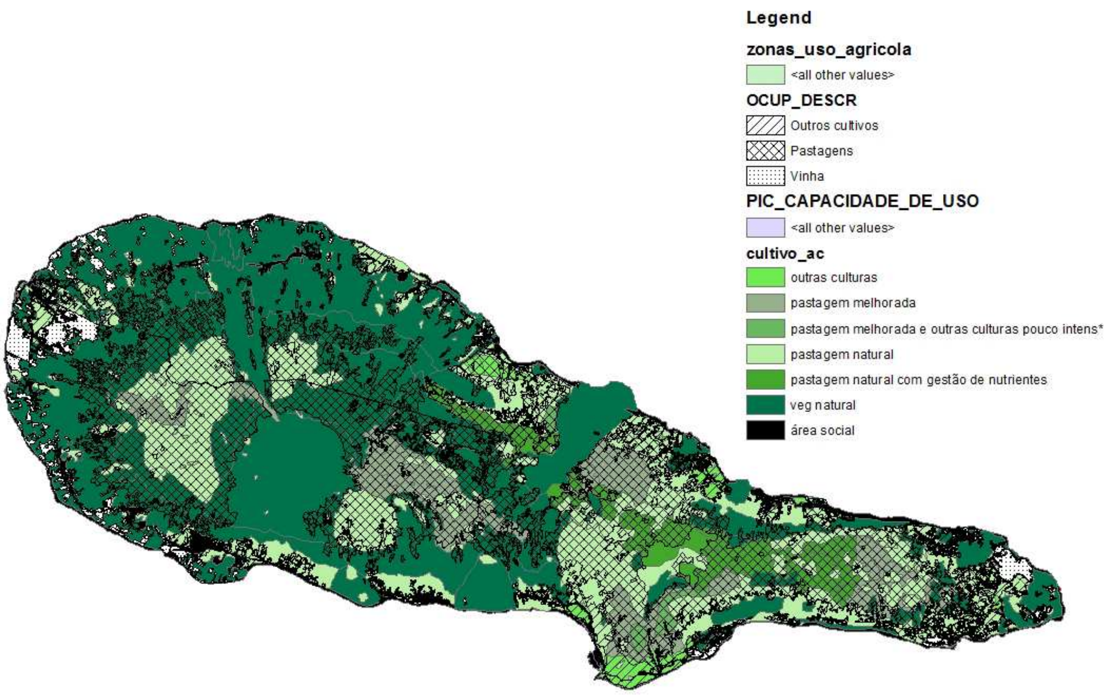


Fig. 5.25 - Potential for agricultural use according to the soil quality map and present agricultural use

Nevertheless Fig. 5.24 shows that the areas more susceptible to erosion are mainly located around the Pico Mountain where there are only marginal fringes of pasture and in a large area in the eastern half of the island in areas with a limited agricultural potential (mainly only natural pasture). This is not a critical situation, because well managed livestock grazing together with the adequate management of the pasture vegetation can be very effective in preventing erosion (as numerous researches in the Alps clearly demonstrate).

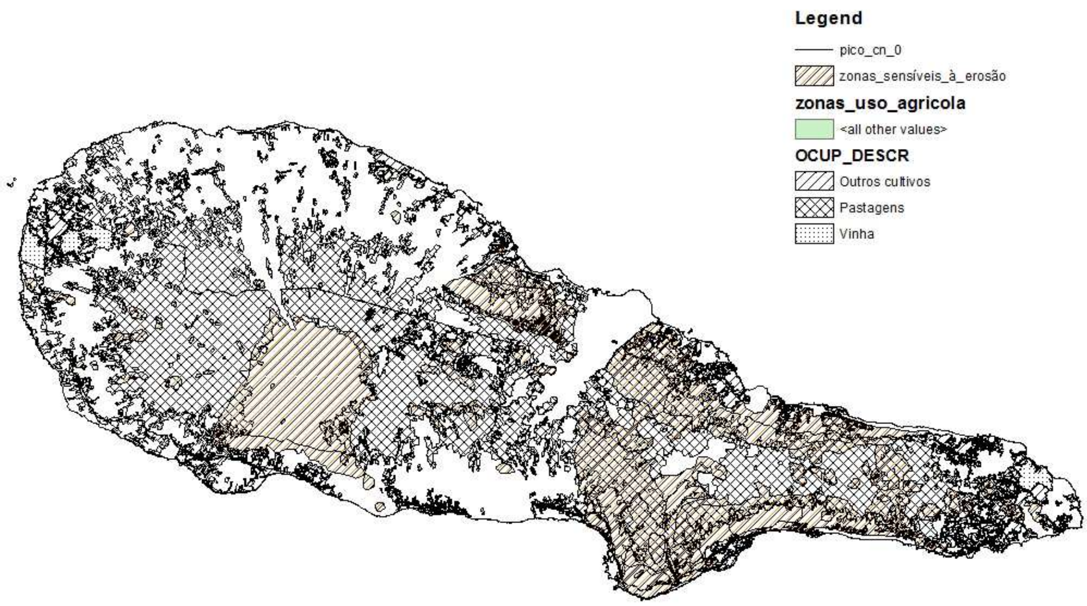


Fig. 5.26 - Present agricultural use and areas of soil susceptible to erosion

5.3.2 - The reference information layer - Ecological reference units

As stated above any characterization and evaluation process needs to have a stable comprehensive reference system with which any item can be compared and to which any evaluation can be referred.

In the case of geographic and land use systems the concept of land unit is used referred to the stable biophysical variables (like geology, soil, climate, morphology, position) and expressed in different ways namely using the natural vegetation corresponding to those stable ecological characteristics.

It is therefore in this context that the ecological reference units where defined considering the geological zoning of the island, the morphology, the soil potential productivity (Pico Island Soil Quality map), the climate zoning (considering rainfall, moisture, prevailing winds, indirect precipitation associated to cloud belts and morphology, internal drainage areas and respective watersheds and gully-similar water courses. 87 ERU where identified (Fig. 5.27) and their main characteristics listed in Tab. 5.6. The selection of the thresholds for variables like rainfall, moisture and prevailing winds was made considering their importance in the occurrence of distinct types of natural vegetation (derived from Dias (2001) and Dias *et al*. (2005)).

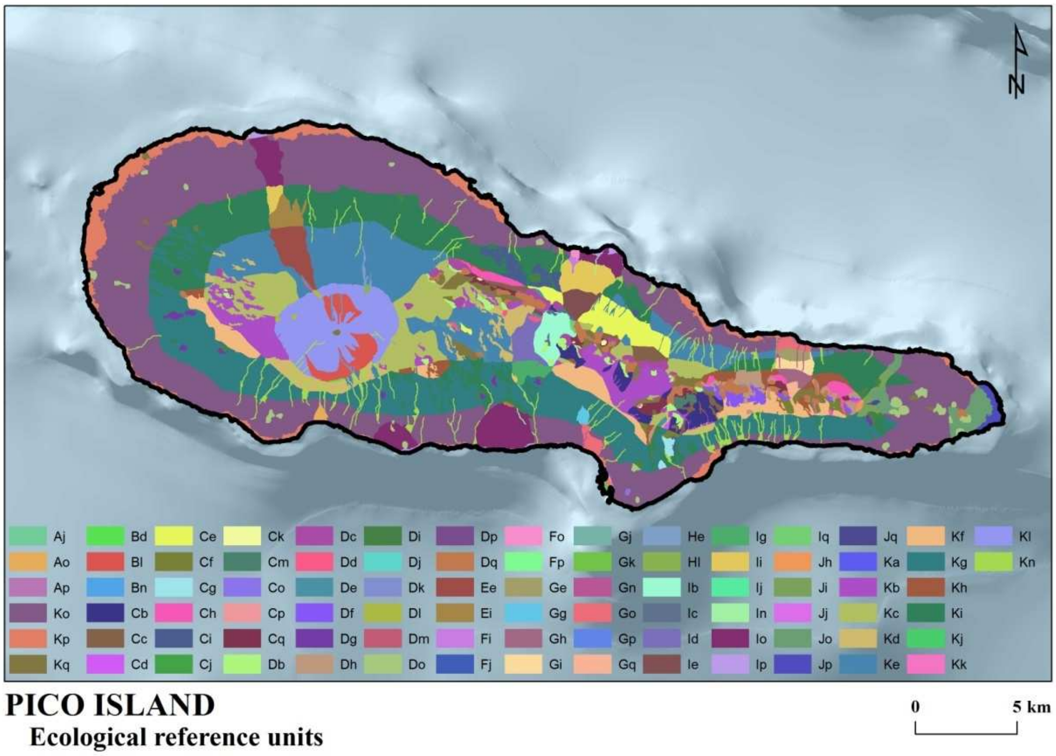


Fig. 5.27 - Ecological reference units

These ecological reference units (ERUs) build the main referential for the modelling and evaluation procedures. They try to reflect, in the best way possible, according to the available biophysical data, the main characteristics occurring in the island. Their boundaries must be considered as having low precision, due to the fact that for some boundaries definition, climatic isolines where used as a result of the absence, for example of natural vegetation map that would show more correct boundaries. Micro-habitats are also not represented for the same reason: low availability and poor reliability of the available information (Fig 5.28).

Given the fact that these units where built based on the combination of the above mentioned factors, (expressing the classic concept of land unit first proposed by Zonneveld (1989), there is permanently the possibility given the availability of better information of correcting the ERU map without invalidating the analytical process and the way the scenarios are built.

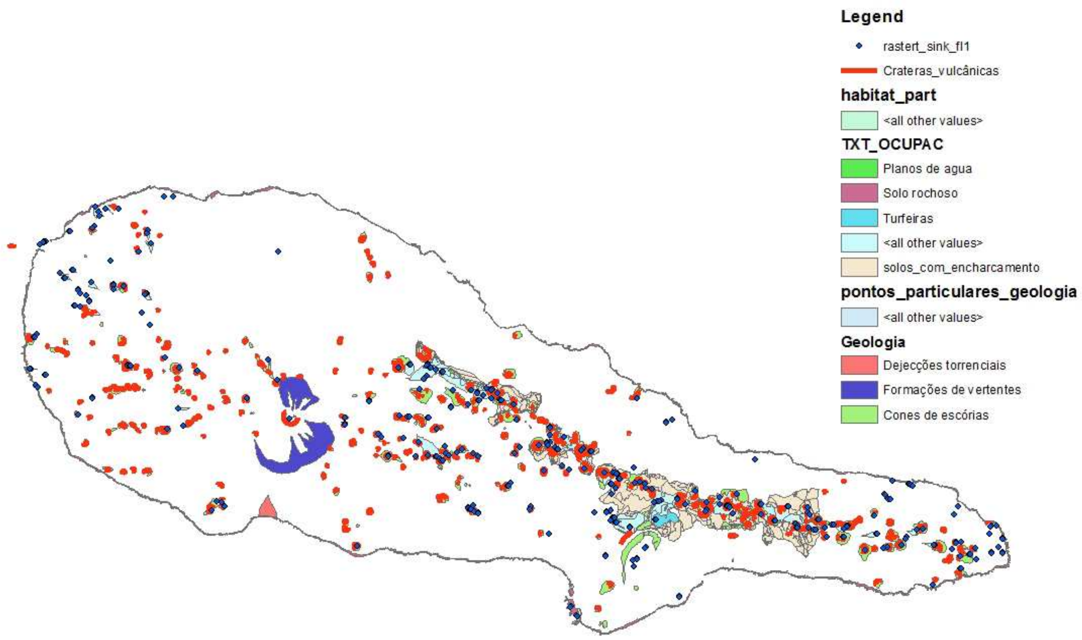


Fig. 5.28 - Particular elements - lakes, springs, mire and rocky costal escarpments (source: PROTA and Geological database)

The analysis of table 5.6 shows apparently a very diversified ecology, although when analyzing with more detail the displayed information one can observe that generally we have a altitudinal differentiation due to climatic variability (Fig. 5..20), some variation between the northern and southern sides due to the prevailing winds and some variability associated with the geological substrata and the presence of drenched soils originating wetlands, lakes and mires.

We cannot, therefore, speak from a high internal diversity (the geology is homogeneous) and the morphology relatively regular, but there is an important micro structural diversity associated with small resource patches that, together with the altitudinal zonation contribute to a relative high potential biodiversity.

Tab. 5.6 - Characteristics of the ERUs with an indication of the most frequent land use in each ERU and the most probable type of natural vegetation susceptible of occurring under those ecological conditions

COD	Integrated morpho-climatic characteristics	Geological formation	Geological type	Most probable natural vegetation	Most frequent land use	Classification	Subclass
Aj	Escarpas	Dejecções torrenciais	Formações sedimentares	Comunidades Halo-rupícolas costeiras em escarpas	Solo rochoso	OC	OC
Ao	Zonas baixas e de transição	Dejecções torrenciais	Formações sedimentares	Floresta de Faial	Área edificada	IV+VI	OC
Ap	Zonas costeiras	Dejecções torrenciais	Formações sedimentares	Comunidades halofíticas e transição para formações arbustivas de Myrica, Juníperos e Erica	Outros cultivos	IV+VI	OC
Bd	Zona climática 3_Precipit Max_Hum med_Vento Max	Formações de vertentes	Formações sedimentares	Floresta de juníperos matos de Erica	Outra vegetação herbácea - arbustiva	VII	e,s
Bl1	Pico	Formações de vertentes	Formações sedimentares	Gramíneas (Deschampia) acima da timberline e matos vestigiais de Erica	Solo nu	VII	e,s
Bl2	Pico	Formações de vertentes	Formações sedimentares	Floresta e matos de Erica e gramíneas (Deschampia)	Erica azorica	VI	e
Bn	Vales com factor LS>500	Formações de vertentes	Formações sedimentares	Comunidades mistas rupícolas e ripícolas em vales de drenagem e de linhas de água encaixados com manchas de Erica	Erica azorica	VI	e
Cb	Zona climática 1_Precipit Max_Hum Max_Vento Max	Materiais de projecção	Materiais piroclásticos	Laurifólia hiper húmida	Cryptomeria japonica	IV	e
Cc	Zona climática 2_Precipit Max_Hum Max_Vento med	Materiais de projecção	Materiais piroclásticos	Laurifólia húmida	Cryptomeria japonica	IV	e
Cd	Zona Climática 3_Precipit Max_Hum med_Vento Max	Materiais de projecção	Materiais piroclásticos	Floresta de juníperos	Pastagens	IV	e
Ce	Zona Climática 4_Precipit Max_Hum med_Vento med	Materiais de projecção	Materiais piroclásticos	Floresta das Nuvens	Acacia melanoxylon	IV+III	e
Cf	Zona Climática 5_Precipit med_Hum Max_Vento Max	Materiais de projecção	Materiais piroclásticos	Floresta de juníperos	Erica azorica	IV	e

Cg	Zona Climática 6_Precipit med_Hum med_Vento Max	Materiais de projecção	Materiais piroclásticos	Mosaico de floresta de Erica e Juníperos	Pastagens	IV	e
Ch	Zona Climática 7_Precipit med_Hum Max_Vento med	Materiais de projecção	Materiais piroclásticos	Laurifólia mésica	Erica azorica	V	e
Ci	Zona Climática 8_Precipit med_Hum med_Vento med	Materiais de projecção	Materiais piroclásticos	Laurifólia mésica	Acacia melanoxylon	III	e
Ck	Planos de água	Materiais de projecção	Materiais piroclásticos	Comunidades de lagoas oligotróficas	Planos de agua	V	e
Cm	Turfeiras	Materiais de projecção	Materiais piroclásticos	Vegetação de turfeiras ombrotr¾ficas	Turfeiras	VI	e
Co	Zonas baixas e de transição	Materiais de projecção	Materiais piroclásticos	Floresta de Faial	Outros cultivos	AS	AS
Cp	Zonas costeiras	Materiais de projecção	Materiais piroclásticos	Comunidades halofíticas e transição para formações arbustivas de Myrica, Juníperos e Erica	Area edificada	AS	AS
Cq	Zonas Palúdicas	Materiais de projecção	Materiais piroclásticos	Formações palustres e palúdicas e/ou floresta de juníperos	Cryptomeria japonica	V	e
Db	Zona Climática 1_Precipit Max_Hum Max_Vento Max	Cones de escórias	Materiais piroclásticos	Laurifólia hiper húmida e comunidades arbustivas de areias vulcânicas	Cryptomeria japonica	IV	e
Dc	Zona Climática 2_Precipit Max_Hum Max_Vento med	Cones de escórias	Materiais piroclásticos	Laurifólia húmida e comunidades arbustivas de areias vulcânicas	Cryptomeria japonica	V	
Dd	Zona Climática 3_Precipit Max_Hum med_Vento Max	Cones de escórias	Materiais piroclásticos	Floresta de juníperos e comunidades arbustivas de areias vulcânicas	Erica azorica	V+VI	e
De	Zona Climática 4_Precipit Max_Hum med_Vento med	Cones de escórias	Materiais piroclásticos	Floresta das Nuvens e comunidades arbustivas de areias vulcânicas	Erica azorica	V	e
Df	Zona Climática 5_Precipit med_Hum Max_Vento Max	Cones de escórias	Materiais piroclásticos	Floresta de juníperos e comunidades arbustivas de areias vulcânicas	Erica azorica	V+VI	e
Dg	Zona Climática 6_Precipit med_Hum med_Vento Max	Cones de escórias	Materiais piroclásticos	Mosaico de floresta de Erica e Juniperus e comunidades arbustivas de areias vulcânicas	Cryptomeria japonica	IV+VI	
Dh	Zona Climática 7_Precipit med_Hum Max_Vento med	Cones de escórias	Materiais piroclásticos	Laurifólia mésica e comunidades arbustivas de areias vulcânicas	Cryptomeria japonica	V	e

Di	Zona Climática 8_Precipit med_Hum med_Vento med	Cones de escórias	Materiais piroclásticos	Laurifólia mésica e comunidades arbustivas de areias vulcânicas	Acacia melanoxylon	IV	e
Dj	Escarpas	Cones de escórias	Materiais piroclásticos	Comunidades Halo-rupícolas costeiras em escarpas	Solo rochoso	OC	e
Dk	Planos de água	Cones de escórias	Materiais piroclásticos	comunidades de lagoas oligotróficas	Planos de agua	VI	e
Dl	Pico	Cones de escórias	Materiais piroclásticos	Floresta de Erica e gramíneas (Deschampia) e comunidades arbustivas de areias vulcânicas	Erica azorica	V+VI	e
Dm	Turfeiras	Cones de escórias	Materiais piroclásticos	Vegetação de turfeiras ombrotr¾ficas	Turfeiras	VI	e
Do	Zonas baixas e de transição	Cones de escórias	Materiais piroclásticos	Floresta de Faial ou comunidades arbustivas de areias vulcânicas	Area edificada	III	
Dp	Zonas costeiras	Cones de escórias	Materiais piroclásticos	Comunidades halofíticas e comunidades arbustivas de areias vulcânicas	Pittosporum undulatum	IV+VI	e
Dq	Zonas Palúdicas	Cones de escórias	Materiais piroclásticos	Formações palustres e palúdicas e/ou floresta de juníperos e comunidades arbustivas de areias vulcânicas	Acacia melanoxylon	V	
Ee	Zona Climática 4_Precipit Max_Hum med_Vento med	Andesitos peridóticos do 'Mistério de Sta Luzia'	Rochas vulcânicas	Floresta das Nuvens	Acacia melanoxylon	V+VI	
Ei	Zona Climática 8_Precipit med_Hum med_Vento med	Andesitos peridóticos do 'Mistério de Sta Luzia'	Rochas vulcânicas	Laurifólia mésica	Acacia melanoxylon	VI+VII	
Fi	Zona Climática 8_Precipit med_Hum med_Vento med	Andesitos peridóticos do 'Mistério da Prainha'	Rochas vulcânicas	Laurifólia mésica	Pittosporum undulatum	VI+IV	s
Fj	Escarpas	Andesitos peridóticos do 'Mistério da Prainha'	Rochas vulcânicas	Comunidades Halo-rupícolas costeiras em escarpas	Solo rochoso	OC	OC
Fo	Zonas baixas e de transição	Andesitos peridóticos do 'Mistério da Prainha'	Rochas vulcânicas	Floresta de Faial	Pittosporum undulatum	OC	OC
Fp	Zonas costeiras	Andesitos peridóticos do 'Mistério da Prainha'	Rochas vulcânicas	Comunidades halofíticas e transição para formações arbustivas de Myrica, Juníperos e Erica	Pittosporum undulatum	OC	OC
Ge	Zona Climática 4_Precipit Max_Hum med_Vento med	Andesitos peridóticos	Rochas vulcânicas	Floresta das Nuvens	Cryptomeria japonica	VI	e
Gg	Zona Climática 6_Precipit med_Hum med_Vento Max	Andesitos peridóticos	Rochas vulcânicas	Mosaico de floresta de Erica e Juníperos	Cryptomeria japonica	VI	e

Gh	Zona Climática 7_Precipit med_Hum Max_Vento med	Andesitos peridóticos	Rochas vulcânicas	Laurifólia mésica	Pastagens	V+VI	e
Gi	Zona Climática 8_Precipit med_Hum med_Vento med	Andesitos peridóticos	Rochas vulcânicas	Laurifólia mésica	Cryptomeria japonica	V+VI	e
Gj	Escarpas	Andesitos peridóticos	Rochas vulcânicas	Comunidades Halo-rupícolas costeiras em escarpas	Solo rochoso	III+IV	e
Gk	Planos de água	Andesitos peridóticos	Rochas vulcânicas	comunidades de lagoas oligotróficas	Planos de agua	VI	w
Gn	Vales com factor LS>500; 50m de largura	Andesitos peridóticos	Rochas vulcânicas	Comunidades mistas rupícolas e ripícolas em vales de drenagem e de linhas de água encaixados	Área edificada	AS	AS
Go	Zonas baixas e de transição	Andesitos peridóticos	Rochas vulcânicas	Floresta de Faial	Área edificada	AS	AS
Gp	Zonas costeiras	Andesitos peridóticos	Rochas vulcânicas	Comunidades halofíticas e transição para formações arbustivas de Myrica, Juníperos e Erica	Área edificada	AS	AS
Gq	Zonas Palúdicas	Andesitos peridóticos	Rochas vulcânicas	Formações palustres e palúdicas e/ou floresta de juníperos	Pastagens	V+VI	e
He	Zona Climática 4_Precipit Max_Hum med_Vento med	Andesitos e Andesitos peridóticos	Rochas vulcânicas	Floresta das Nuvens	Erica azorica	VI	s
Hl	Pico	Andesitos e Andesitos peridóticos	Rochas vulcânicas	Floresta de Erica e gramíneas (Deschampia)	Pastagens	VII+VI	s
Ib	Zona Climática 1_Precipit Max_Hum Max_Vento Max	Basaltos das erupções dos Séculos XVI e XVIII	Rochas vulcânicas	Laurifólia hiper húmida - presença importante de formações de erica	Cryptomeria japonica	V	e
Ic	Zona Climática 2_Precipit Max_Hum Max_Vento med	Basaltos das erupções dos Séculos XVI e XVIII	Rochas vulcânicas	Laurifólia húmida - presença importante de formações de erica	Erica azorica	VI+VII	s
Id	Zona Climática 3_Precipit Max_Hum med_Vento Max	Basaltos das erupções dos Séculos XVI e XVIII	Rochas vulcânicas	Floresta de juníperos - presença importante de formações de erica	Cryptomeria japonica	V+VI	e
Ie	Zona Climática 4_Precipit Max_Hum med_Vento med	Basaltos das erupções dos Séculos XVI e XVIII	Rochas vulcânicas	Floresta das Nuvens - presença importante de formações de erica	Acacia melanoxylon	IV+III	e
Ig	Zona Climática 6_Precipit med_Hum med_Vento Max	Basaltos das erupções dos Séculos XVI e XVIII	Rochas vulcânicas	Mosaico de floresta de Erica e Juníperos	Erica azorica	V+VI	s

Ii	Zona Climática 8_Precipit med_Hum med_Vento med	Basaltos das erupções dos Séculos XVI e XVIII	Rochas vulcânicas	Laurifólia mésica presença importante de formações de erica	Acacia melanoxylon	IV+III	e
Ij	Escarpas	Basaltos das erupções dos Séculos XVI e XVIII	Rochas vulcânicas	Comunidades Halo-rupícolas costeiras em escarpas	Solo rochoso	AS	AS
In	Vales com factor LS>500; 50m de largura	Basaltos das erupções dos Séculos XVI e XVIII	Rochas vulcânicas	Comunidades mistas e ripícolas em vales de drenagem e de linhas de água encaixados	Erica azorica	VI	e
Io	Zonas baixas e de transição	Basaltos das erupções dos Séculos XVI e XVIII	Rochas vulcânicas	Floresta de Faial ou formações arbustivas de Myrica faya e Juníperos	Acacia melanoxylon	AS	AS
Ip	Zonas costeiras	Basaltos das erupções dos Séculos XVI e XVIII	Rochas vulcânicas	Comunidades halofíticas e formações arbustivas de Myrica e Juníperos	Area edificada	AS	AS
Iq	Zonas Palúdicas	Basaltos das erupções dos XVI e XVIII	Rochas vulcânicas	Formações palustres e palúdicas e/ou floresta de juníperos	Erica azorica	VI+VII	s
Jh	Zona Climática 7_Precipit med_Hum Max_Vento med	Basaltos peridóticos de tendência andesitica de Ribeira, Ponta da Ilha e Sta Bárbara	Rochas vulcânicas	Laurifólia mésica	Pastagens	V	e
Ji	Zona Climática 8_Precipit med_Hum med_Vento med	Basaltos peridóticos de tendência andesitica de Ribeira, Ponta da Ilha e Sta Bárbara	Rochas vulcânicas	Laurifólia mésica	Area edificada	AS	AS
Jj	Escarpas	Basaltos peridóticos de tendência andesitica de Ribeira, Ponta da Ilha e Sta Bárbara	Rochas vulcânicas	Comunidades Halo-rupícolas costeiras em escarpas	Solo rochoso	OC	OC
Jo	Zonas baixas e de transição	Basaltos peridóticos de tendência andesitica de Ribeira, Ponta da Ilha e Sta Bárbara	Rochas vulcânicas	Floresta de Faial	Area edificada	AS	AS
Jp	Zonas costeiras	Basaltos peridóticos de tendência andesitica de Ribeira, Ponta da Ilha e Sta Bárbara	Rochas vulcânicas	Comunidades halofíticas e transição para formações arbustivas de Myrica, Juníperos e Erica	Area edificada	OC	OC
Jq	Zonas Palúdicas	Basaltos peridóticos de tendência andesitica de Ribeira, Ponta da Ilha e Sta Bárbara	Rochas vulcânicas	Formações palustres e palúdicas e/ou floresta de juníperos	Pastagens	V	s
Kb	Zona Climática 1_Precipit Max_Hum Max_Vento Max	Basaltos	Rochas vulcânicas	Laurifólia hiper húmida	Cryptomeria japonica	IV	
Kc	Zona Climática 2_Precipit Max_Hum Max_Vento med	Basaltos	Rochas vulcânicas	Laurifólia húmida	Cryptomeria japonica	V	

Kd	Zona Climática 3_Precipit Max_Hum med_Vento Max	Basaltos	Rochas vulcânicas	Floresta de juníperos	Cryptomeria japonica	IV	
Ke	Zona Climática 4_Precipit Max_Hum med_Vento med	Basaltos	Rochas vulcânicas	Floresta das Nuvens	Acacia melanoxylon	III+IV	
Kf	Zona Climática 5_Precipit med_Hum Max_Vento Max	Basaltos	Rochas vulcânicas	Floresta de juníperos	Cryptomeria japonica	V	e
Kg	Zona Climática 6_Precipit med_Hum med_Vento Max	Basaltos	Rochas vulcânicas	Mosaico de floresta de Erica e Juníperos	Acacia melanoxylon	IV	
Kh	Zona Climática 7_Precipit med_Hum Max_Vento med	Basaltos	Rochas vulcânicas	Laurifólia mésica	Cryptomeria japonica	V	e
Ki	Zona Climática 8_Precipit med_Hum med_Vento med	Basaltos	Rochas vulcânicas	Laurifólia mésica	Acacia melanoxylon	AS	
Kj	Escarpas	Basaltos	Rochas vulcânicas	Comunidades Halo-rupícolas costeiras em escarpas	Solo rochoso	AS	
Kk	Planos de água	Basaltos	Rochas vulcânicas	Comunidades de lagoas	Planos de água	V	e
Kl1	Pico	Basaltos	Rochas vulcânicas	Gramíneas (Deschampia) acima da timberline	Solo nu	VII	e,s
Kl2	Pico	Basaltos	Rochas vulcânicas	Floresta de Erica e gramíneas (Deschampia) acima da timberline	Outra vegetacao herbacea - arbustiva	VI	e
Kl3	Pico	Basaltos	Rochas vulcânicas	Floresta de Erica e gramíneas (Deschampia)	Erica azorica	V+VI	e
Kn	Vales com factor LS>500; 50m de largura	Basaltos	Rochas vulcânicas	Comunidades mistas rupícolas e ripícolas em vales de drenagem e de linhas de água encaixados	Acacia melanoxylon	AS	
Ko	Zonas baixas e de transição	Basaltos	Rochas vulcânicas	Floresta de Faial	Acacia melanoxylon	AS	
Kp	Zonas costeiras	Basaltos	Rochas vulcânicas	Comunidades halofíticas e transição para formações arbustivas de Myrica, Juníperos e Erica	Area edificada	AS	
Kq	Zonas Palúdicas	Basaltos	Rochas vulcânicas	Formações palustres e palúdicas e/ou floresta de juníperos	Acacia melanoxylon	IV+VI	

5.4 - Valuation

The process of valuation is critical for the evaluation and scenario building procedures. Therefore it is critical to clarify the criteria inherent to the way values were attributed to the different information and objects.

The context of the present study is development of systematic conservation planning and ecosystem based management practices in the context of small islands, ensuring systems of governance open, and involving an informed and involved participation of all stakeholders.

Therefore there are two main valuation criteria to be simultaneously considered:

- Present (Fig. 5.29) and potential conservation value (Fig. 5.30) (interest for the preservation and promotion of nature, natural functionality and biodiversity value);
- Societal value (present potential economic and welfare value) (5.31).

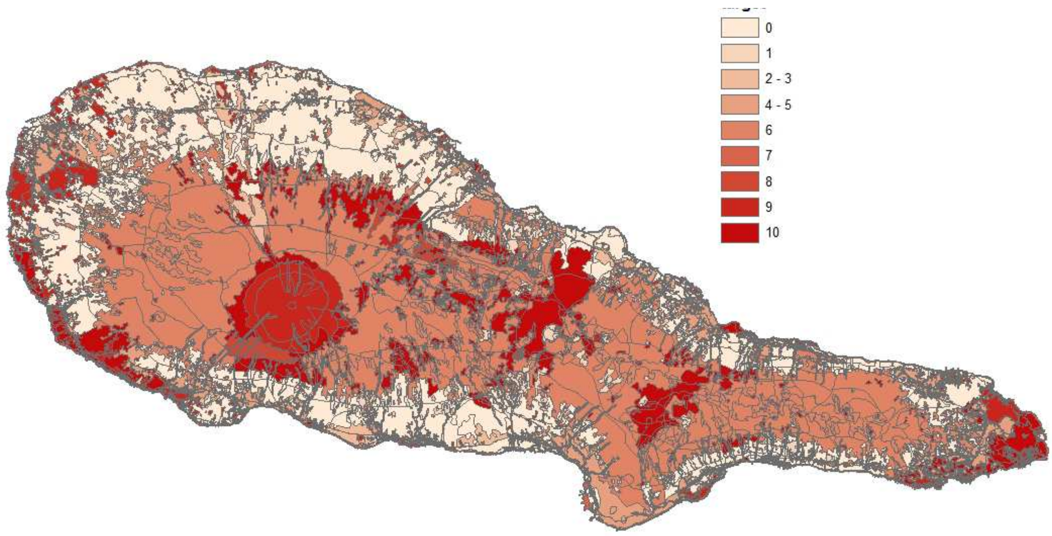


Fig. 5.29 - Qualitative estimation of the present conservation value of the land cover (10 max)

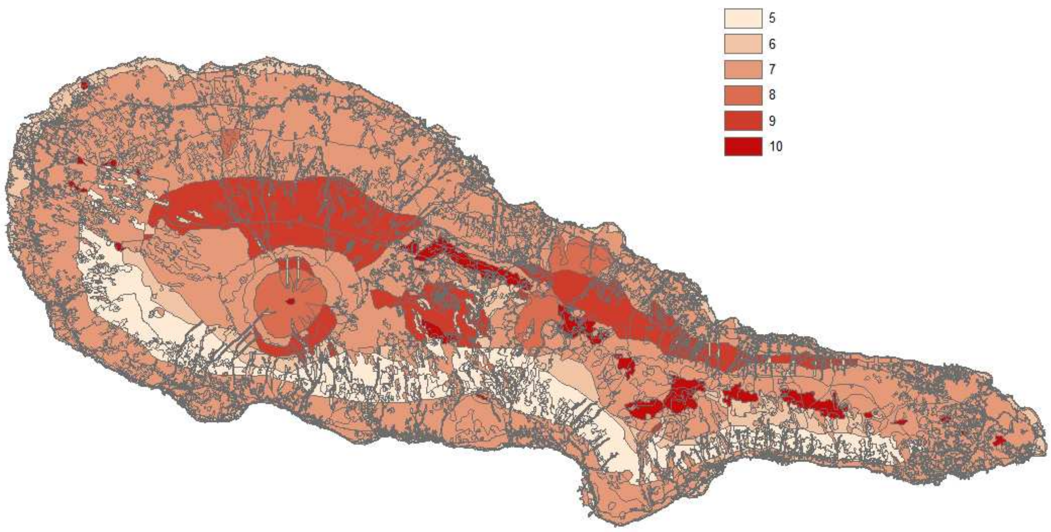


Fig. 5.30 - Qualitative estimation conservation value of the natural vegetation susceptible of occurring in the absence of disturbances (10 max)

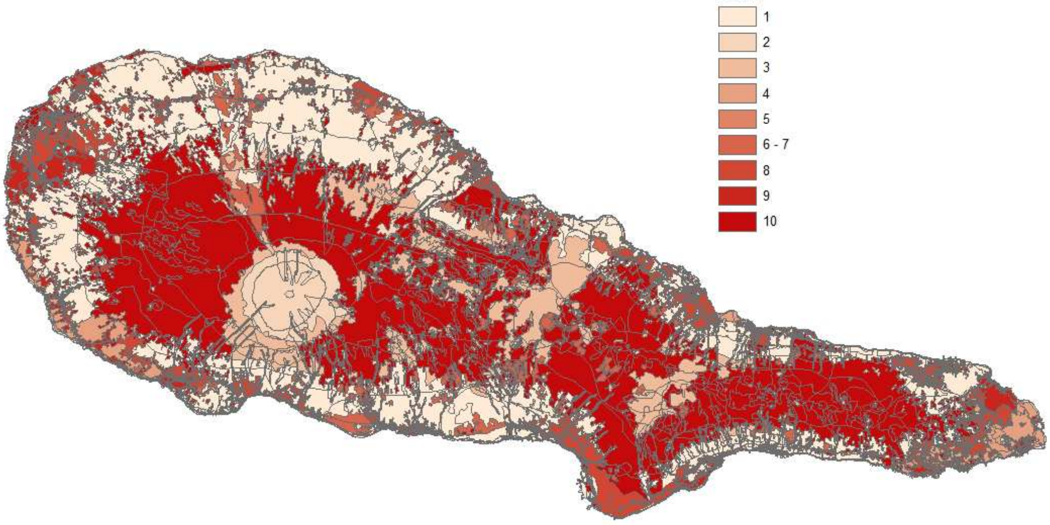


Fig. 5.31 - Qualitative estimation of the relative economical value of the present land use (10 max) - due to lack of precise information, the potential value of the coastal areas (for 2nd housing and touristic development is not included.

Both these criteria are not absolute by the simple consideration of figures (5.23, 5.25 and 5.26), showing how large are the areas occupied by pasture and that have no adequate soil productivity for that land use and that they can even be degraded trough erosion if the pasture management and the grazing intensity are not adequately preformed. So, considering the present land use as corresponding directly to high values when these land uses have an important economic significance is clearly wrong, although it must always be taken into account that it still builds the base of subsistence for an important number of families and of the global economy of the island.

In this sense, the consideration of the value of the agricultural areas or areas of potential expansion must take into account a factor of devaluation corresponding to the situations where the land productivity is too low or the risks of land degradation associated with incorrectly managed grazing are high. Obviously, if these risks are avoided by an adequate use, an immediate revaluation of the parcel must occur.

Another example of how the context must be taken into account when attributing a value to a certain parcel for a given land use is the case of real estate (for second housing or tourism). The first factor that must be taken into account and that is already considered in the Regional Territorial Plan (PROTA) (Cruz *et al.*, 2008) are the costs of building infrastructures (namely water supply and wastewater disposal and treatment - costs that must be incorporated in the parcel cost (in order to avoid socialization of the cost and privatization of profits). Other important factors are, for example, the way in which a certain construction affects landscape and aesthetical values devaluating neighbor or even far away parcels or adding value to those parcels (situation where compensation should be in order). This process of revaluation is of particular importance on an island with a particularly high touristic potential, based mainly in its landscape aesthetical value. Therefore, the global touristic development of the island depends of an adequate management of that landscape. Given that this management is performed by others then the touristic operators, it must be assessed, and the way the entire landscape is managed must be integrated, and all land managers (mainly farmers) must be brought together and compensated for this integrated and concerted management - that should not be solely understood as a conservation management in the sense of preserving the present landscape as it is, but that must also take into account all added value resulting from the recovery of degraded areas, areas infested by alien plant species and mainly recovery of the natural vegetation.

The ERUs allow, also a comparison between the reference situation and the present situation allowing the identification (within the limits of the valuation criteria). Fig. 5.32 and 5.33 illustrate the degree of loss of Conservation Value (Fig 5.32) and Protection Value - calculated by associating the conservation value with the degree of threat of each formation (Fig. 5.33).

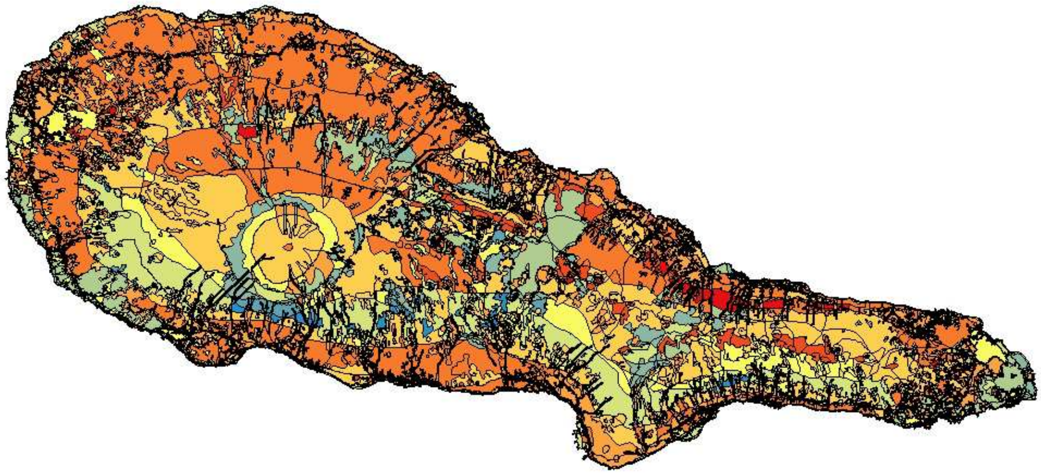


Fig. 5.32 - Difference in the Conservation Value (considering Rarity, Biodiversity, Unique Character and Naturalness) between the reference situation and the present Land Use - the blue tones correspond to relative maintenance of value and the yellow red tones the relative loss of value.

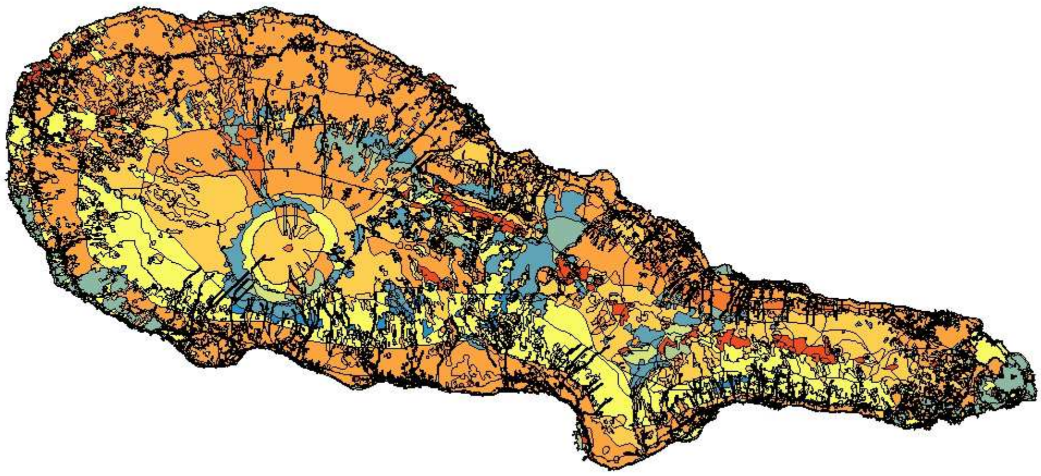


Fig. 33 - Difference in the Protection Value (considering the Conservation Value and the degree of threat) between the reference situation and the present Land Use - the blue tones

correspond to relative maintenance of value and the yellow red tones the relative loss of value.

It is important to stress that the valuation of the present land use is subject to divergence in criteria: for example the biodiversity of the *Pittosporum undulatum* areas should be considered null or very low or, should it be taken into consideration that these *Pitosporum* formation still include an important number of native species (e.g. *Myrica Faya*) that must be taken into consideration because the eradication of *Pitosporum undulatum* must not correspond to the total destruction of the plant cover of the infested areas, but solely to the extraction of the alien species and to promotion of the remaining autochthonous species.

The valuation of the conservation value poses still other types of problems, considering that, on one side, there is the present conjectural value with different levels of degradation or proximity to the natural conditions of a particular site, even when considering the same type of formation. For example, some areas or *Erica azorica* can correspond to pioneer or initial stages of a re-naturalization succession, whereas in other areas it corresponds to the natural community of that particular area. Therefore, the simple fact of having an area with *Erica azorica* cannot be equally valued, but must take into consideration different levels of value: it is a natural formation, but on one site one must support its evolution and eventual replacement by another community, while on the other site this is the target community.

Another problem when considering the valuation of conservation variables is their conservation status. There are different forms of classification of conservation value:

- Belonging to the NATURE 2000 Network quality and boundaries resulting from the present values existing in that area,
- Belonging to any of the conservation figures included in the Natural Park where the boundaries where defined with nature conservation political consideration that do not correspond necessarily with existing of potential values.

While the first case represents an existing value and an obligation to preserve and promote it, the second case does not correspond necessarily to high value areas or represent all potential value areas. It constitutes primarily an administrative instrument aimed at the protection and promotion of conservation values.

In this context, the value associated with the conservation status must be primarily based in the existence of the value (and take into consideration the eventuality that many micro or meso-structures or objects, do not fulfill the scale conditions of the Natura 2000 classification and are, therefore not included, without losing their conservation status of objects corresponding to the Natura 2000 value criteria).

The administrative status (belonging to a Protected Area) is presently more relevant when valuing a parcel for a given use, due the very strong use restrictions associated with this protected status (assuming more a societal and economical character then ecological).

Another criterion for valuing the conservation aspects is the use of the ERUs (ecological reference units). The ERUs try to portray, as best as the available information allows, the existing and potential resources, allowing an evaluation, for example, of aspects like the naturalness of a given vegetation formation (if it corresponds to the ecological characteristics of that site or if it results from any type of disturbance) or its stability according to the deviation degree between the present ecological situation and the situation corresponding to the local stable resources. This last criteria is, for example, very important on the valuation of existing conservation values because it gives an indication on their viability and probable evolution.

The question of being able to identify the viability of an existing value is critical for any conservation policy, because it allows the distinction between values with little maintenance needs (only protection from eventual disturbances) and values whose existence depend on given disturbances implying the need to evaluate if it is better to invest in that disturbance-determined value or invest in the restoration of that value on an adequate site with the adequate resources.

It was therefore in this context that the valuing process conducted in the scenarios and scenarios developed in the frame of this research, was based on the ILA approach, where there is a clear distinction between what's the stable resource layer of characterization is and what are the conjunctural layers (present land use and management scenarios).

Therefore, similar criteria where used to evaluate both layers when considering, for example the plant cover (e.g. structural and floristic diversity, rarity of the formation, naturalness of the formation, resilience), the soil resources (soil agricultural aptitude and risk factors), geology and dynamic processes (runoff, erosion, etc.). This allows the development of the same evaluation procedures to different management scenarios and their comparison in relation to the resources layer (the ERU).

One last remark concerning the valuation process is, let's remember it one more time, the development of methods and instruments for a systematic conservation planning and ecosystem based management in a context of efficient governance. Therefore, the attribution of values has always taken into account this combination of targets, implying that every scenario or evaluation procedure must be soundly explained in terms of the valuing criteria and evaluation perspective applied in that particular case.

Also of particular importance, as the examples of Fig. 5.29 through 5.33 clearly show is the need to ensure that the process of definition of the valuation criteria be as integrated as possible.

This integration is a *sine qua non* condition for governance, in the sense that it is precisely at this level of attribution of value that the different actors and stakeholders must participate actively. In the context of an island where the value attributed to an object can derive from familiar or social factors established centuries ago and strongly preserved by the isolation (or "insularity" assuming a character that outside that context is difficult to understand, this effective involvement is or primary importance.

From the knowledge and consideration of these values and their integration in the different evaluation and simulation models depends strongly the success of any systematic conservation planning aiming at an ecosystem based management integrated in the sustainable development of the island and their inhabitants.

As illustration of the way this process can be conducted, four scenarios where tested (chap. 5.5) corresponding to following value factors (Tab 5.7).

Tab. 5.7 - Scenarios considered in the modellation and evaluation processes

Scenario	Value factors
1 - Evaluation of present land use conservation value	Maximization of natural formations conservation value and of the costs associated with economic activities
2 - Giving absolute priority to conservation	Maximization of potential natural formations value and consideration of restoration cost
3 - Identifying management strategies: investment in restoration, preserving areas of economical significance	Maximization of potential natural formations conservation value and preservation of the economic value of the main economic activities
4 - Identifying management strategies: : investment in restoration, preserving areas of economical significance considering the different soil aptitudes and the need to safeguard given habitats	Maximization of potential natural formations conservation value and preservation of the economic value of the main economic activities introducing a factor of correction of the economic value associated with soil quality and promoting the conservation value of areas associated with wetlands

5.5 - Evaluation of conservation values and management strategies

5.5.1 - Application framework

In this study, in a way to implement systematic conservation planning techniques, two important pieces of software were used: **CLUZ** (Conservation Land-Use Zoning software) and **Marxan**.

CLUZ (Smith, 2004) and Marxan (Ball *et al.,* 2009) are two pieces of software that have been developed to allow this type of planning to be carried out by conservation practitioners and researchers. They work by dividing the planning region into a series of planning units, listing the distribution of the conservation features found in the study planning, setting targets for the amount of each feature to be included in the conservation landscape and using computer software to identify the portfolio of units that best meet these targets (Smith, 2008).

Marxan is an instrument of decision support software used for conservation planning. Nowadays it is the most widely used software for supporting the design and implementation of marine and terrestrial reserve systems. It identifies areas that efficiently conserve an adequate amount of a variety of conservation features at a minimal cost.

It was initially designed to solve a particular classes of reserve design problems known as the minimum set problem, where the goal was to achieve some minimum representation of biodiversity features for the smallest possible cost (Possingham *el al*., 2010).

CLUZ is an ArcView GIS interface that allows users to design protected area networks and conservation landscapes. In addition to other capabilities, acts as a link for the Marxan conservation planning software, and it was in that sense that it was used is this project.

The process at the heart of the Marxan software is the simulated annealing, which is a generic probabilistic metaheuristic for the global optimization problem of locating a good approximation to the global optimum of a given function in a large search space. The method name reflects the analogy with the physical process of heating a material and then slowly lowering the temperature to decrease defects, thus minimizing the system energy. (Fig. 5.34).

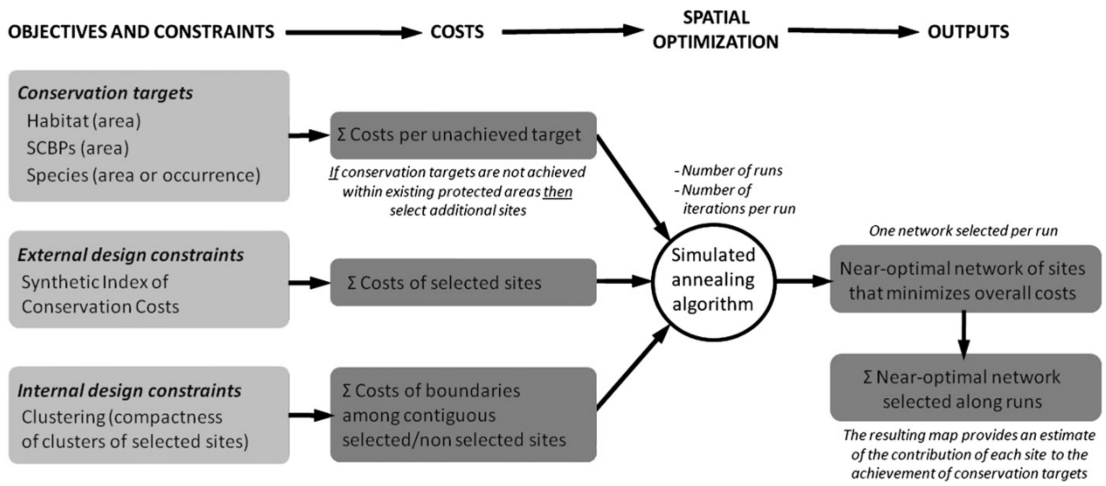


Fig. 5.34 - The spatial optimization process embedded in MARXAN selects an optimal network of conservation sites that achieves conservation targets while minimizing a set of costs. External design constraints are calculated for each planning unit (costly planning units are to be avoided) (extracted from Lagrabrielle *et al.*, 2010)

The implementation of the process consists in finding the combinations of areas or planning units best suited for the goals in question, in other words, with the lowest costs.

For this study, planning units consist of a regular mesh of hexagons, making it easier to combine several types of cost values and better for identifying patches of planning units. The hexagons have an area of 5 ha, which is a spatial resolution that adapts well with the conservation features and cost data used.

The portfolio cost combines three different costs:

- Combined planning unit cost – It´s assigned to each planning unit a cost value, based on its area, financial value, the opportunity cost of it being protected (e.g. lost income from farming) or any other relevant factor. Marxan calculates the combined cost of all the planning units in the portfolio.
- Boundary cost - Measures the amount of edge that the planning units in a portfolio share with unprotected units. Thus, a portfolio containing one connected patch of units will have a lower boundary cost than a number of scattered, unconnected units. The length of edge is multiplied by the Boundary Length

Modifier (BLM) constant, which is a user-defined number. Increasing the BLM increases the cost of having a fragmented portfolio.

- Species penalty factor (or target penalty cost) – It is calculated whether the target for each conservation feature is met by a portfolio and includes a cost for any target that has not been met.

5.5.2 - Results for conservation programs

Evaluation of present land use conservation value

A first scenario using Marxan was conducted considering the following costs and targets (Tab. 5.8).

The definition of cost corresponded to the societal cost of changing that land use (in a scale from 1 to 10 land uses of important economic significance where highly valued - it was considered that natural formations of *Erica azorica* or *Myrica faya* are not considered generally as relevant by the society of Pico), while the target corresponded to the interest for Nature Conservation (the more near to natural the formation the higher the score).

This scenario didn't introduce any correction factors associated with soil aptitude or inaptitude and with "naturalness" of the *Erica azorica* communities in order to simulate a typical scenario of identification of areas to protect as the Marxan framework is normally used.

Tab. 5.8 - Values for Cost and Target for the present land uses

Land use	Cost	Target
Acacia melanoxylon	1	-1
Área edificada	10	0
Cryptomeria japonica	7	1
Erica azorica	4	10
Eucalyptus globulus	7	1
Myrica faia	4	10
Outra vegetação herbácea - arbustiva	3	8
Outros cultivos	8	5
Pastagens	10	6
Pinus sp.	7	3
Pittosporum undulatum	1	-1
Planos de água	5	9
Solo nu	2	2
Solo rochoso	1	4
Turfeiras	7	10
Vias de comunicação	10	0
Vinha	9	8

The results are depicted on Fig. 5.35 where the limits of the Natural Park are also represented and it is possible to verify that the Natural Park incorporates the most important areas with the exception of the large area of "Faial Forest" in the eastern extreme of the island (it only partially incorporated and some areas to the south of the Pico Mountain).

This results that can be subject to adjustments by changing some of the values for Cost or for Target is, nevertheless a good way to assess the quality of the Marxan framework for targeting areas of interest for conservation as can be.

Nevertheless when considering the result from a management perspective it does not give any indication on the interest of restoring areas with potential conservation interest (like the areas invaded with *Pittosporum undulatum* that can be recovered to the natural "Faial forest" if the alien species is eradicated) - we can observe important areas with an high density of *Myrica faya* in the invaded area pointing to a more or less easy recolonization if the invader is remove or its density lowered (Costa *et al*., 2012).

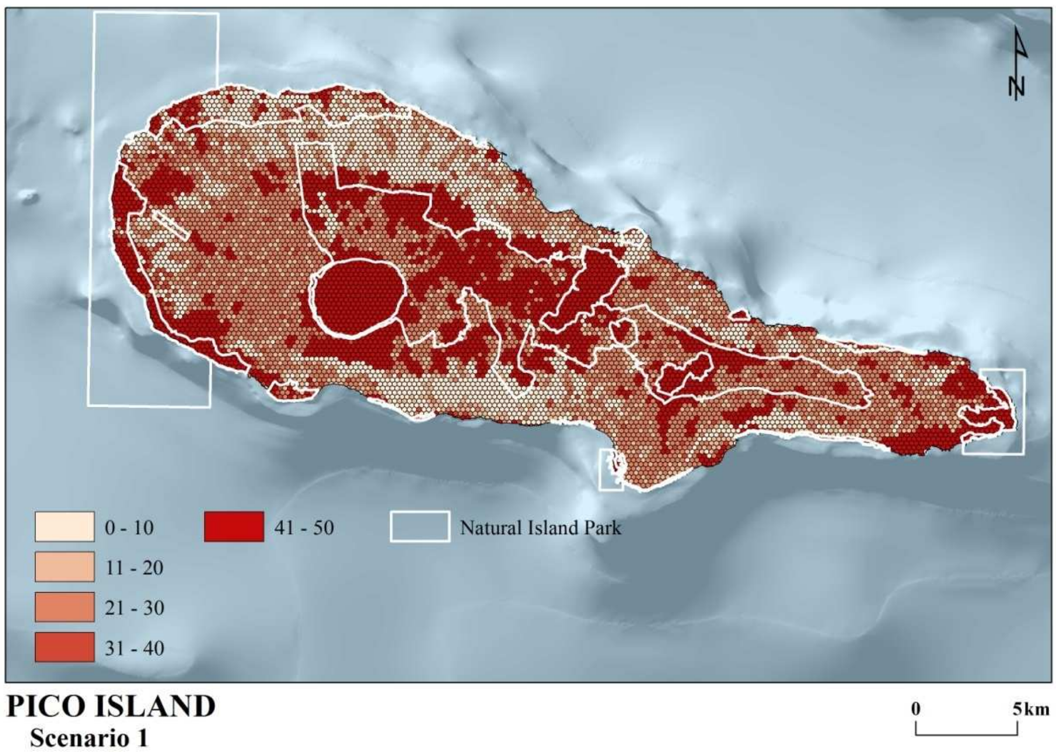


Fig. 5.35 - Results of Marxan 1st scenario considering the present land uses and values and the societal cost of changing land uses . The numbers (1 to 50) represent the number of times that the planning unit was selected to be part of the optimized portfolio, considering 50 runs of the software.

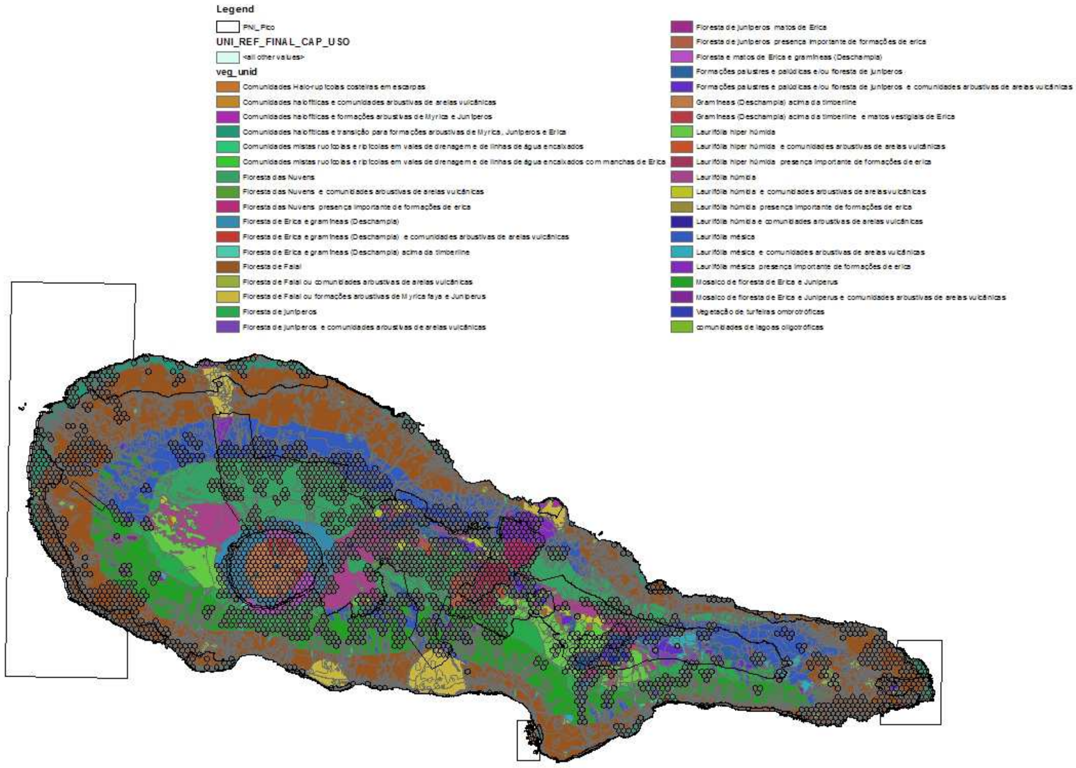


Fig. 5.36 - Priority areas of the first Marxan scenario and natural vegetation potential distribution (derived from Dias (2001) and Dias *et al*. (2005))

When considering the other different potential vegetation formations (Fig. 5.36) we can observe that many of them are not included in the protected area even when it is enlarged to the most valuable areas resulting from the simulation scenario. This is due to the fact that on one side the land use map has a legend that does not identify natural formation and even identifies as naked soil important areas of grassland and bushes on the Pico mountain. On the other side, basing this scenario only in the present vegetation does not allow it to consider the diversity of potential formations and the possible target areas for conservation planning and management.

5.5.3 - Using Marxan to compare management scenarios

Giving absolute priority to conservation

In order to analyze what would be the results of the model when full priority was attributed to ecological restoration and preservation independently from the economical value of the land, a second scenario was performed where the cost and target functions where now calculated on the basis of the natural vegetation potential distribution attributing to each vegetation community a conservation and a protection value (based on criteria like rarity, diversity, naturalness, unique character, resilience, threat (adapted from Marks *et al*., 1989 and Fernandes *et al*., 2006) where qualitatively established and whose combination produced a value for Cost considered as the integration of both interest (protection value) and threat (economical value of the present land use ("Cost" from the first scenario)). As Target the conservation value was chosen as corresponding to the aim of a recovery project (Tab 5.8).

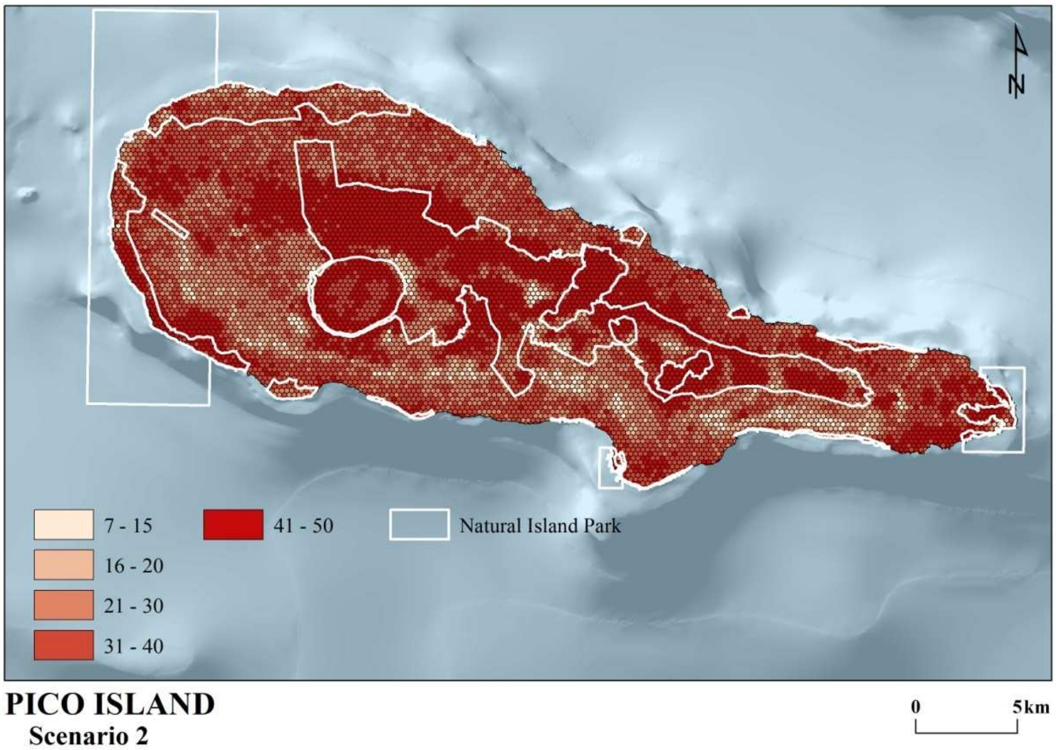


Fig. 5.37 - Scenario 2 - priority to ecological restoration and conservation

It must be stressed that this scenario is completely opposed to the consideration of the societal values and considers only the importance of restoring the natural habitats of the island.

The result is depicted in Fig. 5.37, where it is possible to see that when the land use constraint is not taken into account, the only differences in terms of management priorities is the result of the qualification of the conservation and threat value. Like any expert classification it is strongly subject to error and bias, but, nevertheless, it cannot be considered as a management alternative because it excludes the human presence, what is totally unacceptable for the purpose of developing a conservation and management program able to involve all stakeholders.

Tab. - 5.8 - Values used in the calculation of the nature conservation cost (2nd scenario)

Vegetation units	Valor ameaça	Valor conservação	Valor protecção	Cost CN
comunidades de lagoas oligotróficas	8	7	8	4
Comunidades Halo-rupícolas costeiras em escarpas	6	7	7	5
Comunidades halofíticas e comunidades arbustivas de areias vulcânicas	8	5	6	11
Comunidades halofíticas e formações arbustivas de Myrica e Juníperos	8	6	7	12
Comunidades e transição para formações arbustivas de Myrica, Juníperos e Erica	8	6	7	12
Comunidades mistas rupícolas e ripícolas em vales de drenagem e de linhas de água encaixados	7	6	6	11
Comunidades mistas rupícolas e ripícolas em vales de drenagem e de linhas de água encaixados com manchas de Erica	7	6	6	2
Floresta das Nuvens	8	9	8	13
Floresta das Nuvens e comunidades arbustivas de areias vulcânicas	7	9	8	13
Floresta das Nuvens e presença importante de formações de erica	6	9	8	13
Floresta de Erica e gramíneas (Deschampia)	8	7	7	9
Floresta de Erica e gramíneas (Deschampia) e comunidades arbustivas de areias vulcânicas	8	7	7	9
Floresta de Erica e gramíneas (Deschampia) acima da timberline	9	7	8	6
Floresta de Faial	7	7	7	12
Floresta de Faial ou comunidades arbustivas de areias vulcânicas	8	7	7	12
Floresta de Faial ou formações arbustivas de Myrica faya e Juníperos	7	7	7	12
Floresta de juníperos	6	6	6	11
Floresta de juníperos e comunidades arbustivas de areias vulcânicas	7	6	6	8
Floresta de juníperos e matos de Erica	6	7	6	4
Floresta de juníperos e presença importante de formações de erica	6	7	6	9
Floresta e matos de Erica e gramíneas (Deschampia)	9	9	9	11
Formações palustres e palúdicas e/ou floresta de juníperos	9	10	10	15
Formações palustres e palúdicas e/ou floresta de juníperos e comunidades arbustivas de areias vulcânicas	9	10	10	15
Gramíneas (Deschampia) acima da timberline	9	8	8	4
Gramíneas (Deschampia) acima da timberline e matos vestigiais de Erica	9	8	8	4

Laurifólia hiper húmida	6	7	7	12
Laurifólia hiper húmida e comunidades arbustivas de areias vulcânicas	7	7	7	12
Laurifólia hiper húmida presença importante de formações de erica	6	8	7	10
Laurifólia húmida	6	7	7	12
Laurifólia húmida e comunidades arbustivas de areias vulcânicas	7	7	7	12
Laurifólia húmida presença importante de formações de erica	6	8	7	9
Laurifólia húmida e comunidades arbustivas de areias vulcânicas	7	7	7	9
Laurifólia mésica	6	7	7	12
Laurifólia mésica e comunidades arbustivas de areias vulcânicas	7	7	7	12
Laurifólia mésica presença importante de formações de erica	6	8	7	12
Mosaico de floresta de Erica e Juníperos	5	5	5	10
Mosaico de floresta de Erica e Juníperos e comunidades arbustivas de areias vulcânicas	6	5	6	11
Vegetação de turfeiras ombrotróficas	9	10	10	5

Identifying management strategies: investment in restoration, preserving areas of economical significance

In order to be able to developed a conservation strategy integrating societal factors, two new scenarios where carried out aimed at identifying target management areas that correspond to areas where the management effort in order to recover the natural vegetation and ecosystems with as less an impact on the key land uses as possible, should be conducted.

The first scenario was conducted considering that the cost corresponded to the conceptual distance between the present vegetation and ecological conditions, and the conditions susceptible of occurring when that area suffered no disturbances. This cost tries to express the effort needed to achieve the restoration of that vegetation and ecosystems.

As target it was considered two different types of areas: for those areas with low economic value (Cost from the first scenario equal or lower than 5) the target was defined as being the difference between the Protection value of the ERU and the conservation value of that particular use. For the land uses with a high social value (Cost of the first scenario higher than 5) the target considered was the conservation value calculated for that use.

The result (Fig. 5.38) illustrates a clear differentiation between two types of areas: those clearly targeted as management areas and those where the present land use is considered as having priority over the restoration of the natural vegetation.

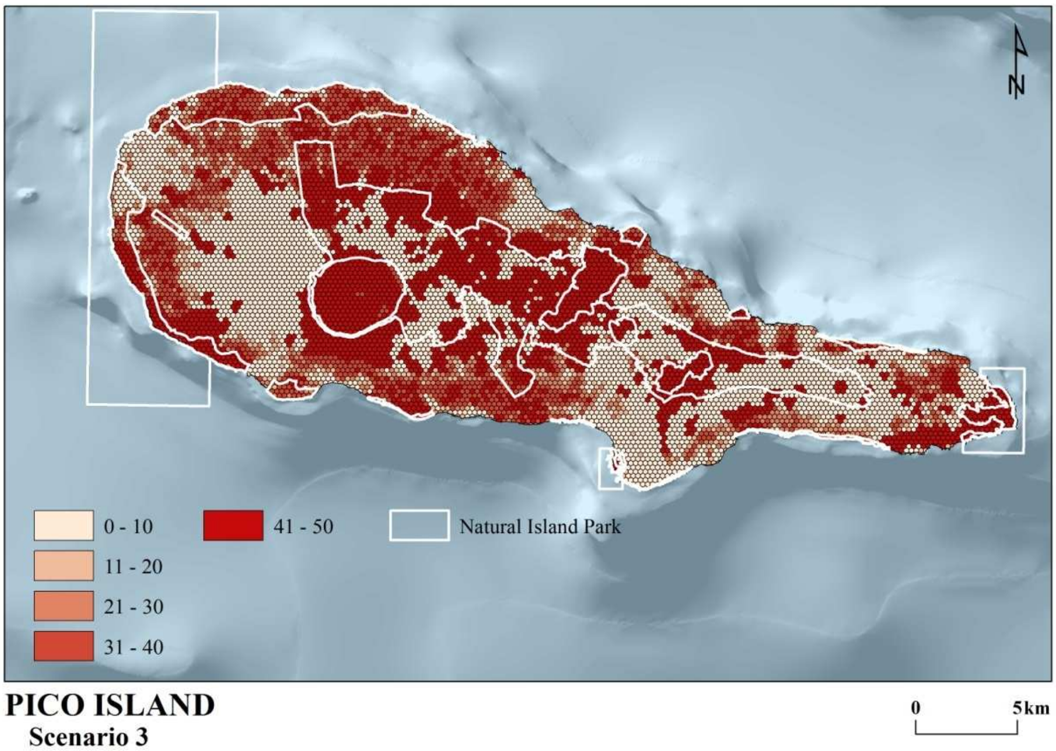


Fig. 5.38 - Results of the scenario aimed at the identification of target management areas (including areas of high conservation value and areas strongly degraded (mainly due to invasive species)

Analyzing these results it is clear the relevance of the protection of agricultural areas and the maintenance of the already identified existing values (similar results to the 1st scenario), but it also points to the importance of managing (recover) the areas presently occupied by invasive species and forestation with alien species (Fig. 5.39).

This scenario points, therefore for two types of Target Management Areas: Areas already with high conservation value and areas with a land cover of no or with negative ecological value, aiming at the restoration on those areas of the corresponding natural vegetation.

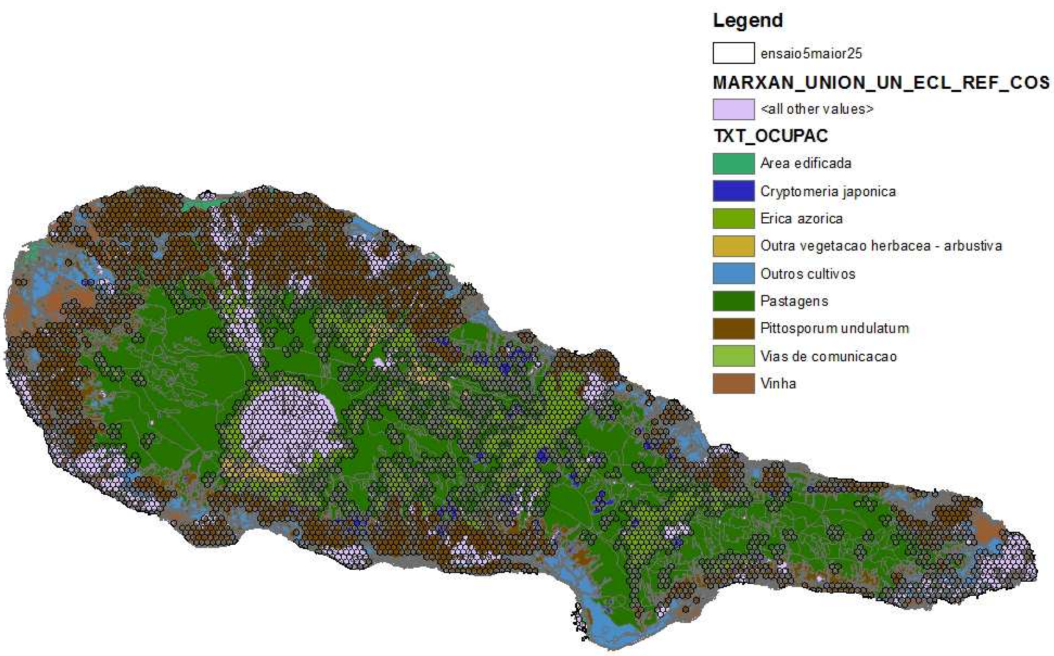


Fig. 5.39 - Illustration of the areas with higher score in the scenario (>25/50) showing how the pasture and other agricultural areas are not included in the target management areas.

Nevertheless, the fact that the target for the areas with predominant economic value was maintained high, implied that very important habitats (particularly the habitats associated with wetlands) are not included in the target management areas (Fig. 5.40).

In terms of building a management plan this is not necessarily negative, because those areas are already identified as target areas and because they demand a particular type of management that, although not incompatible with grazing and pastures, implies particular attention to the prevention of the eutrophication of the sink areas, eventually compromising the potential vegetation communities.

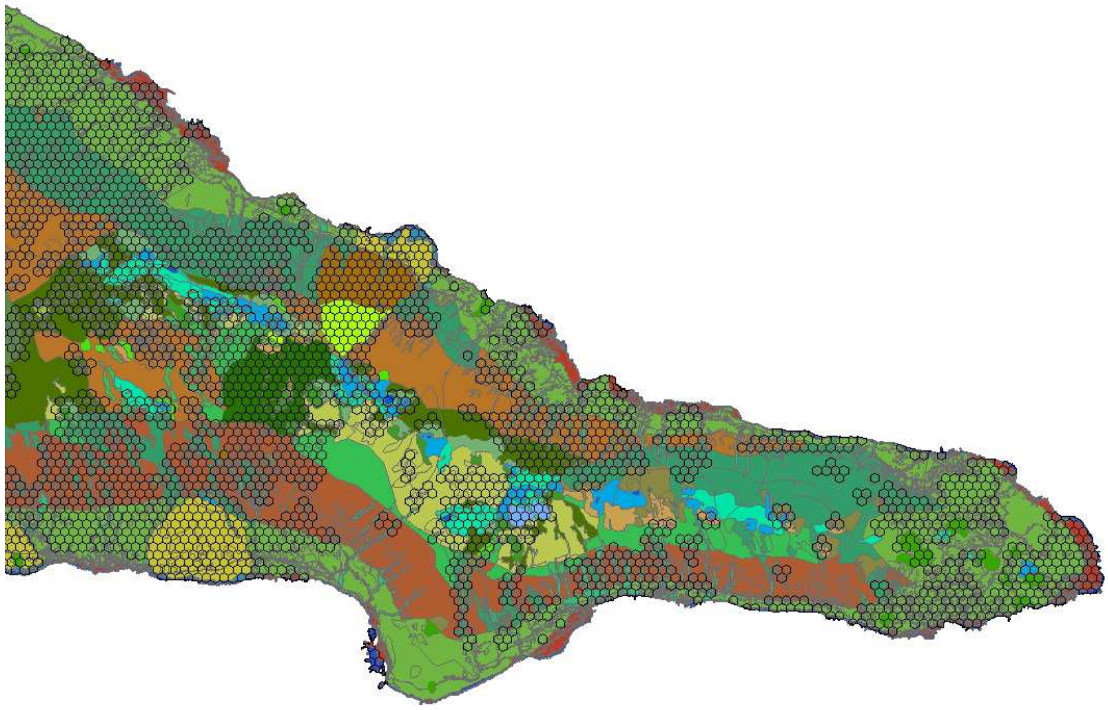


Fig. 5.40 - Illustration of the areas with higher score in the scenario showing that the criteria used in the scenario excludes as priority most of the areas associated with wetlands (blue areas), because they are mainly used as pastures.

Identifying management strategies: investment in restoration, preserving areas of economical significance considering the different soil aptitudes and the need to safeguard given habitats

A second scenario was carried out integrating, this time, a correction of the societal cost trough the consideration of the soil aptitude (productivity - soil quality map). This was achieved considering that the agricultural areas (pasture, vineyards and other cultures) presented an higher Cost if they occupied soils of high quality and reduced if they occupied soils of low quality (with the exception of the vineyards due to their particularity (cultural landscape of intense work creating the conditions for vine growth in low quality soils (World Heritage of the Pico Vineyards). The cost for the target habitats corresponded to their Protection Value, while as target the Conservation Value was still the selected criteria.

The results are presented in Fig. 5.41 where one can observe that the main targets resulting from the scenario correspond to the recovery of the Laurisilva forest and the protection of the wet areas. Again, as already stress in chapt. 5.4 the valuation of the different types of potential natural vegetation is subjective and can if altered lead to somewhat different results (for ex. we can clearly observe that the lower value attributed to the Forest (shrubland?) mosaic of *Erica azorica* and *Juniperus brevifolia* compared with the high value for Laurissilva clearly determined the higher importance attributed to the northern side of the Mountain and the Achada Plateau.

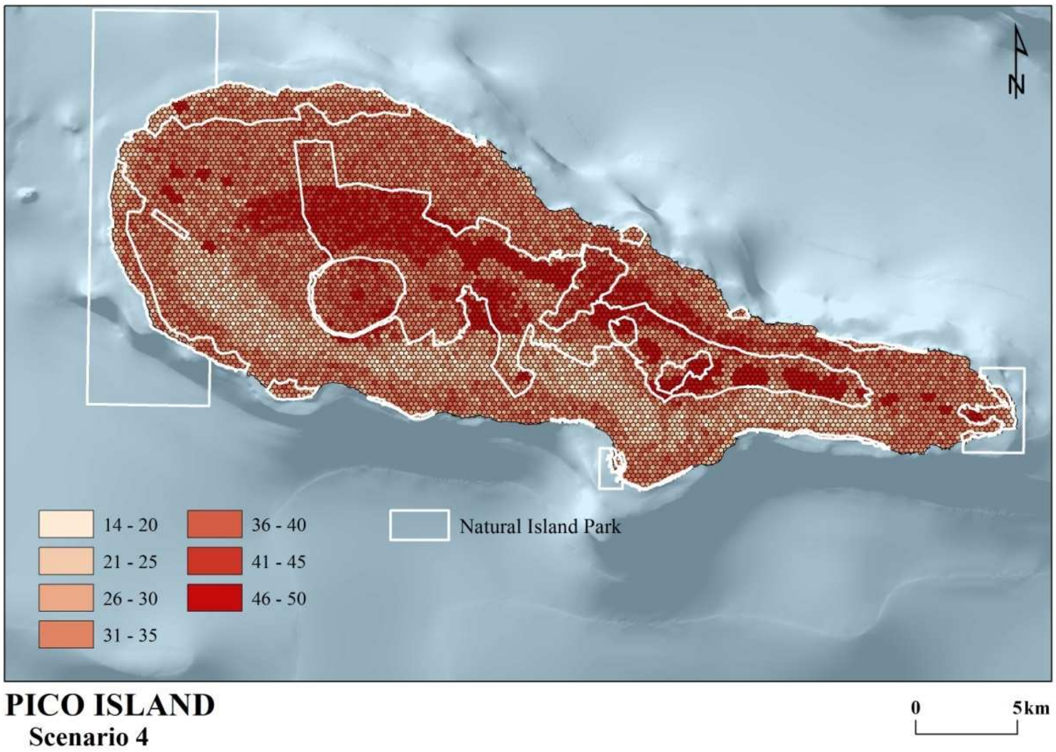


Fig. 41 - Scenario 4 - correction of the societal cost according to soil quality

Combining the two scenarios we obtain different Target Management Areas (Fig. 5.42) with following characteristics and management targets:

- Scenario 3 - protection of the Pico mountain the existing formations of *Myrica faya* and *Erica azorica*.
- Scenario 4 - protection/recovery of the cloud forest and the different wet lands (expanded to all drenched areas.
- Maximum priority for scenarios 3 and 4 combined - Wetlands and protection/recovery of Erica azorica forest formations located in the slope deposits of the Pico mountain.
- As a complementary proprietary management area we must consider the recovery of the areas infested by *Pittosporum undulatum*.
- The coastal escarpments are also included due to their particular character and sensitivity.

These examples illustrate the way this approach can define management targets and areas for the ensemble of the island based on the integrated landscape characterization system and using existing and tested methods for the evaluation of areas with more priority for conservation management (like the Marxan approach).

These results can be still developed, complementing the Target Management Areas with habitats occupying small patches (Fig. 5.43) where particular values (not only floristical) can occur and demand, therefore a targeted management approach. These patches are associated with small volcanic formation, wet areas, springs, lakes, deposits and particular geological characteristics.

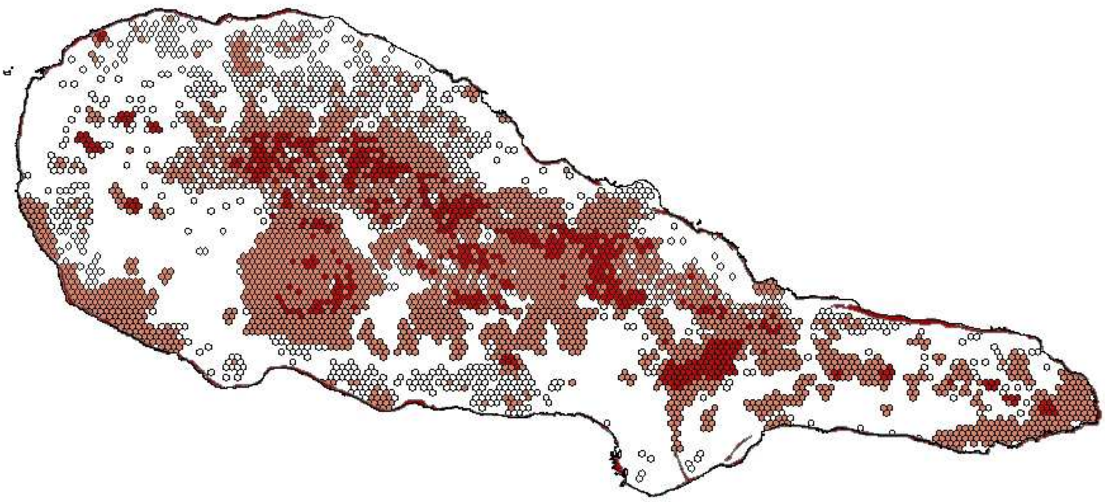


Fig 5.41 - Combined Target management areas resulting from scenarios 3 and 4 (pink - present in only one scenario, red - present in the two scenarios)

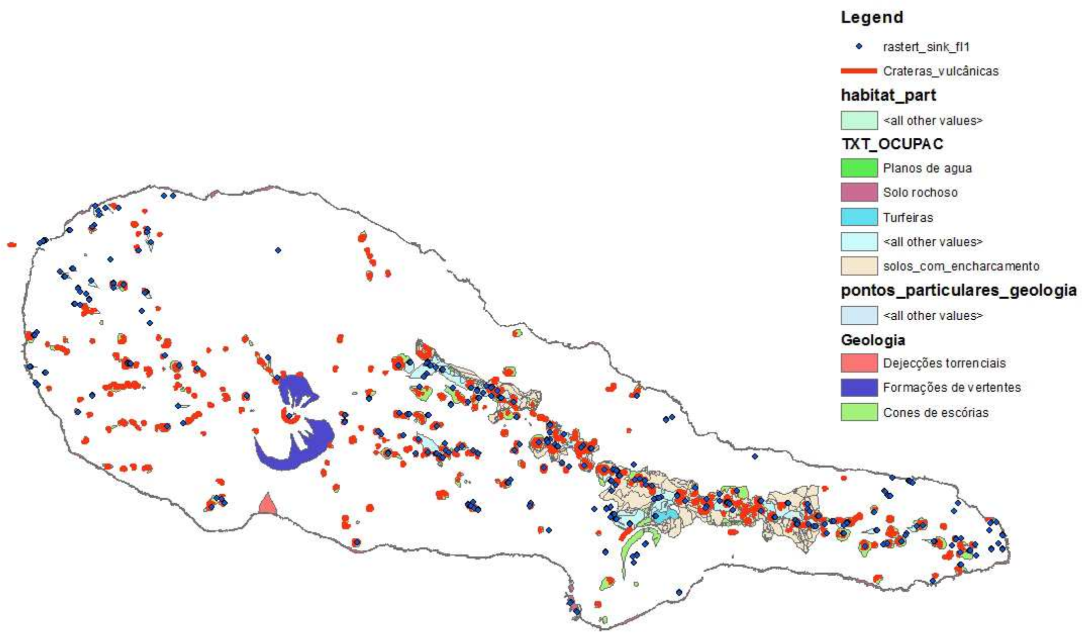


Fig. 5.43 - Particular areas in Pico Island corresponding to potential small resource habitats of high conservation value

Also important to consider are areas of particular morphology like escarpments or areas of high slope where also particular characteristics can occur and that, simultaneously have a very high sensitivity to disturbance (Fig. 5.44).

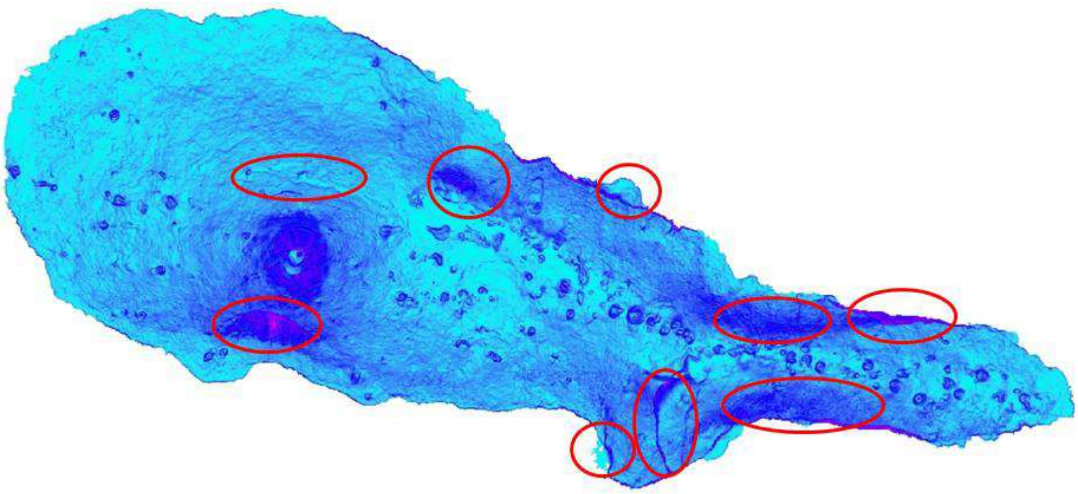


Fig. 5.44 - Examples of areas whose morphology can point to the need of special management approaches

5.6 - Final remarks

The use of the ILA framework by allowing the possibility of comparison between the present situation values and constraints with a reference situation corresponding to the existing stable natural resources, illustrates clearly the management challenges faced in Pico or any other small island.

The scarcity of resources (economical and biogenetical) imposes that the attribution of values to enable comparative evaluations and decision making within a sound ecosystem based management aimed at a systematic conservation in the frame of an efficient and functional territorial governance illustrate the need for methodological approaches able to display and evaluate management scenarios in order to fulfill the conditions that Davoudi *et al*. (2008, pp. 37-38) considers necessary "to describe, analyze and evaluate territorial governance actions we can consider 3 types of factors (Fig. 5.45):

1. Context: to describe the general structural conditions, features and dynamics of the territory. Describing the favorable territorial preconditions for defining and implementing territorial governance actions (institutional thickness, innovative milieu, territorial capital, etc.);
2. Policies: to describe the institutional frameworks of territorial policies, instruments and procedures for governance (i.e. the “governing” of governance);

3. Territorial governance actions, defined as the experiences, projects, programmes, etc., that need or stimulate a territorial governance approach: to evaluate governance processes and results, at different levels, considering both process criteria and results criteria, and their interaction (does a good process always correspond to a good result?).

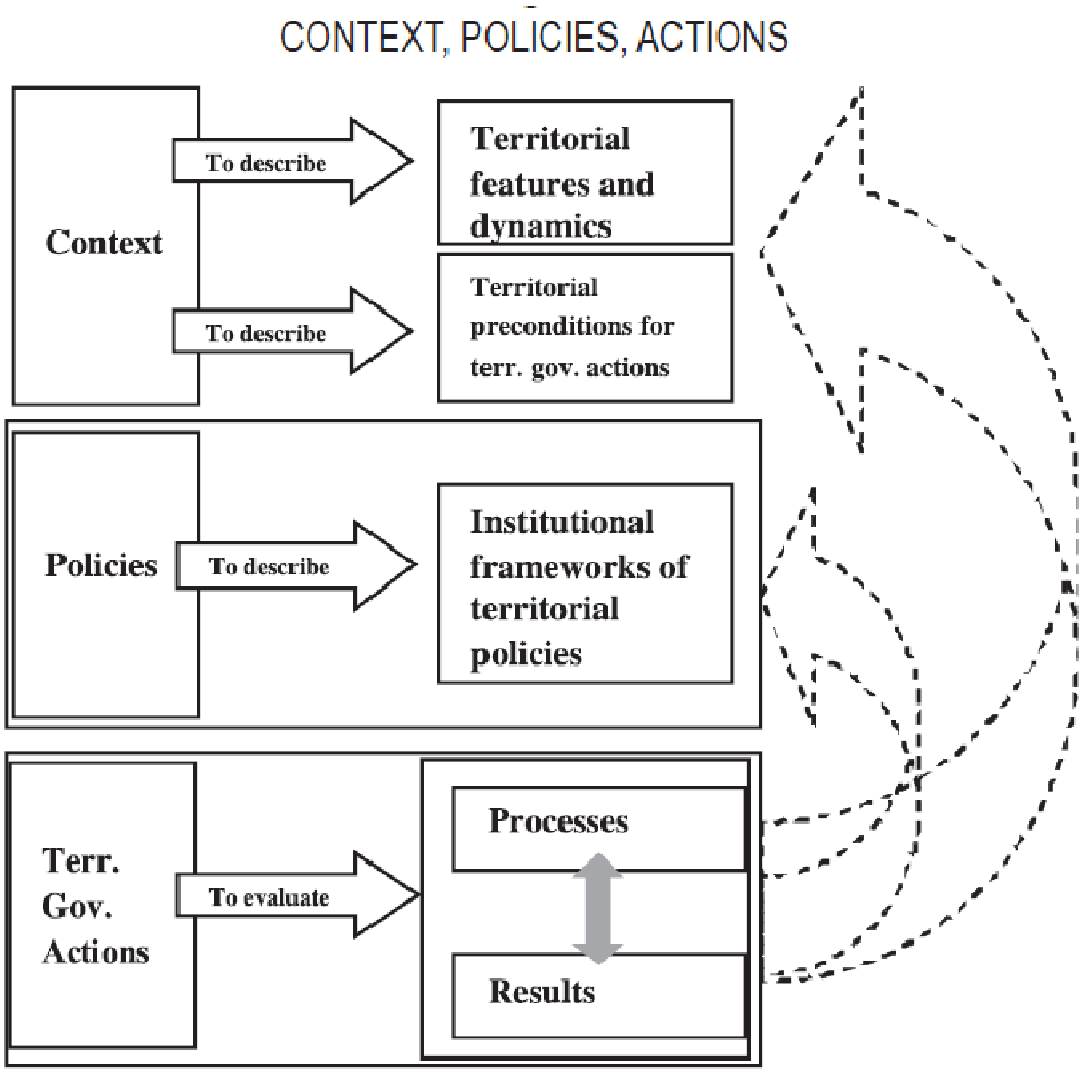


Fig. 5.45 - Information in the context of territorial governance (Davoudi *et al*. 2008, pp. 38)

Obviously, the presented approach is not the only system of characterization and diagnosis (there were no economical, social and cultural data incorporated and considered in the presented methodology with the exception of land use). Nevertheless, the present methodological framework proved to be a powerful consolidated tool in the evaluation of strengths, weaknesses, opportunities and treats of the biophysical systems and the land use systems in regard to the natural resources and constraints, and mainly in depicting and justifying those values. These last characteristic is critical for the full involvement of all stakeholders in the governance process.

6 - The evolution of the island park concept in the context of the systematic conservation approach - from the island to the archipelago

One of the main conclusions of the previous discussion is the impossibility to perform a systematic conservation planning and an ecosystem based management only in partial areas of a region and particularly in an island. Also of primary importance is the limitation associated with the lack of integration of the different administrations leading to conflicting targets and promoting stakeholder conflicts when the main priority must be the mobilization and active integration of all stakeholders in the planning and management process.

Therefore, the concept of Island Park that is, without question, one huge conceptual and innovative step in the domain of protected areas must evolve in the sense of integrating itself in the global planning and management of the entire island and assuming a stronger management perspective as it is presented in the legal documents that have created them.

Effectively when analyzing this decrees one is unable to know what are the exact values whose protection is aimed with that protection regimen, what protection targets there are, how is it possible for the present land users to pursue their activity within the conservation and protection objectives, all this because the decrees that create the Park are a long list of interdiction without any objectives and without any complementary information on the why, the how and the what for.

This approach is clearly extremely negative and goes against all the rules for an active involvement of every stakeholder in an effective planning and management policy within the broad concept of governance.

Therefore, the present situation must evolve on several domains:

1. Clear identification of the values, dangers, disturbance thresholds, promoting and damaging factors.
2. Clarification of the global objectives for the island (namely recovery of the areas invaded by alien species that can evolve to areas of high conservation value) and integration of all planning and management processes in an integrated multifunctional, multi-thematic and multi-scale process, integrating all active and passive actors. This clarification allows a better targeting of the investments by differentiating the areas of high value but little need of intervention and areas of low value but with high potential within reasonable investment costs.
3. Articulation between all land users in order to turn them into active managers and not repressed angry non-managers due to the diversified, and for them unjustified or at least, incomprehensible, interdictions.
4. Development of an Integrated Island System Management (Wong *et al.*, 2005) corresponding to a "*multidisciplinary, integrated mechanism, offers an adaptive management strategy that both addresses the issue of resource-use conflict and provides the necessary policy orientation to control the impacts of human intervention on the physical environment of islands.(...) However, its effectiveness depends on an*

institutional and legal framework that coordinates the initiatives of all sectors, both public and private, to ensure the achievement of common goals through a unified approach. The long-term development objectives of islands also need to be considered. Despite physical and natural resource limitations, important consideration will need to be given to integrated planning, social cohesion, increased attention to managing biodiversity (in particular, invasive species), and a strengthening of territorial planning if islands are to become economically, socially, and ecologically resilient and self-sufficient." (pp 678) that, although exemplified for islands states can be perfectly extended to autonomous regions like the case of Azores, Madeira or Canary archipelagos.

5. Promotion of multifunctional economic instruments searching to develop an adequate retribution for the different kinds of services each land user provides or profits from.

It is therefore in this context and given the fact that archipelagos have a certain degree of ecological connectivity and complementarity that this integrated approach must be extended also to the global archipelago or sub archipelagos, in order to maximize at each moment the viable populations and reduce the risks associated with local disturbances.

The leading management idea must be maximizing the efficiency of the conservation efforts through the maximization of the involvement of all stakeholders and the promotion of the secondary benefits for conservation of a more sound and accepted multifunctional management. In this way it is possible to reduce cost because many of them will be integrated in the normal management costs of each land user, conscientious of the insurance of the remuneration of the NCOs resulting from its effort.

This implies trust and accountability but mainly the coming together of all involved and the conscience that everyone and every perspective is not only important or acceptable, is indispensable because it builds at least one facet from the multidimensional reality that is the island.

7 - Discussion

7.1 - *The Regional Landscape Plan (PROTA*)

The territorial model (Fig. 7.1) defines the central axe of the island as a protection system justified by the presence of extensive nuclear areas for nature conservation, partially surrounded by complementary protection areas with a similar area. This equivalence between nuclear and complementary conservation areas is a distinctive characteristic of the island resulting from its particular orography. Although the tree urban concentrations show a significant polarizing capacity, the distribution of the population follows a linear pattern along the road that circles the island where many houses for secondary housing can be found. This development pattern must be controlled not only because along this road the coastal areas with a high environmental and cultural value with particular protection status like those that integrate the Pico Wine landscape Protection Area can also be found but also because the construction of adequate infrastructure like wastewater collection and treatment are very costly. It must also be taken into account that a road that as simultaneously street road and field road character is unacceptable..

The proposed territorial model emphasizes the connections between the tree main urban centers that build the island urban structure, recognizing that, due to the island dimension longitudinal as well as transversal connections are needed although the they must cross protected areas of high conservation value. It is of the utmost importance to ensure that these protection areas are only crossed and not cut (fragment) by these existing of planned road infrastructures.

From a economical perspective, the island has revealed un interesting dynamic in the agro-industrial and touristic sector that justifies the proposal for the creation of an area for t providing advanced services to the productive activity in Madalena, sole urban center where there is a justification for the enlargement of the area susceptible of being urbanized. This urbanization should be directed towards the interior and follow an orthogonal organization.

This guidelines extracted from the summary of the proposed territorial model (Cruz *et al*., 2008, Vol. 2 pp. 21-22) illustrate the main difficulties in implementing a comprehensive process of integrated conservation planning and management in the sense that territorial and urban planning are defined and determined independently from conservation planning and management and even the consideration of the conservation aspects is only referred to a particular area (the present Park Island without being able to have an integrated approach to every aspects of the multifunctionality of the entire island.

This is precisely the problem that must be addressed in future developments of the planning, management and particularly governance in the global island context. It is exactly in this context that Pereira (2009) considers that "*because the territory is a complex of values and resources, product of the collective appropriation by groups and institutions, it constitutes an interactive system and not a passive support for actors enabling therefore the need to speak of* *territory governance. (...) In this context governance is the ability of the actors public or private to achieve an organizational consensus to define targets and a common vision for that territory and cooperate in its implementation*" (Pereira, 2009, pp. 822)

Pereira (2009, pp. 822) states still that "*The interaction of the actors and the resources can occur at other scale(s), implying the redefinition of the territory of intervention and, eventually, of the solutions. When reading the territory capital, a concept similar to the one of endogenous capital (when applied to the regional and local level), its diversity (geographically determined structuring and intrinsic characteristics), influences the ability to promote and attract investment. Governance is now understood as the territory organization that arises from the multiplicity of relations that characterize the interaction between actors. This vision, built on the acknowledgement and valorization of the territory capital, promotes a sustainable territorial cohesion in a multi-scale perspective in the respect for the subsidiarity principle*."

This perspective reinforces what was stated in chapter 2 about the importance of involvement of all stakeholders according to the multifunctional nature of the landscape and territory and the need to develop forms of ensuring methods of governance based on:

- Contratualization
- Accountability
- Valuation

and consequently,

- Trust

In order to be able to build such a planning and management framework the production, operation and making available information, scenarios, criteria etc. is of critical importance.

Therefore the ability to identify present and potential values (conservation, production, aesthetical, etc.), present those values by itself and in the frame of alternative scenarios, discussing the criteria like value, const, targets, etc. is the main support for a comprehensive planning and management.

Fig.7.1 - Regional landscape plan for Azores - PICO Island territorial model

7.2 - Building a contratualization framework for Pico

Most parts of the factors involving a consistent systematic conservation planning and ecosystem based management in the island of Pico are connected with the agricultural activity (mainly pastures, but also production of forage, other cultivations in small holdings and vineyards), the invasion of vast areas of the island by *Pittosporum undulatum* (and additionally *Acacia melanoxylon*), and on limited regions (for the moment) touristic and urban development (2nd houses).

The main area of "conflict" with the nature conservation targets seems to be the occupation by pastures of many areas that area sensitive (mainly associated with wetlands and mires). This occupation poses a serious problem because of the strong connection existing between the land owners and their parcels, turning processes of land redistribution and the definition of grazing intensity or calendar constraints very difficult. Nevertheless there is an important soil reserve that must be taken into account: the infested areas, although occupying mainly soils of very low quality, occupies also areas that can be turned into pasture land and use, therefore in the compensation process of negotiation with the land owners (Fig. 7.2). The most problematic issues are undoubtedly the areas of pasture on the northern side of the island that correspond to the target management areas previously identified (chapter 5) (Fig. 7.3).

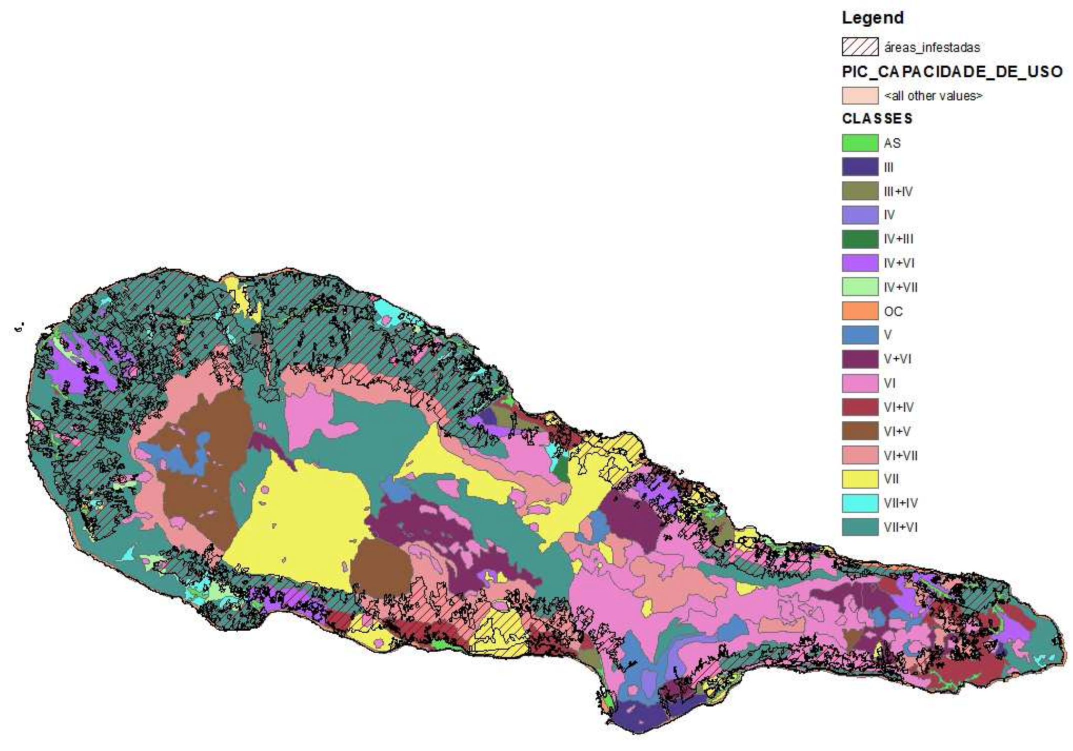


Fig. 7.2 - Infested areas and soil quality

These areas represent more than one third of the total area of pasture and have, therefore to be handled with the utmost care in the process of identifying areas more suited for the recovery of the Cloud forest and safeguarding the areas of higher grazing productivity.

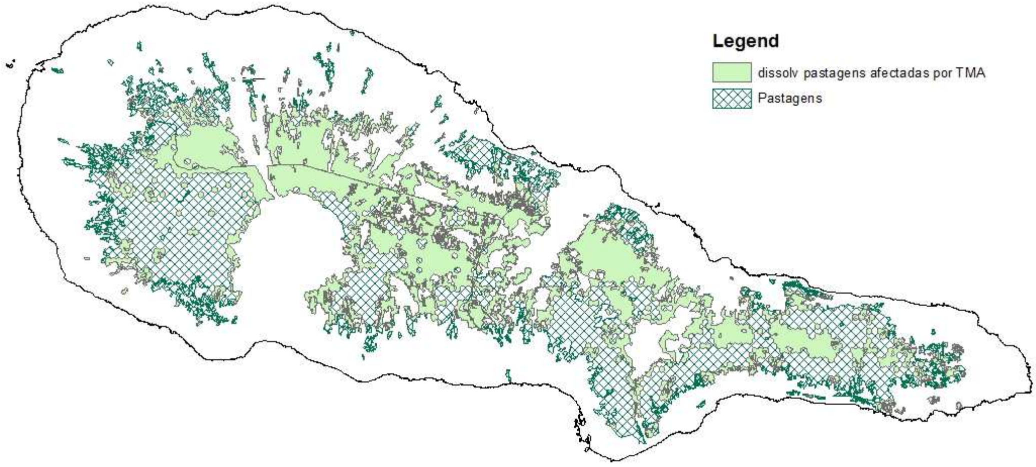


Fig. 7.3 Area of pasture affected by TMAs

This target can be derived from the differentiation of targets resulting from the combination of scenarios 3 and 4 and the location of the different priorities, as well an evaluation of the minimal areas necessary to ensure cohesion and viability to the grazing activities and to the recovered vegetation patches (Fig 7.4).

We can therefore conclude, with these simple scenarios, that although the conflict areas seem to be very important, the compensation of new pasture in good soils presently infested and other compensation measures together with a fine management of the pasture and recovered forest patches can build a strong base for the process of rearranging some land use patterns and promote the recovery of viable patches of natural vegetation.

Additionally to this "bargaining" process it is important to evaluate the added values resulting from the recovery of the Faial Forest trough the eradication of the *Pittosporum undulatum* and the recovery of important patches of cloud forest in terms of touristic attractiveness. This attractiveness can be still reinforced by the possibility of recolonization of these forests by endangered bird species. All these new economic activities and added values must be included in the contractualization process in order to pay each land owner all the values and services he provides, and, in the case of investment, build trust and ensure accountability.

These are examples how the results from the analysis performed in this study can be integrated into decision support tools (Beukering, 2007) and how they can be introduce in more complex valuation processes (eg. Tab. 7.2) allowing a sounder process of integration of all the different stakeholders (as illustrated in Lagabrielle *et al.*, 2010).

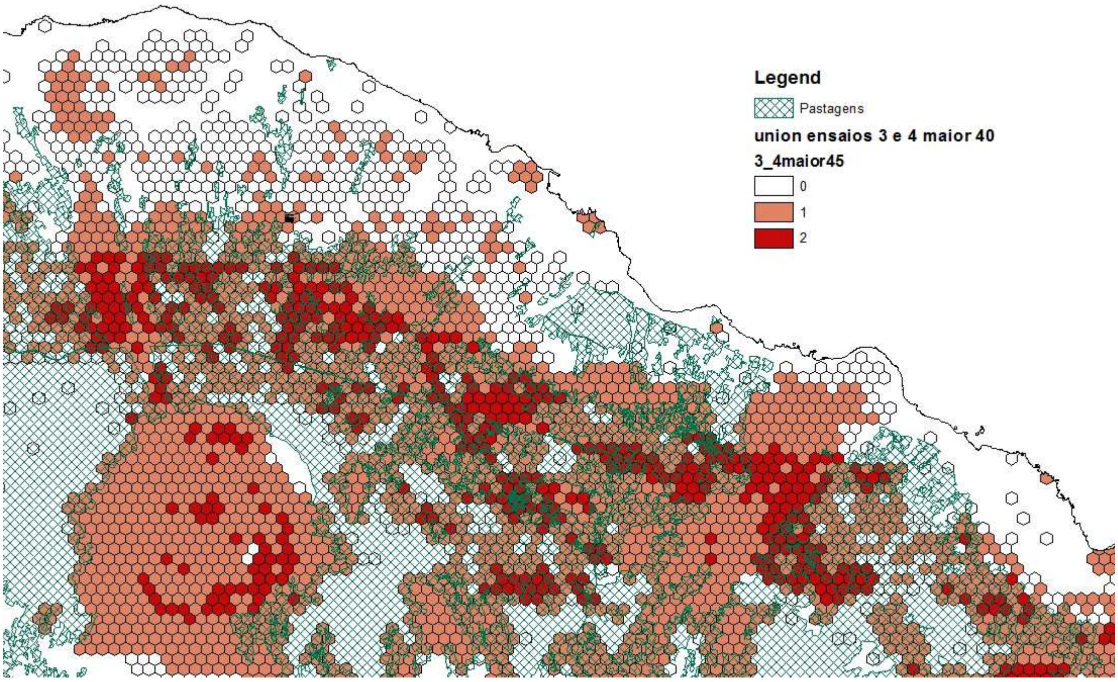


Fig. 7.4 - Areas of pasture and key Target Management Areas in the NE side of the Pico Mountain (pink - present in only one essay, red - present in the two essays)

Tab. 7.2 - Audiences and their interests in the context of evaluation and decision making (adapted from Beukering, 2007)

Audience	Interest in the resource	Use of valuation study
Local residents / primary stakeholders	• Extractive use • Recreational use • Harvesting • Aesthetic use • Derived economic benefit's (e.g. dive industry from mangrove and sea grasses)	• Increase knowledge about the range of ecosystem goods and services provided by the resource • Inform about the range of uses • Detail the direct and indirect costs associated with ecosystem degradation • Detail potential economic benefit's from ecosystem health and sustainable use
Politicians and national policy makers / secondary stakeholders	• Possibly none • Possible lack of awareness of uses and services provided and associated economic benefit's	• Increase awareness of the economic uses of the ecosystem • Describe economic benefit's/costs locally and nationally from ecosystem health or failure • Describe economic benefit's nationally from ecosystem health or degradation
International and local NGOs / external stakeholders	• Conservation • Exploitation • Development	• Provides all parties with same data on which to come to a consensus about the resource. • Explicit valuation

Considering again the development perspective presented in the PROTA, one can conclude that the entire area of the TMA is outside the main domains of conflict identified by the plan.

This situation allows a great degree of freedom to the application to these areas of the innovative territorial governance approaches due to the relative lack of conflicts and of involved stakeholders. The main variable to be handled will be the management of grazing, the "bargaining" of areas presently occupied by invading species and the need to make this "bargaining" without blessing the sense of property and freedom of management of the land owners.

Additionally, it must be taken into account the issue of the micro target habitats, whose characterization is only approximate, and that demand not only a case by case approach, but also innovative methods of conservative management: for example some habitats can be grazed during large periods of the year and it is only necessary to control its intensity or even the access of animal during critical periods, other cases imply a more strict control of grazing, but here again we are talking of small areas that handled individually can be easily integrated in multifunctional solutions.

Outside the identified TMA we find the most critical areas identified in the PROTA: the periphery of the island and the urban pressure that is being felt. This is a classical domain of planning (definition of areas to be urbanized combined with mechanisms of compensation for the transferred construction rights associated with a very detailed analysis (on similar bases as the one presented, but at a much more detailed scale and based on an extensive characterization and location of values and management objects (whatever their nature)), in order to identify the target resources that must be protected or restored, the best areas to allow an urban and touristic development that can profit from those values without endangering them.

Let's consider, for example, the area from Fig. 7.5.

It clearly visible the linear occupation of the coastal road preventing an adequate protection of the landscape values and building an effective barrier to the micro continuity of the island. The general concerns and guidelines from the PROTA are clearly illustrated in the small section, but it is also possible to identify the diversity of microstructures (e.g. land parcels delimitations or water courses), that build the above mentioned micro-continuity network that must be preserved and reinforced (namely when it proves necessary to control invading species associated with these formations. This micro-continuity is important at the level of micro and meso fauna and, in association of flora because of the dispersion ability of some of that fauna.

Also important are particular micro-habitats (namely associated with rock formation that complement the coastal escarpments) that build elements of the micro-complementarily network of same animal species.

These are only examples of ecological functions that must be taken into account. At the same time we have to consider the human landscape (intensely used in this area) where aspects like better management practices to prevent soil erosion or preserve water and nutrients must be evaluated in order to preserve the viability of this rural landscape, not only as a source of direct income, but also as producer of non-commodity-outputs (NCOs) like the image of the landscape, the regulation of water and nutrients runoff, prevention of erosion, but also as source of nourishment for many types of fauna and micro-fauna, etc.

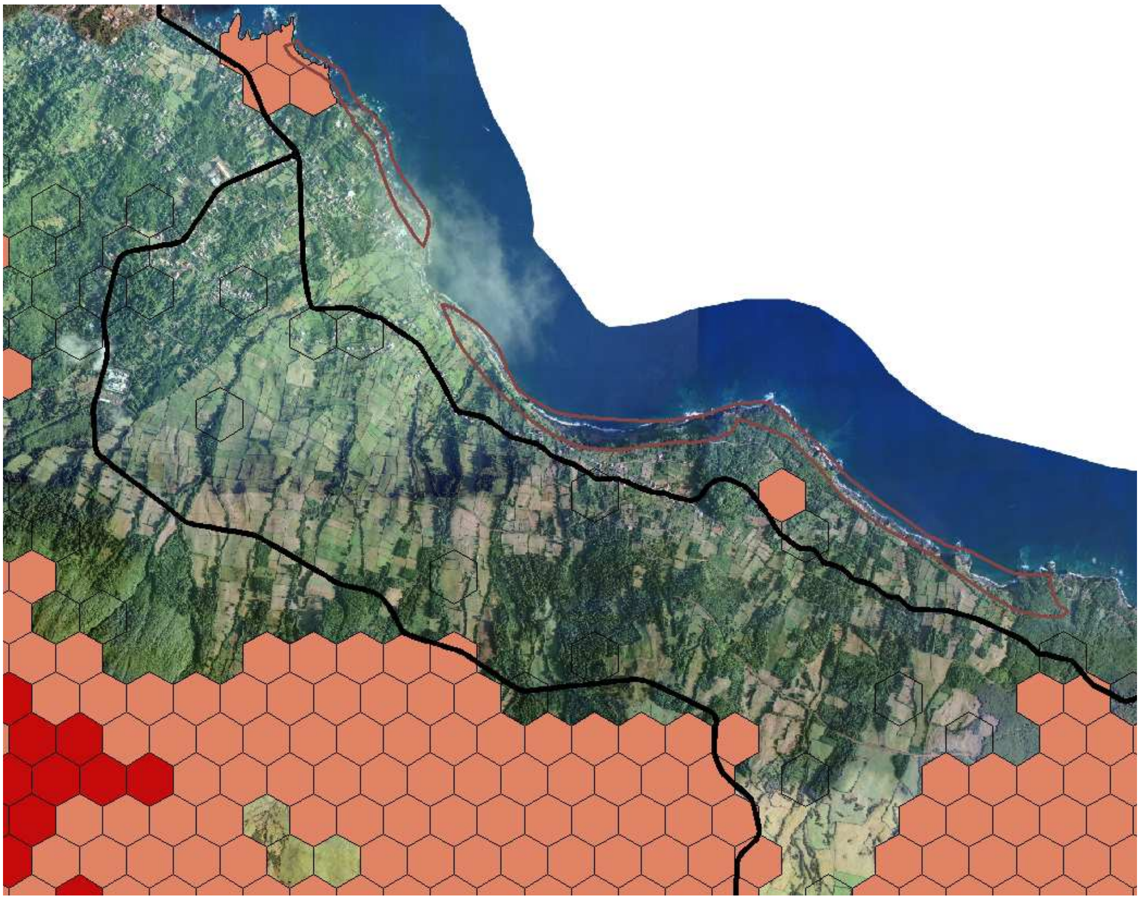


Fig. 7.5 - Area east of São Roque do Pico

Another important consideration in terms of the multi-functional perspective of conservation management is well displayed in Fig. 7.6 where we can observe by comparison with Fig. 7.5 that the strong slopes are protected by vegetation partly *Pitosporum undulatum* dominated communities, part *Erica azorica* communities, part *Cryptomeria japonica* production forests. This dense tree and shrub land cover acts as a soil protector in the areas more erosion susceptible. This is another example of an environmental service that must be included in the global evaluation of the value of the different objects and functions to be integrated in the contratualization model.

One must, therefore, always focus on the need to identify existing but also potential values and evaluate the relative costs of preservation and restoration in the frame of the entire management area aiming at making the best of the available scarce resources and allowing the maximization of the global value of each area and of the entire island.

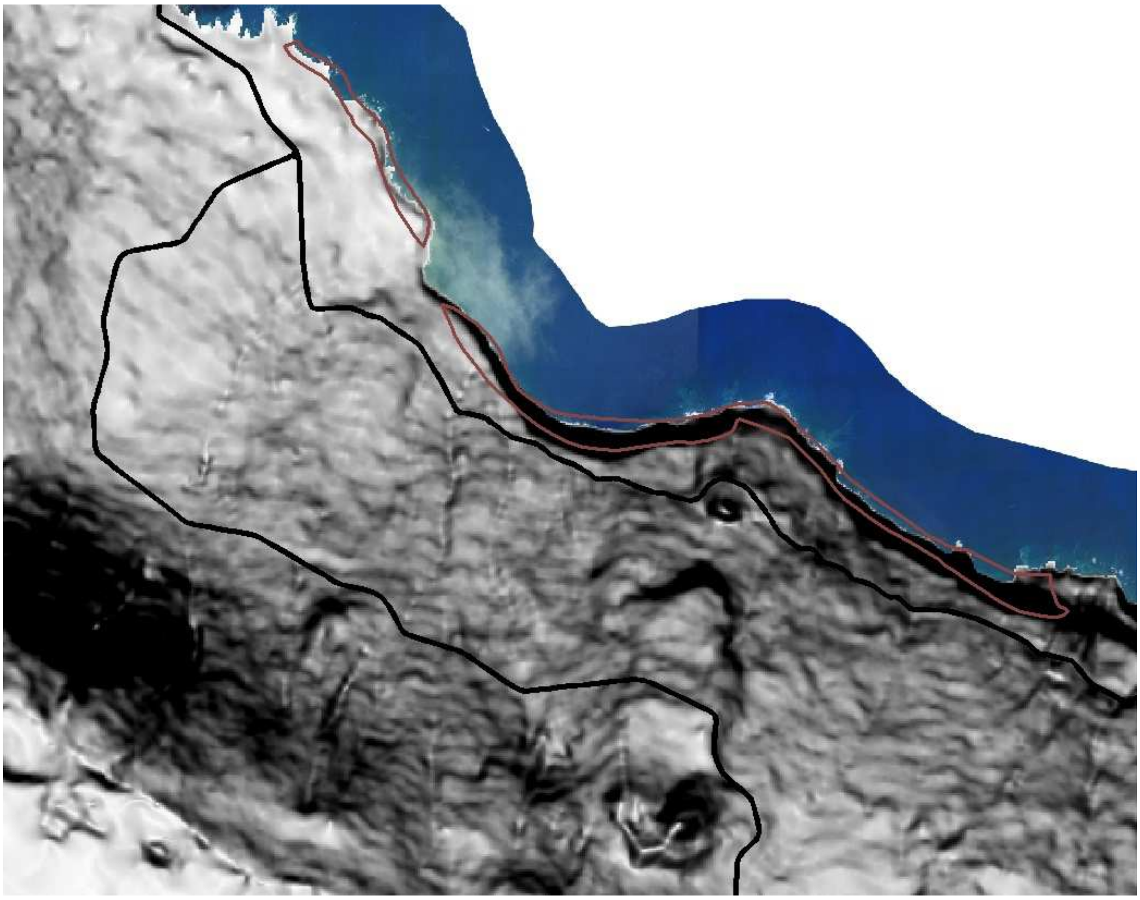


Fig. 7.6 - Slope of the area east of São Roque do Pico

7.3 - Conclusion

Building a characterization and evaluation tool must take into account two types of problems:

- one is the ability to represent
- the second is the ability to display

Both these problems are well depicted in the following image (Fig. 7.7). On one side there is the difficulty of translating the reality of the territory to the representation codes we dispose (in a translation process). Then there is the difficulty of developing models and other evaluation, characterization, simulation systems, ensuring always its analogy with reality and not with each one's perception of the reality.

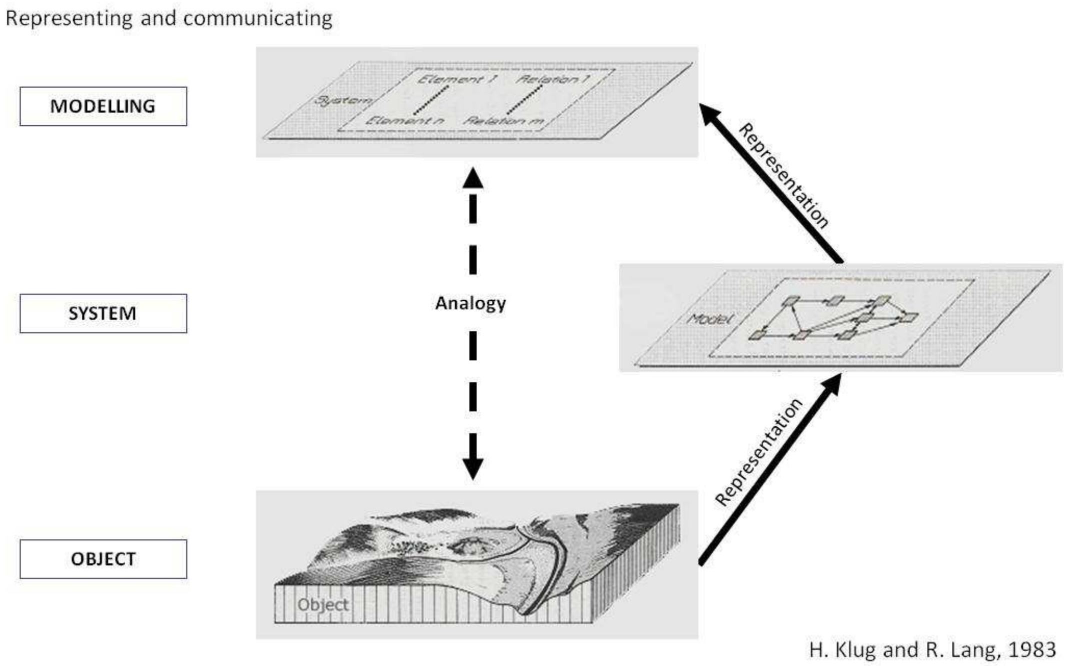


Fig- 7. 7 - Process of representation of the territory (adapted from Klug and Lang, 1983)

The second problem can also be represented by the same image when we think that all the processes of characterization an evaluation in a management context imply the ability to translate the reality and the different representations of that reality to the different involved actors. This process of communication is always a translation process (as the representation) where it is critical to be able to produce information (not data) understandable, accessible and verifiable to al persons involved independent of their type or degree of expertise.

The framework developed in this project tries to build a contribution to facing these problems consistently.

But the quality and efficiency of any characterization and evaluation tool is always dependent of the available information. In the present project, there were important variations in the quality of the available information (either cartographic or bibliographic. That is a situation one faces everywhere and cannot be a ground for poor processes of characterization and evaluation. Data gathering is, therefore, the primary target of any management process, particularly in the new highly demanding governance contexts.

This project illustrates how with information that was of very different quality, detail, precision, it is possible to build a sound coherent characterization and evaluation tool.

It also illustrates, how the gathered and processed data can be used in models to simulate and evaluate scenarios and particularly, to build management criteria according to the reality of the territory and not according to the limited perspectives of any group, entity, organization or administration.

(...)

Closing, it is important to stress:

On one side:"**Nobody wants Data, everybody wants Information**" (Kias and Traschler, 1985)

On the other, the agents involved in the data-processing, don't acknowledge many of their knowledge limitations, preferring to make expert-statements instead of using objective models and accepting its intrinsic or extrinsic limitations.

This "expert-panel" tendency lead to a normally almost impossible ability of updating or readjusting each model or plan and to a difficult compatibility with neighbouring objects or hierarchical-different plans: scientists "*commonly make the mistake of thinking that their familiarity with scientific claims means they are in an expert's position with respect to claims concerning the nature of scientific propositions. (...) they are in possession of at most half of the requisite expertise; the other half being an understanding of the concepts involved in epistemological and logical classification schemes*." (Scriven, 1994, pp. 149). Simultaneously, the subjectivity of many statements, avoid the possibility of a comparative analysis of the produced information, and the possibility of establishing a productive and founded dialog with other disciplines involved in data generation and evaluation process.

(...)

These are the questions that the present project tried to face in the frame of this **Task 1 - *Characterization and Diagnosis***

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