Map of Natural units of Espirito Santo State, Brazil

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1. Abstract

Espirito Santo State (ES) in SE Brazil has in its relatively small area a great diversity of landscapes, ecology and land uses. To indicate the degree of natural regional variability, a map was constructed using information from a variety of sources. Clustering of variables was a particular challenge. Both expert and personal experiences were used to develop geographical indicators of climate, soil and relation between humans & other living forms and land condition. Some of these indicators assisted the identification of different classes of each variable considered. These variables and their classes were subsequently clustered in order to set boundaries for the natural regional units. In turn, the classes were related to key biophysical aspects in order to develop some “genetic” relationship with problem issues in the natural regional units. This process led to units, which not only have direct relevance to environmental conditions in ES but also are of immediate support to regional development in terms familiar to potential users. The option of a simplified model of the environment for the identification of natural regional units was chosen.

Two distinct aspects are involved in the design of the map of natural units: 1) preservation of original quality of information and 2) improvement in communication. Five situations in the preservation of quality were challenged: development and execution of a process involving 1) many key variables; 2) intelligibility for non-specialists in natural resource information; 3) flexibility of operation to re-access original information; 4) units related with easily identified field indicators. 5) technical transparency in the map about criteria and basic principles used. In order to meet the needs of communication, the following attributes were important: 1) development and execution of a process for designation of units and with immediate explanation of their content; 2) legend for immediate mental image of unit irrespective of user background, language or previous experience; 3) representation of units at both formats (a) digital and (b) hard copy format, for areal references (map) and (c) also in schematic diagram (decision tree).

2. Statement of the Problem

Espirito Santo State, with an area of 45,597 km² is located in South-eastern Brazil. It has high mountainous, low mountainous and plateau areas along the Atlantic coastline and, consequently it has a great diversity of environments, ecology and land use. This diversity found over a relatively small area gives rise to a wide range of agro-ecosystems.

ES State is satisfactorily served with information allowing general environmental zoning of large areas. The problem is that most of these data are available only for analysis at a general regional level by

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trained professionals, and not in a form useful to non-specialists[2]. As a consequence the actual users of this information are few at a general level and even fewer at field detailed level. Important projects are launched without the necessary knowledge of the ecosystems. Field training in perception, interpretation and transference of knowledge related to agricultural ecosystems is arousing considerable interest in Espirito Santo State. The mere desire for this training points to the need for an additional and instructive-educational approach alongside the current scientific and technical "information system". Moving from one traditional technical communication practice to another which aims to increase understanding is a challenge. It involves not only terminology translation but also the addition of new information combined in a way that will be usable in the field and easily understood by non-specialists. The new information must be user friendly and needs to be integrated with the original format in which the traditional source is set. This paper outlines part of a research program to provide just such a new information design.

The key problem areas identified are the need:

- to develop a method to engage a new user community of regional planners, policy makers, and a public concerned about energy and environment issues (AUSTIN, 1977; WARD, 1978; DENT & YOUNG, 1981; BELL & WOOD-HARPER, 1992; DALAL-CLAYTON & DENT, 1993; STOCKING, 1994b);
- for both specialists and non-specialists to have a common baseline of spatial reference and terminology (MITCHELL, 1991);
- for the involvement of geoscientists in the design of an improved information system (WARD, 1978) based upon current developments in information science (GILCHRIST, 1986);
- to encompass a much larger range of activities in a improved information system, including (1) deciding who needs a particular information, (2) information product planning, (3) acquisition, selection and conceptual structuring of information, (4) finding appropriate ways of presenting (forms of words and non-verbal forms), (5) making decision on format, and (6) translating decisions (ORNA & STEVENS, 1991).

3. Research Area Demarcation

Two principal difficulties in the delivery of information need to be studied (Figure 1): (1) the provision of usable information in the context of broad perspective for regional analysis (strand **A**); and (2) the process for display of information for specific purpose use (strand **B**). The map of natural regional units (strand **A**) contains a careful selection of physical and ecological information designed for non-specialist users. The original source of physical information, by itself, is difficult to be immediately used by non-specialist users for practical purposes. The natural units format was designed for the user to access related spatial information for biophysical and socio-economic uses. The information for specific purpose use (strand **B**) is a process for presentation of information. In a specific purpose use (strand **B**), not only the use of detailed information can be required but also data for regional analysis (e.g. small scale map – see Figure 2).

2Non-specialists are information systems users who, while having specialist knowledge in some subjects do not have the particular skills and in-depth knowledge of the original natural resources information being brought through the information system.

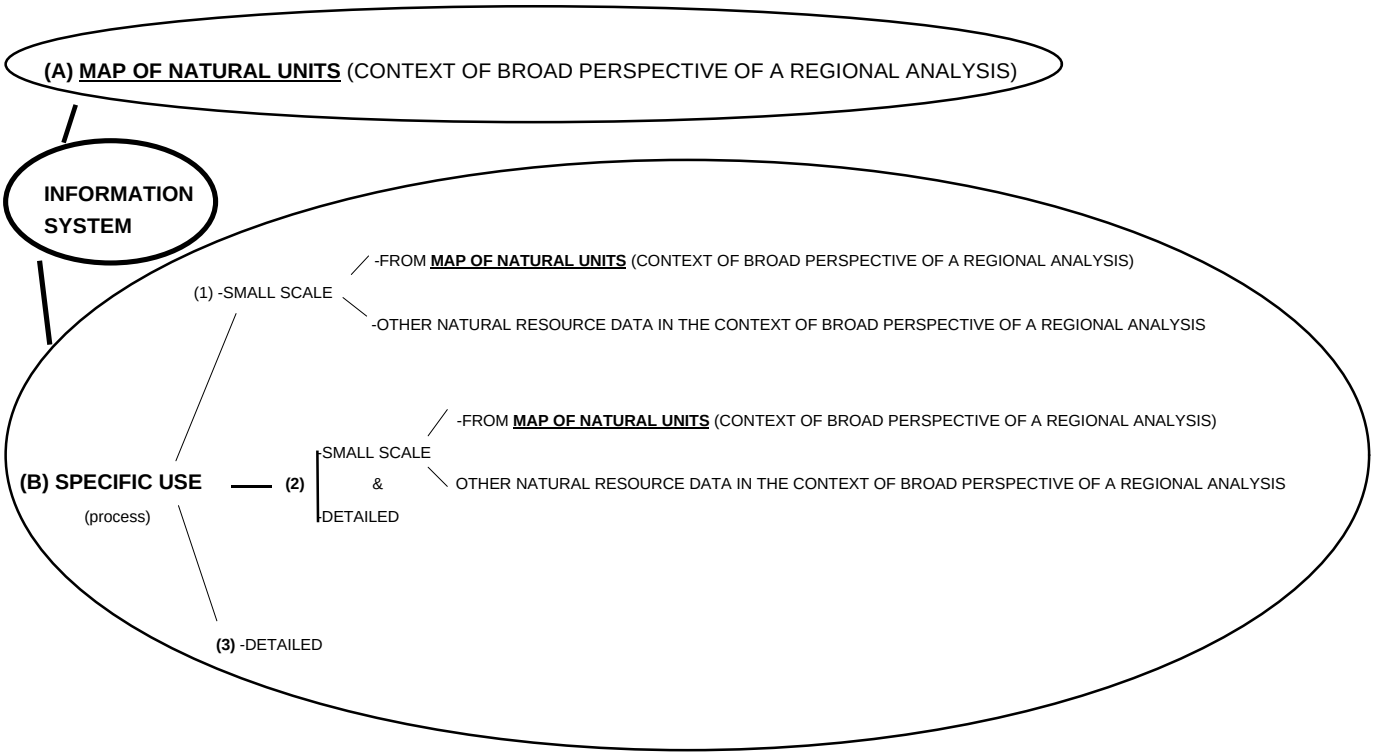

FIGURE 1. The use of the map of natural units in the information system context.

In Espirito Santo, the current problems with the descriptive information provided are:

- the ambiguity in the characterization and location of areal references (Strand **A**),
- difficulties in retrieving information from dispersed sources, and the wide range in type and level of regional information provided (Strand **A**),
- the lack of identifiable indicators for the considered variables (Strands **A** and **B**),
- the lack of obvious relevance for local decision-making (Strand **B**) and
- the available information systems for specific practical use are not structured for receiving new information derived from the users' experience (Strand **B**).

The strand **A** of the information system represented on Figure 1 is a natural unit division and needs to be developed to solve shortcomings corresponding to points **(a)**, **(b)** and (**c)**. The strand **(B)** of the information system is a process for information design (or for data presentation) and needs to be developed to solve shortcomings corresponding to **(c)**, **(d)** and **(e)**. Both strands **(A)** and **(B)** are synergistic in the solution of current problems with descriptive information in Espirito Santo State. Improvements on the current problems with descriptive information need to be separately evaluated for strands **A** and **B**. This paper concentrates upon the challenge of improving information design for strand **A**, although there are important implications for strand **B**.

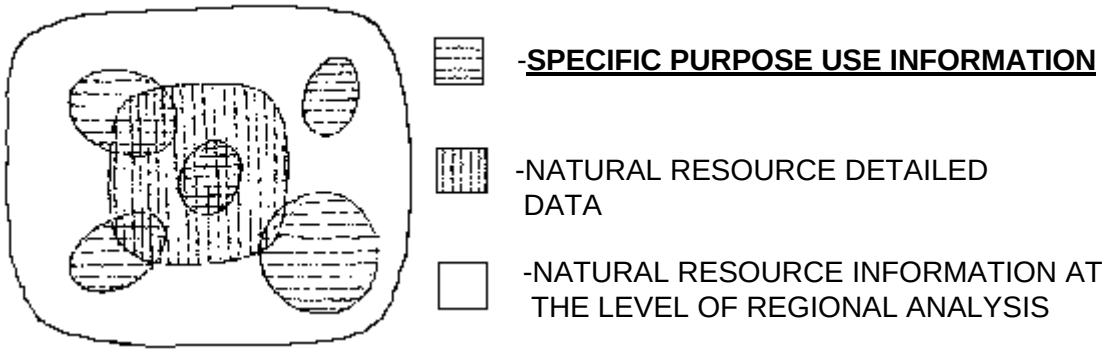

Figure 2. Information for specific purpose use relates to natural resource information at two levels of detail. For specific purpose use non-natural resource information is also included.

Three principal objectives have been formulated:

- To characterize units of the environment, their qualities and problems, in an accessible way to the non-specialist users of natural resource information.
- To improve the performance on the use of information to assist the implementation of programs of transference of technology, credit, land use, investment and research in tropical regions.
- To make spatial data intelligible for non-specialists, and to offer users better recognition of information of complex environments in order to match program and planning decisions with the characteristics of each environmental unit.

4. Methodology

This research involves the bringing together of information from diverse sources and experiences: 1) variables considered important in existing methods; 2) analysis of existing databases; 3) demands in the form of development plans and priorities in ES State; 3) relation with indicators; 4) characteristics of ES in terms of spatial differentiation in some important variables and 5) observation surveyed especially for the purpose. Feasible design is important in this process.

The performance of the map of natural units in providing better perception, interpretation and transference of knowledge was tested. This included verifying among non-specialist users the accessibility of information. Validation of the research is accomplished through assessing improvements to the current situation. In particular, the capability of users to handle information is analyzed. This is an aspect often neglected, which this research attempts to redress.

The development of the map of natural units for regional analysis has three steps (Table 1): (1) design, (2) appraisal and (3) implementation.

Table 1. Component items in the design, appraisal and implementation of the natural units

Item	Map Of Natural Units For General Regional Analysis
Design	
Subject	Natural Units
Vehicle For Information	Flow Diagram, Text And Map
Participants	Specialists
Appraisal	
Aspects	Improvement In Perception, Interpretation And Transference Of Knowledge
Appraisers	Non-Specialists
Implementation	
Characteristics	Broad Natural Units Zoning And Mapping To Guide More Detailed Analysis

4.1 Design

According to MITCHELL (1991), a parametric approach adds precision and reliability to the physiographic approach. A model associating parametric and physiographic information obtained from a variety of sources is used in the development of natural units. If the design of ecological areas as a baseline for regional communication is not improved, users would be hampered in accessing most of the important regional data especially about climate and soil usually required in display of information for specific purpose use.

Key factors considered in natural units development can be seen in Figure 3. Clustering of variables to make them more purposeful was a particular challenge of the development of this map. Assessments by knowledgeable persons and personal experiences in geographical indicators on climate, soil and relation between humans & other living forms and land condition were considered. Based upon these considerations, a comparatively small number of variables were chosen. Every variable still in their original sources was divided into classes. These classes were related to key biophysical processes in the landscape in order to provide a “genetic” basis for understanding the derived units. Variables were clustered to define natural units. Although specific to ES, the process of classification and clustering assists ready communication and provides basis for field area location by users.

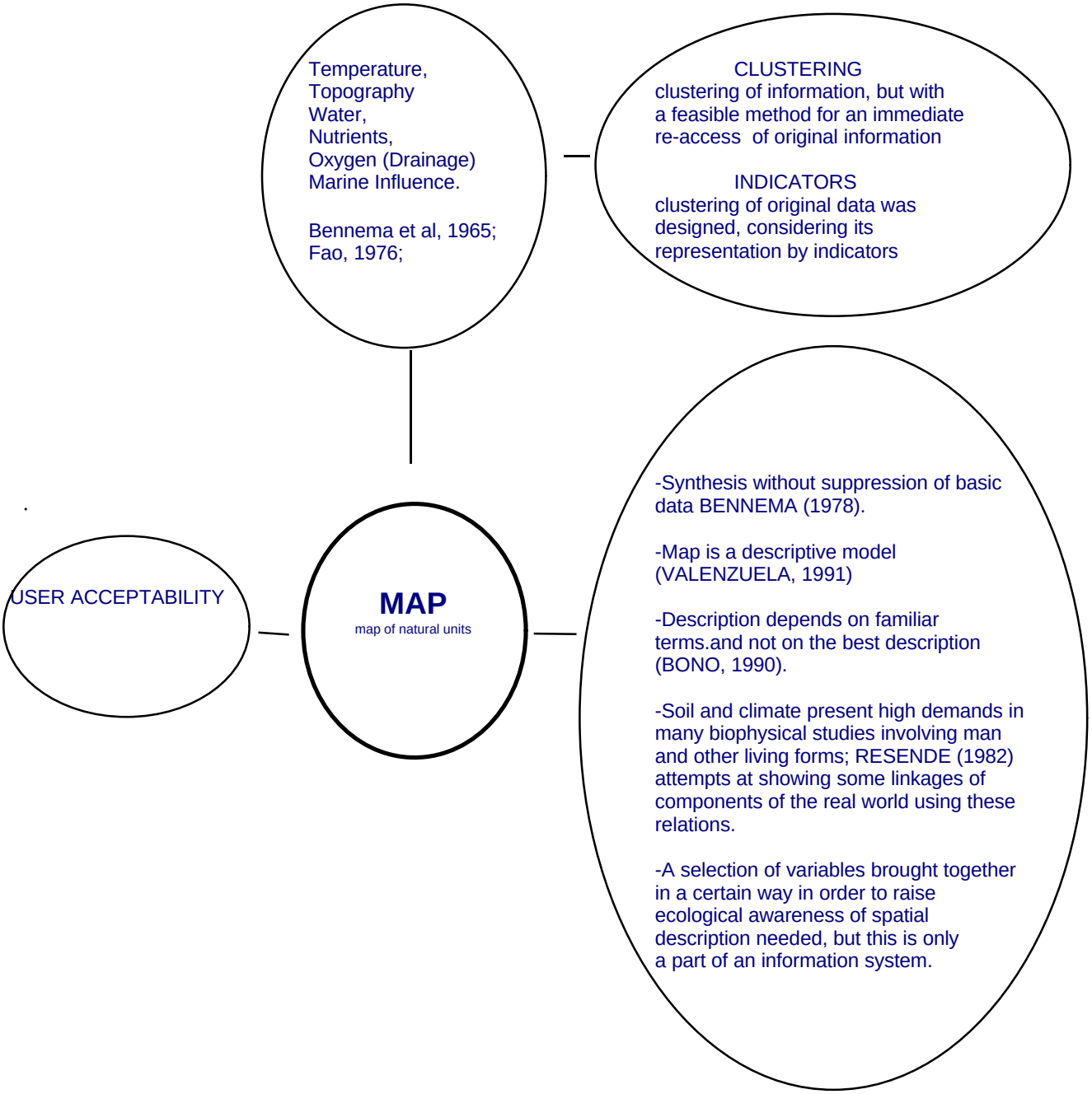

Figure 3 - Key factors considered in the development of the map of natural units

Terrain units provide an integrated framework for a wide range of land resources, notably soils, water, and vegetation, and thus for an equally wide range of users (MITCHELL, 1991). Human perceptions of environmental problems may include particular views about natural resource elements of the environment such as climate, soils, human beings and other living forms (BRINK et al., 1968; MILLER, 1968; CHRISTIAN & STEWART, 1968; BECKETT & WEBSTER, 1969; HOWARD, 1970; STRAHLER, 1976; BUTZAR, 1976; RESENDE at al., 1993). These natural resource variables and interrelationships between them and living organisms are key inputs to our human perception of the environment, its exploitation and associated problems. The approach here emphasizes surveying and interpretation of information on climate and soil sources, and their relation to human and other living forms that are relevant to Espirito Santo State (Table 2 and Figure 4). Clustering of climate and soil data was highlighted and displayed in a practical form even though this was at the level of general regional analysis[3].

In order to retain as much information as possible and not to lose data during the process, special care was taken to extract relevant information on climate and soil from the original data base of Espirito Santo State (Figure 3). From climatic data, the aspects related to temperature and water were highlighted; from soil survey data, the availability of nutrients, oxygen (drainage) and general topography (land degradation) were considered. Instead of considering the standard soil characteristics such as texture, depth, slope, stoniness, for the selection of variables, the advice of BENNEMA et al. (1965) and BENNEMA (1978) was followed in the broad regional context and those aspects of direct interest to plant and animal growth were concentrated on. A plant's basic requirements are nutrients, water, radiation energy, temperature regime and air. Because topography (relief) is related to surface water availability (streams and rivers), trafficability by machinery and soil erodibility, these aspects were also incorporated in this natural resource assessment. Data on radiation energy was not directly used for the division of natural regional units. This is because (1) original regional data and regional indicators are not readily and clearly available and (2) absorbed radiation is partly converted into thermal energy which is already incorporated in temperature. However, radiation energy can be included in presentation of information for specific use in, for example, landscape exposure. Other attributes, such as soils under marine influence, tidal flooding and sandy coastal areas, were also highlighted in the map of natural units since they are already familiar as important development constraints and have been used as a basis for making natural divisions of the State.

[3] **General regional level refers to the natural resource level where general attributes may be recognised; it can be classified as an exploratory level.**

Table 2. Key variables for natural regional units: primary human and biological influences in their clustering in the original sources and their spatial organization

Primary Influence for Clustering Original Sub-Divisions	Effect On Spatial Organization
Temperature	
Cultivation or non-cultivation of coffee and the varieties grown were taken into account in boundary settlement between different thermal regions. Coffee growing is (1) a very important activity for the sustainability of a significant labour force constituted by small farmers and sharecroppers (GOVERNO DO ESTADO DO ESPIRITO SANTO, 1992; LOSS, 1994), (2) largely cultivated State-wide and (3) related the thermal regions (FEITOZA & RESENDE, 1993).	Sub-divisions of the temperature original data were clustered to represent (1) cold mountainous high, (2) mild mountainous medium and (3) hot low areas both crystalline and flat sedimentary zones which correspond to these clustering of temperature and can be expressed roughly through their altitudes and other biophysical indicators. Identification of transition areas causes no confusion to user.
Relief	
Distribution and activities of man over the sloping and flat areas of the State and spatial aspects of human settlement and use of these areas can vary. Sloping relief contains more rivers, streams, water sources and small farmers than flat areas (RESENDE et al. 1994) and this difference may cause marked differentiation in land-use systems (FAO, 1993).	Soil units from the level lands of the sedimentary zone (plain) and the soil units which amalgamate the crystalline areas (sloping) were clustered separately and highlighted which can be seen through direct landscape observation.
Water	
The number of dry months annually was adopted as easily understood by users. STOCKING & ABEL (1981) emphasize that by its very complexity and sensitivity, the use of plant indicators is replete with difficulties and, a local knowledge is invaluable in deciphering the causes of vegetation changes. Field observations were undertaken to find one plant indicator for hydrological zones, which could be easily observed at any season of the year. A specific survey was undertaken State-wide for the registration of *Calotropis procera* occurrence, checking if its incidence in different geographic positions shows a regularity of natural distribution demarcated by the dry region (more than 6 dry months) boundaries.	In some transitional parts from mild mountainous to hot and low zones, the length of the dry season shows a steep gradient in increase in number of dry months. Consequently, a parameter based on number of dry months was determined, with 4 to 6 dry months characterizing the rainy/dry transition zone. Indicators which can be observed in field trips help to locate only some dry zones (>6 months dry). Identification of rainy/dry transition areas without map indication may cause confusion to the user.
Nutrient	
Since eutrophic soils are 1) not abundant, 2) react differently to the degradation process and 3) are of special importance to the small farmers' maintenance, general regional analysis should highlight the soil units with one or more eutrophic components. Indicator as soil colour (STOCKING, 1980) can also be applied to this purpose in Espirito Santo (RESENDE et al, 1994).	The decision in considering soils of intermediate fertility (moderate) was much more in function of the invaluable need to find location of better quality in land nutrients. Spatial organization related to soil nutrients presents, in field conditions, a satisfactory pattern for practical regional location in terms of identification of rich and poor lands. To locate areas of intermediate fertility (moderate) without map support may cause confusion to the user.
Flooding and Marine Influence (Tidal Flooding and Soil Texture)	
Liability to flooding was used in determining soil oxygen at regional level in a simple manner. Liability to tidal flooding was a refinement for more subdivision of an already familiar natural area, which is fast developing in tourism (HOLANDA et al., 1993).	After a preliminary trial embracing classification and spatial analysis of all soil units, it was realized that criteria applied to these parameters were confined to flat lands along the coast. Those soil units with marked oxygen deficiencies in the low crystalline and level lands of the sedimentary zone were clustered and highlighted. The Tidal Flooding and Sandy Coastline familiar to the user, were also separated and highlighted.

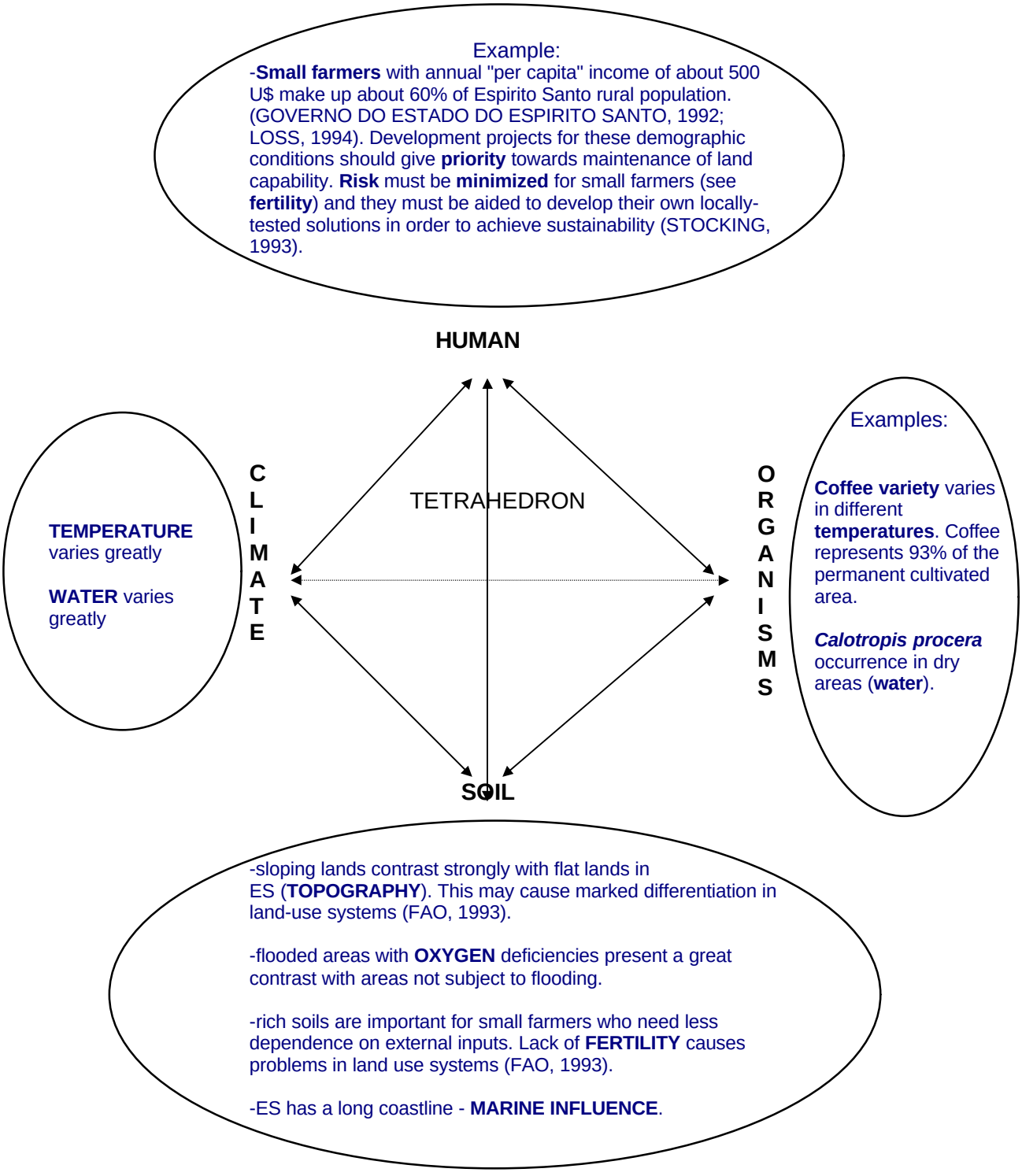

Figure 4. Ecological tetrahedron adapted for explanation of the interrelationships of variables used in the development of the map of natural units of this research (after RESENDE, 1982)

For general regional analysis, the State is divided into natural units presented in a map. The degree of homogeneity within each mapping unit across a broad array of factors was the overriding criterion for aggregation. Homogeneity was determined **(1)** by the variation of the factors (a) temperature, (b) water (climate source), (c) relief, (d) nutrient, (e) oxygen/root zone and (f) marine influence/soil texture & tidal flooding (soil source) and the criteria for determining categories in the process of clustering of each variable in their origin (Table 3) and **(2)** by the results in terms of possible display of the subsequent integration of all those previous individual clusters {(a), (b), (c), (d), (e) and (f)}. The result within regional units is the synthesis of properties of temperature, relief, water, nutrient, oxygen (in the root zone) and marine influence (soil texture and tidal flooding) also related human and biological issues relevant to ES State.

Every unit specifies natural resource qualities and problems as identified by traditional information sources, integrating variables that are identified as relevant to Espirito Santo State conditions (Table 4 and Figure 4). Indicators are useful in order to enhance practical interpretation and to provide a rapid field reconnaissance of a particular natural unit. When possible, units are differentiated by specific indicators that are common in Espirito Santo State. Categories of (a) temperature and (b) water **(1)** clustered in the climate map (FEITOZA, 1986) and categories of (c) relief, (d) nutrient, (e) oxygen (in the root zone) and (f) marine influence (soil texture and tidal flooding) **(2)** clustered in the soil map & its manual (OLIVEIRA et al., 1983; SANTOS et al., 1987; IBGE,1994) and their corresponding denomination are shown in Tables 3 and 4. Non-specialist information highlighted from the climate (FEITOZA, 1986) and soil (OLIVEIRA et al., 1983 and SANTOS et al., 1987) map at the level of regional analysis are shown in the first column of Table 3.

The criteria were evaluated for the choice and clustering of original variables from soil and climate data sources. Twelve information providers, most of them specialist users of natural resource data, participated in the discussions. Designing regional units required experience in contacts, knowing the providers of information, interacting and consulting with key users, planners and decision makers. Common qualities of immediate relevance and applicability to users, and the correction of acknowledged deficiencies in existing systems, were identified in order to design the method.

Table 3. Applied criteria used in soil[1] and climate[1] database to classify natural regional units

(1) Temperature

Denomination	Criterion: Altitude① (metres)	Frost period② (months)	Degree-days above 10°C ③ (degree-days/year)	Mean maximum temperature for the hottest month (°C)	"Cold period"④ (months)	Number of hours with temperature below 7°C ⑤(hours)	Mean minimum temperature for the coldes month (°C)
Cold	> 1.200	> 3	< 2.440	< 25,3	5,5	> 150	<7,3
	850-1200	0 - 3	2.440 - 3.190	27,8 - 25,3	4,5 - 5,5	50 - 150	9,4 - 7,3
Mild	450 - 850	0	4.040 - 3.190	30,7 - 27,8	0,0 - 4,5	0 - 50	11,8 -9,4
Hot	0 – 450	0	5.080 - 4.040	34,0 - 30,7	0	0	18,0-11, 8

① Lands above 1,200 metres are inhabited by farmers and above 1,800 metres they are decreed for permanent protection.
② Month with a minimum of one frost in each four years (25% probability). Frost only occurs in specific places of the farm landscape.
③ Temperature of 10° C was used as reference because it is base temperature for most of the traditional crops of Espirito Santo State - this information is useful for the inference about thermal availability.
④ Number of months too cold for cultivating *Phaseolus vulgaris* which is a traditional crop of Espirito Santo. The behavior of this crop is known by all farmers. This parameter aims to express the "cold state " of regions through the prognostic behavior of a plant avoiding the expression of degree centigrade of meteorological data.
⑤ Useful parameter in the study about regional potentiality for growing varieties of many fruit trees from temperate climate origin.

(2) Relief

Denomination	Criterion	Relief	Slope (%)
Sloping	Clustering of soil mapping units of components with slope above 8 %.	Rolling hilly mountainous escarpment	8 - 20 % 20 - 45 % 45 - 75 % > 75 %
Plain	Clustering of soil mapping units with at least one component with slope below 8 %.	flat gently undulating	0 - 3 % 3 - 8 %

(3) Water①

Denomination	Criterion	Wet period (U)② (months) J F M A M J J A S O N D	Annual precipitation excess ③ (mm)	Summer wetness index PP/ETP④ (dec.jan.fev.)	Dry period (S)⑤ (months) J F M A M J J A S O N D	Annual precipitation deficit (mm)	Winter wetness index PP/ETP (jun.jul.ago.)	Map indication
Rainy	< 4 dry months	U U U U U U U U U U U U	1016	1.90	U U U U U U U U U U U U	0	1.81	1
		U U U U U U U P P U U U	430 - 676	1.39 - 1.74	U U U U U U U P P U U U	23 -140	0.44 - 1.07	2
		U P U U U P P P P U U U	236 - 366	1.00 - 1.46	U P U U U P P P P U U U	56 - 174	0.67 - 0.86	3
		U U U U P P P S P U U U	267 - 623	1.44 - 1.83	U U U U P P P S P U U U	89 - 339	0.41 - 0.78	4
		U P U U P P P S P U U U	178 - 393	1.08 - 1.29	U P U U P P P S P U U U	126 - 191	0.46 - 0.67	5
		P P P P P P U P P U U U	95 - 157	0.82 - 1.04	P P P P P P U P P U U U	147 - 274	0.69 - 0.96	6
Rainy /dry transition	4 to 6 dry months	U P P P P P P S P U U U	87 - 378	0.96 - 1.31	U P P P P P P S P U U U	157 - 284	0.47 - 0.69	7a
		U U U U P S S S S U U U	222 - 494	1.31 - 1.83	U U U U P S S S S U U U	170 - 237	0.30 - 0.39	7b
		P P P P P P P S P U U U	21 - 145	0.81 - 1.00	P P P P P P P S P U U U	139 - 372	0.65 - 0.79	8
Dry	> 6 dry months	P S P P P P P S P P U U	28 - 58	0.68 - 0.85	P S P P P P P S P P U U	251 - 388	0.56 - 0.74	9a
		P P P P P P P S S P U U	11 - 91	0.91 - 1.02	P P P P P P P S S P U U	255 - 426	0.48 - 0.64	9b
		U P P P P P S S S P U U	36 - 185	0.85 - 1.21	U P P P P P S S S P U U	223 - 448	0.39 - 0.44	9c
		P S P P P P S S P P U U	28 - 31	0.68 - 0.74	P S P P P P S S P P U U	388 - 496	0.38 - 0.59	10a
		U P P P S S P S S P U U	28 - 268	0.85 - 1.40	U P P P S S P S S P U U	210 - 360	0.38 - 0.61	10b
		U P P P S S S S S P U U	92 - 123	1.07 - 1.30	U P P P S S S S S P U U	325 - 407	0.22 - 0.33	11
		P P P S S S S S S P U U	29 - 62	0.86 - 0.94	P P P S S S S S S P U U	429 - 606	0.17 - 0.37	12
		S S S S P P P S S S S S	0	0.27	S S S S P P P S S S S S	977	0.46	13

① The hydrological number of map indication is displayed according to its regional number of dry months. Every month partially dry (P) is considered a half dry month.

② Number of months with precipitation equal to or greater than the potential evapotranspiration. The wet period allows inference about the rainy season location throughout the year. The P character means month partially dry (potential evapotranspiration > precipitation> ½ potential evapotranspiration).
③ Sum of the monthly precipitation excess in relation to the potential evapotranspiration.
④ Ratio precipitation **/** evapotranspiration in the summer.
⑤ Number of months with precipitation smaller than half the demand of water by evapotranspiration.Dry period allows inference about the dry season throughout the year.
Sum of the monthly precipitation deficit in relation to the potential evapotranspiration.
Ratio precipitation / potential evapotranspiration in the winter.
Numbers indicated in the original climate map (FEITOZA, 1986). They are in order from the wettest to the dryest region. Every region is represented by a number and remains within discreet boundary.

(4) Nutrients

Denominaton	Criterion
Poor	Clustering of soil mapping units without eutrofic components.
Moderate	Clustering of soil mapping units (1) with three component soils, where only the second in aerial extent is eutrofic; (2) with three components, where only the third is eutrofic .
Rich	Clustering of soil mapping units (1) where the first component is eutrofic; (2) with two components where the second is eutrofic; (3) with three components, where the second and third are eutrofics.

(5) Flooding, Soil Texture And Tidal Influence

Denomination	Criterion
Not subject to flooding	Clustering of mapping units with flat or gently undulating relief without a gley horizon.
Fine Fine textured	Clustering of mapping units, not sandy and with flat or gently undulating relief.
San Sandy	Clustering of mapping units of flat relief with Hidromorfic Podzol and marine Arenosols.
Subject to flooding	Clustering of mapping units with flat relief and gley horizon.
Not t Not tidal	Clustering of mapping units of flat Gleysoils not tidal , with no salts or sulphur accumulation.
Tida Tidal flooding	Clustering of mapping units of Mangrove Undifferentiated soils, Salty Soils or Solonchacks and Thiomorphic Gleys.

[1]All original data (soil mapping units) remained discreetly shown in the map of natural units, but only the clustered data was highlighted. A table synthesis of the most important observation of every soil mapping unit component is shown in the map for technical purposes)
[2]Temperature data was clustered and highlighted but the original data did not appear in the map of natural units. The original data about water availability remained in the map of a natural unit but only the clustered data was highlighted

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The variables, which constitute the inputs for the general regional units, are handled in a defined order. The final assembly, adopted after a trial procedure to set sequence, is as follows: (1) temperature, (2) relief, (3) water, (4) nutrients and (5) flooding & marine influence (soil texture and tidal influence). This sequence helps for: 1) explanation, 2) designation of units, 3) design of the legend and 4) arrangement of flow diagrams (e.g. decision tree).

The key objective of the map design was to clarify and to set a layout that would encourage understanding of its content. The legend was designed to provide the users with an easy-to-learn model thereby dispensing with the need for constant referral. The mapping symbols' use colour and signs is intended to convey directly a meaning without use of text and without need to learn a particular language.

The number of variables selected is limited only by the complexity of the mosaic of natural units that must be generated. Clustering the data is a process which involves: 1) identifying a reliable indicator, preferably for at least one major unit (range) per variable; 2) having an indicator which may be recognized in the field and in all seasons; 3) presenting the criteria used in a transparent way.

For quicker recall, memorization and easier recognition of the location of natural units on the map and field, the original data were divided into two sets of factors (Table 4): (1) temperature (cold, mild and hot), relief (sloping and flat), sufficiency of water (rainy, rainy/dry transition and dry); These determine **Zones** and (2) availability of nutrients (poor, moderate and rich), flooding (not subject to flooding and subject to flooding), soil texture (fine textured and sandy) and tidal influence (tidal and not tidal) to determine **Sub-zones**. Sub-zones are also sub-divided into **Provinces** exclusively for technical communication.

Table 4. Original data and its role in the designation of natural units[1]

Factor	Parameter	Land designation
Zone		
Temperature	ALTITUDE	COLD MILD HOT
Relief	NUMBER OF COMPONENTS OF SOIL UNIT CLASSIFIED AS LEVEL LAND	SLOPING PLAIN
Water	NUMBER OF DRY MONTHS	RAINY RAINY/DRY TRANSITION DRY
Sub-Zone		
Nutrient	TOTAL NUMBER OF SOIL UNIT COMPONENTS AND NUMBER AND POSITION OF SOIL UNIT COMPONENTS CLASSIFIED AS EUTROPHIC	POOR INTERMEDIATE RICH
Flooding	PRESENCE OF GLEY HORIZON	NOT SUBJECT TO FLOODING SUBJECT TO FLOODING
Soil Texture	PRESENCE OF SANDY COASTAL AREA	FINE TEXTURED SANDY
Tidal Influence	OCCURRENCE OF TIDAL FLOODING OCCURRENCE OF SALTS OR SULPHUR ACCUMULATION	NOT TIDAL TIDAL FLOODING

[1]**Province is the lowest level after sub-zone but its denomination is exclusive for technical communication**

Except for temperature, all original information taken from climate and soil maps have their original sub-division of information preserved and transferred to the map of natural units (Table 5). The original and detailed sub-divisions of temperature were the only ones not completely transferred because (1) they could not feasible to be represented and (2) the result of the simplification with the new clusters was considered detailed enough.

Table 5. Procedures for integration of information and overall appearance of the climate and soil sources and the new outcome

Procedures	
First Step	**Second Step**
WATER and **TEMPERATURE**: original parameters were separately clustered from the climate map source (FEITOZA, 1986) and transformed into individual temporary plains of information. Original parameters of water were clustered but all original intermediate detailed values were preserved in a non-highlighted format. **TOPOGRAPHY** (RELIEF), **NUTRIENTS**, **SOIL/OXYGEN** and **MARINE INFLUENCE**: original parameters were separately clustered from the soil map sources (OLIVEIRA et al., 1983; FAUSTINO NETO et al.; 1987 and IBGE, 1994) and transformed into temporary plains of information. All variables had their original parameters clustered but all original intermediate detailed values were preserved in a non-highlighted format. **BIOPHYSICAL RELATIONS**: each clustering has parametric values and recurrent physiographic expression which may be represented by a relevant biophysical relation for ES State.	Integration of the clusters of (1) temperature, (2) relief, (3) nutrient, (4) soil/oxygen (in the root zone) and (5)marine influence (soil texture and tidal flooding) ending in physiographic units with parametric correspondence.
Overall Appearance	
Source	**Outcome**
CLIMATE: coloured map at 1:400,000 (FEITOZA, 1986) with thirteen climatic variables. **SOIL**: uncoloured map at 1:250,000 (IBGE, 1994) and user manual with coloured map at 1:1,000,000 (OLIVEIRA et al., 1983; FAUSTINO NETO et al., 1987). Soil maps embraces many variables. Soil coloured map at 1:400,000 with user manual from ACHA PANOSO et al.,1978 was specifically used to study the original vegetation phase.	Coloured map, scale 1:400,000 with zones and sub-zones levels with parametric and physiographic expressions, showing criteria used and with the unusual and additional characteristic of also providing details of the origin. The natural units synthesise parameters of (1) temperature, (2) relief, (3) nutrient, (4) soil/oxygen (in the root zone) and (5)marine influence (soil texture and tidal flooding). Hard copies available through electronic computer printout or normal print run processes. An extensive cartographic data-base as reference to orientation in subjects other than thematic issues is also provided.

Only one plane of information for regional analysis (map of regional units) was used because:

1) The reasoning for one plane of information includes the needs for: a) a common source of information for multiple users which can also be a common basis for areal references; b) one accessible information source so that non specialist users can regionally perform on regional perceptions, interpretations or even simple decisions not having to revert to subject-matter specialists.

2) The merits found on the development of one plane of information include: a) the accomplishment of a complex design with the attendant risk of occurrence of unintelligible mosaics; b) the educational, instructive and user-friendliness of information; c) the simultaneous accessibility of original information sources; d) the accomplishment of a design with suitability for further connections with models for more detailed analysis.

3) The assumptions are: a) for the presentation of synthesis of key multi-factor for specific purpose, the specialist and non-specialist must participate jointly; b) for the presentation of synthesis of key multi-factor for specific purpose other sources or planes of natural resource information are constantly considered; c) for the presentation of synthesis of key multi-factor for specific purpose the map of natural regional units is merely considered a source that runs alongside other regional sources providing information for multiple users also acting as a common basis for areal references.

4.2 Appraisal

The design and application of the map of natural units was evaluated for its ability to provide useful information and with an emphasis on the improvement of the degree of **perception**, **interpretation** and **transference** of knowledge for practical application of the information for developmental purposes (Table 6). These evaluations were undertaken through a specially constructed set of questions designed to elicit the views of relevant people at two key time periods: 1) before discussion of this research - i.e. with no knowledge of the reasons for or objective of this study; and 2) after the display of information.

For the map of natural units, the appraisal emphasized the interviewees' perception of the strengths and weaknesses of the division of ES into natural units as an information source. This was done by drawing comparisons between (1) the derived map of natural units and (2) existing information sources for regional description, such as climate, soil, regional geo-political division. Appraisal was then based on interviewee's reactions to the two sets of information sources. In support of the quantitative assessment of responses to individuals' questions, anecdotal evidence was compiled for specific questions that attracted additional comment by interviewees.

Face-to-face interviews were undertaken to assess the performance of the new system for a variety of user perspectives. Three factors were observed in the selection of interviewees: (1) potential as a user of natural resource information, (2) availability for lengthy interviews in Espirito Santo State at two different times and (3) variability of experience. Twenty-two decision-makers and planners, non-specialist users of natural resource data from different backgrounds, involving a wide variety of clients (agronomists, biologists, economists, medical doctors, civil engineers, veterinarians, economists, teachers, businessmen and rural extensionists) were interviewed.

Interviews were carried out using the following procedures: 1) appointment at the user's place of work or other convenient locality; 2) the initial interview was conducted in the ambience of the traditional methods and sources without mention of the methods or procedures of this research; 3) the topic was treated as an open-ended discussion; 4) interviewee reactions recorded through a) answers to multiple choice questions related to the degree of certainty and b) observation of user expression from free answers to questions and free observations without questions.

Descriptive statistical analysis of frequency distribution was the method adopted in the questionnaire analysis (SAS, 1982; GOMES, 1977). Specifically for the observations related to perception, interpretation and transference of knowledge a non parametric statistical test was used (CAMPOS, 1979; CONNIVER, 1971). Free observations were classified, clustered and registered by frequency of distribution per group. For the development of diagrams Harvard Graphics software was used (LARSEN, 1990).

In particular the appraisal process takes in consideration the use of the current methods for displaying natural resource and correlated information as its baseline condition, and compare the change in perception, interpretation and transference of knowledge by the new system. In

this research, in order to evaluate the **utility of the natural regional units**, a **principal criterion** was the improvement of intelligibility of the format, which comes from different observational inputs unfamiliar to the user.

Appraisal is an essential process because many studies of natural resources have simply assumed that the standard collection and dissemination of parametric information is all that is required - the utility of the information is assumed.

Table 6. Map of natural units and its evaluation

Interview Before any Discussion	Interview after Map Presentation
A_1-Natural Resource Data For Regional Analysis	A_2-Map Of Natural Regional Units
Ambience 1 Existing Information Sources (Individual Or Sets) for Regional Description of Climate, Soil, Geo-Political Divisions and Others Which Are in Everyday Use as Zoning Units to Guide More Detailed Analysis. How To Evaluate Non-Specialist Users' Support To Perform Simpleregional Analysis.	**Ambience 2** A Single Integrated Regional Source to Guide More Detailed Analysis. To Evaluate Non-Specialist Users' Support To Perform Simpl Regional Analysis.
Questionnaire A1 Emphasis: -Perception[1] -Interpretation -Transference -Synthesis[2] -Didatic[4] -Free User Observations Number[5]: 22 Interviewees	**Questionnaire A2** Emphasis: -Perception -Interpretation -Transference -Synthesis[3] -Didatic[4] -Free User Observations -Field Indicators Checked Number: 22 Interviewees

[1] PERCEPTION - Usefulness of the format in order to provide the non-specialist user with the best advantage for more regional perception.
[2] SYNTHESIS - how well information guides the user;
[3] SYNTHESIS - how well some information brought together (natural units) guide the user;
[4] DIDACTIC - how enlightening and user-friendly is the presentation;
[5] The same interviewees before and afte

The literature review demonstrated that rapid field indicators are useful and acceptable to users (STEA, 1969; DOWNS & STEA, 1973; LEWIS, 1974; STOCKING & ABEL, 1981; WARD, 1989; FEITOZA & PACOVA, 1984). In this appraisal, field observations were checked to verify that ecological and environmental indicators developed here were, in fact, appreciated. Key indicators for the map units were checked. The importance here is that indicators are in this research related to parametric information which are also conveyed in the denomination of a natural unit.

4.3 Implementation

A first print run can then be made to disseminate these divisions to non-specialist users to feed back information on the general utility of the units. In the ES situation, two thousand maps will be printed in order to assist non-specialist user demands. The mapping information was also kept in electronic and digital format to facilitate the up-dating of further editions with the inclusion of other views or corrections.

Table 7 summarizes the main methodological steps and procedures for implementation of natural units developed and validated under actual real-life use.

Table 7. Methodological stages in implementing the map of natural regional units to assist non-specialist users

1. Planning Stage
• Identify natural regional causal factors and constraints related to important biophysical, economic and social aspects • Take users' views about shortcomings in natural regional divisions • Conduct information survey to support the study • Identify the main feasible information to be displayed
2. Display Design Stage
• Synthesize all information into an integrated design for a map of the natural units in such way that the user will be able to access it all immediately; all information must also be shown on one map • Design of clustering of original natural resource information based upon important biophysical, economic and social relations • Provide separate maps for every variable • Information altogether can be managed using digital or conventional hard copy process • Settlement of legend layout that encourages prompt reading and understanding of all content immediately
3. Pre-Implementation Stage
• Make sure that non-specialist users' views, taken in the initial interview (see stage 1) about shortcomings in natural regional resource data presentation are considered
4. Implementation Stage
• Make sure availability of enough copies of map in order to meet demand of every potential non-specialist user in ES State • Dissemination of information and meetings to provide instructions about its use • Keep information in a digital format (optional) for eventual further improvements • The Nuclei of Studies about Land Use Planning – NEPUT at Espirito Santo Agricultural and Animal Husbandry Research Public Enterprise – EMCAPA is the place for occasional meetings to assess modifications to the map

5. Results

5.1 Natural Units

A colour map, scale 1:400.000, divides Espirito Santo State into 9 zones or major units and each zone is composed of a number of sub-zones varying from 3 to 6 synthesizing information for a large complex region within 34 natural units. The audience of non-specialists users can use zone and sub-zone levels as baseline communication. An example of a natural unit is the reference for the Zone 7 - Hot lands (temperature), plain (relief), rainy (water sufficiency), and Sub-zone 7.3 which refines the natural unit with the terminology: poor (nutrients), subject to flooding but not tidal (marine influence). Province is the lowest level of a mapping natural regional unit and there are 204 in total. The added information for the province level (database and terminology) assists specialist users on technical matters.

The natural unit can also be depicted as a decision tree, showing the typical arrangement of the natural units. Besides the map legend, the body of the map contains further information to allow the user to verify the evidence upon which a criterion for highlighted information was based. Each natural unit can be accompanied by a technical synthesis of the relevant and specific information concerning: (a) temperature, (b) water (climate source), (c) relief, (d) nutrient, (e) oxygen/root zone and (f) marine influence/soil texture & tidal flooding (soil source) of each land unit and other original data from climate and soil which is presented in a non-highlighted way. That is to say, the original technical information used in the process can be reassessed

simultaneously. Also featured is a table giving a resume of the principal attributes for each soil (Synthesis model developed by RESENDE, 1993c) unit and indicating the natural units into which they are allocated. The map of Natural Units has either a part of soil unit or an entire soil unit as the lowest level within a sub-zone - for this level the terminology is “province”. The visual communication was essential for speedy recognition of map units by interviewees Immediate textual description or a mental image of the map unit can be retained.

A feature, such as a plant species or a surface soil colour, is in this research considered an indicator if (1) it is related reliably and consistently to a specific amplitude or range of a variable of key interest and (2) there is a rational association between the feature and the variable. Indicators are a way of engaging our mental perceptions of the environment and our constructions of reality. In practice, we have to compartmentalize the real world in order to store information, access it for analysis, make decisions and plan action. This compartmentalization is a type of construction readily perceived at the field level when associated with field indicators. Associations of indicators to components of natural units, which have been consistently checked, are shown in the Table 8 and Table 9. These indicators represent a selection of current knowledge of field association with mapped natural regional units. These associations come from a process of field perception which is ongoing and kept under a continuum revision toward stable conclusions.

It is expected that, because of the increasing familiarity of the natural regional unit division, there is a temptation for the user to regard this division as more valid than others with obscurity in relationships with field indicators. The natural unit is strengthened each time it is successfully used as a natural unit description. The more useful it appears, the more it comes to be used; the more it is used, the more useful it seems. For this type of division which aims to convey regional differences feasible for immediate perception and location having potential for strengthening its recognition for a wide use is valuable.

TABLE 8 Indicators related to natural resource factors that delimit the natural regional units

TEMPERATURE Some human activities and biotic and abiotic relations with temperature at zone level.			
Mean Temperature[2]- Coldest - Hottest month month °C	Number of dry month[2]	Indicators[3]	Some peculiarities
Hot and Sloping[4]; Hot and Plain (red)[5]			
12 – 18 31 - 34	2 - 8	0 to 450 metres of altitude1 Robusta coffee and other tropical crops	The Hot Lands contain most of the(1) rich soils,(2) extensive flat land soils, (3) dry lands, and (4) great rivers of ES State.6 They also contain most of the fragile Natural Units, affected both by long dry seasons and low soil fertility
Mild and Sloping[4] (green)[5]			
9.5 – 12 28 - 31	0 – 4.5	450 to 850 metres of altitude1 Arabica coffee	Notable presence of deep soils and extensive rainy zone.7 High density of drainage network with permanent water sources
Cold and Sloping[4] (blue) [5]			
7 – 9.5 25 - 28	1 - 3	850 to 1.200 metres of altitude1 Little coffee arabica(just ascribed to the boundaries of mild zones) with simultaneous increase of farms which depend upon vegetable growth. More well drained dark soils, typical of high lands	Notable presence of deep soils and entire region into a rainy zone. High density of drainage network with permanent water sources. Absence(or nearly absence) of moderate or rich soils.

[1] Clustering information from climate map which was highlighted in the map of natural regional units; [2] Information found in climate map; [3] Biophysical field relations with temperature (altitude) were initially made looking at the original sub-divisions at the map of climate. [4] The first word refers to thermal condition and the second to the general relief landscape. [5] Colour in the map of natural regional units (See APPENDIX 9) [6] It also has great surface of poor plain and sloping soils and rainy lands. [7] It also has lands with the winter markedly dry in some points of the mountainous massif.

RELIEF Flat and sloping areas are easily identified at field level

NUTRIENT Red soils are an important indicator for a wide range of rich soils in Espirito Santo State (RESENDE et al, 1994).

FLOODING AND MARINE INFLUENCE (SOIL TEXTURE AND TIDAL FLOODING) Subject to Flooding, not Subject to Flooding, Tidal and Sandy Coastal areas are familiar at field level

WATER Some relations with water availability at zone level								
Hydrological Clusters[1]	Hot and Sloping, Hot and Plain (0 - 450 m)		Mild and Sloping (450 - 850 m)		Cold and Sloping (> 850 m)		Indicators	Some Peculiarities
	Legend[2]	Nº Dry month[3]	Legend[2]	Nº Dry month[3]	Legend[2]	Nº Dry month[3]		
Rainy	- - 3 - - 6	- - 2,5 - - 4	1 2 3 4 5 -	0 1 2,5 3 3,5 -	- 2 - 4 - -	- 1 - 3 - -	- - - - - -	- - - - - -
Rainy/dry Transition	7a 7b 8	4,5 4,5 5	- 7b -	- 4,5 -	- - -	- - -	- - -	- - -
Dry	9a 9b 9c 10a 10b 11 12 -	6 6 6 6,5 6,5 7 8 -	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - - - - - -	Presence of *Calotropis procera*[4]	Contain most of the rich soils of the State

[1]Clustering information from climate map which was highlighted in the map of regional units. the original subdivisions were discretely kept in the map of natural units. [2] Hydrological regional numbers found in the climate map which follow an order according to their amount of dry months. [3]Every month partially dry (P) is considered half a dry month.
[4]Field observation about the plant incidence and its relation with the hydrological original climate map number were taken through many trips in different places and in different year season.

Table 9. Factors and parameters for denominating natural regional units and examples of their relationships with field indicators

Factor	Parameter	Denomination	Examples Of Indicators[1]
		Zone	
Temperature	Altitude	Cold	- Altitude > 850 metres - Decreased occurrence of arabica coffee, and more vegetables.
		Mild	- Altitude between 450 and 850 metres - Arabica coffee
		Hot	- Altitude < 450 metres - Robusta coffee and intensification of other tropical crops
Relief	Quantity Of Components Classified As Level In The Soil Unit	Sloping	- Easily identified in the regional landscape
		Plain	- Easily identified in the regional landscape
Water	Quantity Of Dry Months	Rainy	- Descriptive and narrative examples (vigour of vegetation , for example)
		Rainy/Dry	- Only descriptive and narrative examples
		DRY	- Presence of *Calotropis procera*

Sub-Zone			
Nutrient	Total Quantity of Components, Quantity of Component Classified as Eutrophic and Its Rank Within A Soil Unit Remark: if a component is dystrophic or allic it is classified as poor.	Poor Intermediate Rich	- Absence (or near absence) of red soils - Presence of some red soils - Marked presence of red soils
Flooding	PRESENCE OF GLEY HORIZON	Not Subject To Flooding	- Easily identified in the regional landscape
		Subject To Flooding	- Easily identified in the regional landscape
Marine Influence	SOIL TEXTURE	Fine Textured	- Absence of sandy coastal lands
		Sandy Coastal Lands	- Sandy coastal lands
	TIDAL FLOODING	Not Tidal	- Easily identified in the regional landscape
		Tidal Flooding	- Easily identified in the regional landscape

[1]**These indicators are to complement information for the user who needs to locate a natural regional unit in the field which is represented in the map. Therefore, abstraction by the users is required for a field location of a regional mapped area.**

DOWNS & STEA (1973) explain that an attribute originates from a peculiar pattern of stimulation consistently associated with a particular phenomenon which, in combination with other attributes, signals the presence of the phenomenon.

The use of altimeters or visual indicators such as (1) arabica coffee grown in the Mild Lands, (2) robusta coffee grown in the Hot Lands (**temperature**) and (3) absence of arabica coffee growing with the concomitant increase of vegetable growing for the Cold Lands are examples of indicators for natural units at zone level (Tables 8 and 9).

Some natural restriction can control the opportunities for the development of some individuals of a species inside some boundaries. The "algodao da praia" or "algodao de seda" plant (*Calotropis procera*) originated in Africa, found favourable environments to propagate in Brazil and today is common all over its Northeast region(LIMA, 1975). As an indicator it has the advantages of being (1) easily spread, (2) easily identified and (3) it is sui generis in terms of capability to identify at zone level complicated phenomena (**water**).

Because most eutrophic soils are red in Espirito Santo State (RESENDE et al, 1994), colour can be useful to identify sub-zones of rich lands (**fertility**). STOCKING & ABEL (1981) also suggest the use of soil colour as an indicator

Relief, **flooding** and **marine influence** (texture and tidal flooding) indicate themselves directly for regional zones and sub-zones.

Other information making linkages between natural regional units and visual indicators, could be added. Attributes such as surface water availability (streams and rivers) and, soil erodibility are of considerable interest to natural resource assessment (FAO, 1993). For the Flat Lands not Subject to Flooding there are less streams and rivers than the Sloping Lands where the small farm population is greater. Within the Zone of Hot Lands, Dry and Poor can be found more problems of soil erodibility than inside Hot Lands Rainy and Poor because the action of two stresses simultaneously (poor and dry) is more severe (RESENDE et al.,1995).

The 9 zones and 34 sub-zones were also classified on the current degree of certainty in their identification with indicators. They can be broadly classified as: 1) unambiguous, 2) ambiguous

but promising and 3) ambiguous. The terminology **unambiguous** signifies an indicator readily recognizable and always present. **Ambiguous but promising** means (a) indicator readily recognizable but not always present or (b) expressed with reduced degree of ambiguity due to a notable presence of a causative factor but still depending upon descriptive or narrative explanation. **Ambiguous** means an indicator expressed with ambiguity due to a gentle presence of a causative factor but possible in being well expressed when supported by descriptive or narrative explanation.

The nested areas which form spatial patterns that come from the adopted ranges for temperature, relief, flooding and marine influence (soil texture and tidal flooding) belong to the category of indicators unambiguous which means prompt, logically and clearly identified. Because altitude is an easy parameter to be assessed, even the transition zones for temperature (mild zones) do not provide problem, being promptly and clearly identified.

For both water and nutrient criteria for transition zones, the identified indicators are somewhat inexact. For example, in the rainy/dry transition zone or moderate fertility transition sub-zone only descriptive narrative is currently available to identify the mapping unit. Where *Calotropis procera* comes in for dry lands, greater certainty is possible. Moving into either rich or poor fertility areas, the presence or absence of red soils reduces the degree of ambiguity.

For the extreme zones in the aspect of parameter 'Water' (dry and rainy) the presence of *Calotropis procera* is enough to indicate dry land in the surrounding area. Aspects of vegetation forms in rocky surfaces, in sandy coastal areas or vigour of vegetation during the year are potential examples just to name a few of many other probable observations that can be developed. For the extreme zones in the parameter 'Nutrient' there are indicators such as intensity of red or "white" (pale) soil in the landscape, presence of cocoa farms along the river on a non red coloured soils and many other situations which are able to lead the user to match the mapped natural unit with the characteristic of the landscape. That is why for both these conditions of extreme (1-dry and rainy; 2-rich and poor) the possibilities of indicators is classified as "ambiguous but promising".

Within each unit, combinations of indicators for different specific ranges of variables help to identify the natural unit at Zone and Sub-zone levels. Although the development of this approach using indicators was somewhat subjective, they facilitate the field identification of the unit. The identification of indicators shows a satisfactory coverage for the different range of variables and the progress achieved suggests that the current degree of ambiguity can be reduced with the development of more studies involving field observations are done.

5.2 Suitability to ES' s needs

Due to the multiplicity of aspects involved it is impossible for any one natural regional unit description to accommodate all complexities. However the interviewees strongly agree that the Espirito Santo State needs a simple procedure to express its natural divisions. The map of natural units tends to encompass regional topical questions relevant to the development of needs in Espirito Santo rural areas. From the functional perspective there is also a need to look not only at the advantage in having indicators but also to see how demands for the development plans and priorities in ES can be met by adjusting the process of natural units design (Table 10).

Table 10. Demands in form of development plans and priorities in ES State and its translation into design information priorities for representation of natural regional units

Es Demands	Priorities In The Design Of Nat. Reg. Units
Map Scale	
- map which covers a large area (45.000 Km^2) on one map sheet, e.g. a scale of 1:400.000.	- small number of key variables selected only from original basic data source. Possibilities to re-access the original data source.
Interpretation And Transference Of Knowledge	
- Practical and simple to be interpreted and transferred.	- values of physical information which provide fundamental "genetic linkages" with the potential biological or social performance. - field-based systems (indicators) for natural regional resource data interpretation. - involvement of geoscientists in the necessary changes in the scientific and technical communication. - evaluation in the light of the user views - providing workability with data which were usually restricted to the use by trained professionals.
Decision-Makers, Planners And Planning Team	
- natural regional resource information capable of integration into decision-making processes of different professions.	- terminology and display in a format which is familiar to non-specialist users.
Information Management	
- selection of fundamental physical information which underlies causative regional qualities and constraints in biophysical, economic and social aspects. - ability to extrapolate for a wide range of different demands.	- to speed data access. - new variables and new rearrangements of feasible variables must be related to the pattern of old original source. - clear meaning and location of the selected physical attributes. - selection of clustering of some original values of temperature, relief, water, nutrients, oxygen (in the root zone) and marine influence (soil texture and tidal flooding) according to specific design for ES.
Regional Zoning/Rapid Regional Appraisal	
- diversification of activities taking advantage of the diversity of environments, ecology and potential of land use. - information workable for policies of project prioritisation, and spatial investment distribution. - information that makes clear remarkable environmental differences as a preliminary source of data for different specific practical use.	- expressing fundamental regional diversity of environments and ecology. - natural regional units description avoiding shortcomings of descriptive ambiguous terms - natural resource data providing linkage with the main biophysical qualities and problems. - divisions displayed through an intelligible natural regional unit.
Support To Sustainable Development	
- land tenure and settlement of peasants. - suitable activities which demand low input technologies for those who have limited land, labour capacity, capital and inadequate access to credit, infrastructure, technology and social assistance. - activities that provide more income and control over their own resources for those neglected socially, economically and physically (environmental limitations). - activities that help stem the massive rural-urban migration. - maintenance of land capability and intrinsic productivity.	- emphasise the regional natural resource points that should clarify and encourage a quick understanding of the natural units content emphasising those main limitations which the development of activities or any other biological phenomena should cope with.

6. Evaluation

This research addresses the difficulty that non-specialists face in accessing and using information on natural resources (See confirmation by users on Table 11). The map of natural units (1) considers only the use of original source of natural resource data and (2) aims to provide information for non-specialist users. It asks: can the power of perception, interpretation, and transference of knowledge be improved?

Dividing the real world into 'natural units' is somewhat arbitrary and subjective but for the current problem area on descriptive information in Espirito Santo, a design is needed where ecological information of the spatial patterns of the State can be used as a common baseline for communication. A general aspect evaluated after the map presentation was how well some information brought together (natural units) guide the user. Different angles for analysis of improvements on this general question were explored by a questionnaire. Paired histograms corresponding to all these questions were analyzed and improvement on user' guidance can be consistently seen cross-checking trends of many related questions.

Table 11 summarizes the spontaneous user views (e.g. interviewees' free opinions) about the use of the available source of natural resource information for general regional analysis (1) before the presentation of the map of natural units and (2) after the map of natural regional units was presented by this research. It is interesting to consider how individual spontaneous expressions are touching different relevant angles of the problem area in study. Because the response reported in Table 11 was spontaneously given, and because it is grouped under single expressions, some detail is lost. Nevertheless, the frequency of response gives a good measure of the strength of feeling in the interviewee group as a whole. However, individual responses are valued for their perspective insights of the success of the map of natural units.

Table 11. Extracts from interviewees' free observations[1] which spontaneously emerged before (A_1) and after (A_2) the presentation of the map of natural units developed by this research

Before Any Discussion	After Map Presentation
A_1-Natural Resource Sources For Regional Analysis	A_2-Map Of Natural Regional Units
Accessibility	
Shortcoming * difficult comprehension and practical application, slow access to information and skills for the user is required (12) * simplification of details required (1)	**Quality** * intelligible, simplified, clear, well displayed and easy for transmission (17) **Shortcoming** * skills for the user required (1)
Presentation	
Shortcoming * need for map synthesis (15) * legends simplification required (5) * standardised scales required (4)	**Quality** * coherence, feasible design for a quick recall, representing well the factors and easy for regional comparison (10) * much information shown simultaneously(1)
Effectiveness	
Quality * feasible use (1) **Shortcoming** * time and effort required (6) * need for computer support (5) * updating required (3) * field indicators required (3) * data access (2) * quality of information required (1) * regional comparisons difficult (1)	**Quality** * easy comprehension and fast access to information (3) * self-explanatory (3) * clear spatial divisions (1) * development of subsequent detailed levels feasible (1) * synthesizes information (1) * practical application (1) **Shortcoming** * need for different additional data possible (1)
Others	
* variation on intelligibility of sources (3)	

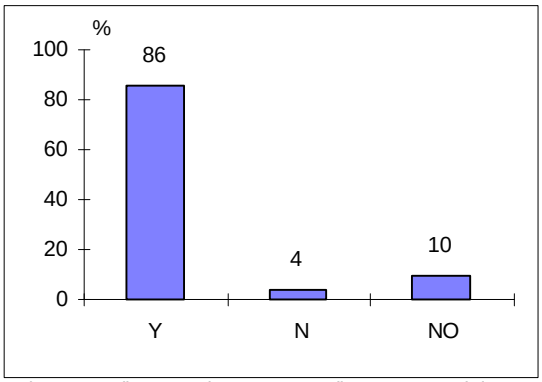
[1]**Number between brackets represents interviewees of whom information was taken to form that expression.**

It is interesting to note in Figure 5 the difference in type and form of responses between the two interviews. In the first, shortcomings in the traditional information sources were usually noted. At this interview many suggestions for improvements were given. The second interview had fewer responses and suggestions for improvement decreased considerably. Reasons for this could include the significantly (1) better system when a selection of information is brought together (natural units) and (2) the complete contrast in user-friendliness.

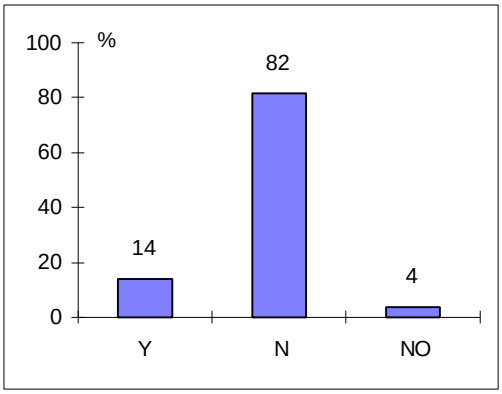
Trends on improvement of perception, interpretation and transference are analysis selected and shown on Figure 6 It can be concluded through the sign test (CAMPOS, 1971; CONNIVER, 1971) that the perception, interpretation and transference of knowledge, **before** and **after** presenting the map of natural units, are different at a significance level of 5%. It may be concluded that the values of medians taken before and after the research presentation (Figure 6) demonstrate significant improvements in perception, interpretation and transference of knowledge.

Before Any Discussion	After Method Presentation
A_{1}- Natural Resource Sources For Regional Analysis	A_{2}- Map Of Natural Regional Units

Percentage Of Respondents Who Displayed Ideas For Improvements

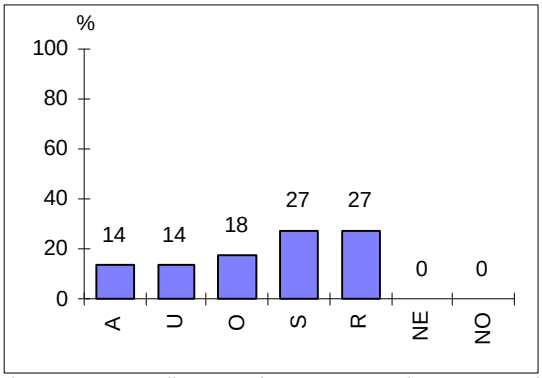


Y - yes(presented); N - no(not presented); NO - no opinion



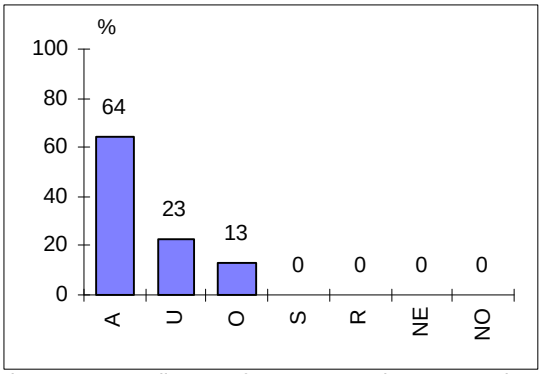
Y - yes(presented); N - no(not presented); NO - no opinion

% Respondents consulting sources when information is required[2], divide into categories of consistency of use



A - always; U - usually; O - often; S - sometime; R - rarely; N - never;
NO - no opinion

% Respondents that would consult the map when information is required[2], divide into categories of consistency of use



A - always; U - usually; O - often; S - sometime; R - rarely; N - never;
NO - no opinion

[1]Questions and response categories were fixed and determined in advance; respondent chooses from among these fixed responses.
[2]It should be pointed out that even in situations, which require such consultations, some users avoid doing so.

Figure 5. Interviewees' observations [1] taken before (A_{1}) and after (A_{2}) the map presentation about (1) suggestions for improvement (percentage of interviewees) and (2) frequency of access to sources when required [2] (percentage of interviewees)

Figure 6 Gain perception, interpretation and transference of information on the views of the non-specialists interviewees[1]

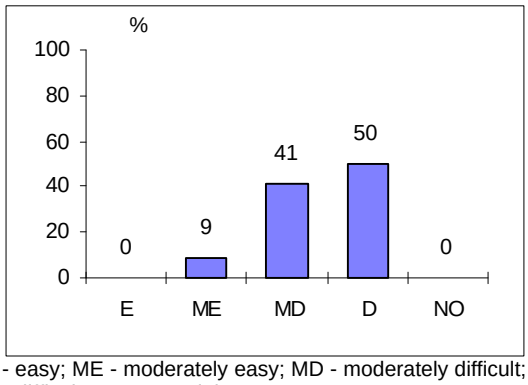
Before Any Discussion

A_{1}- Natural Resource Sources For Regional Analysis

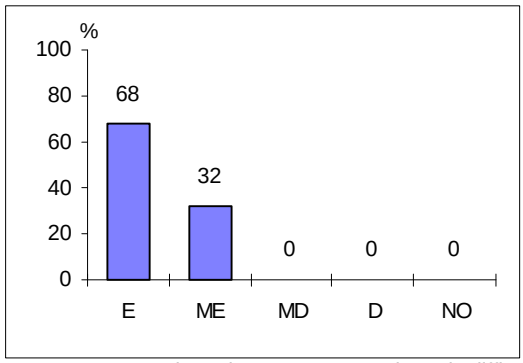
After Method Presentation

A_{2}- Map Of Natural Regional Units

Perception

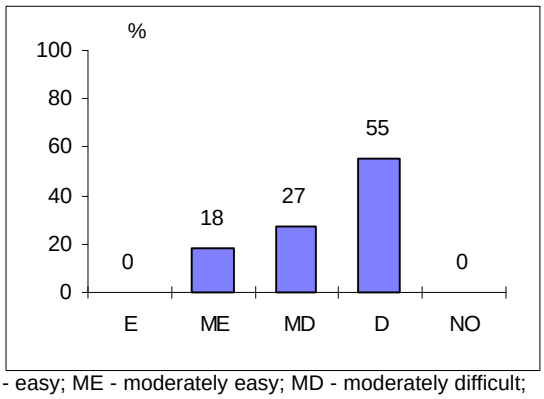


E - easy; ME - moderately easy; MD - moderately difficult; D - difficult; NO - no opinion

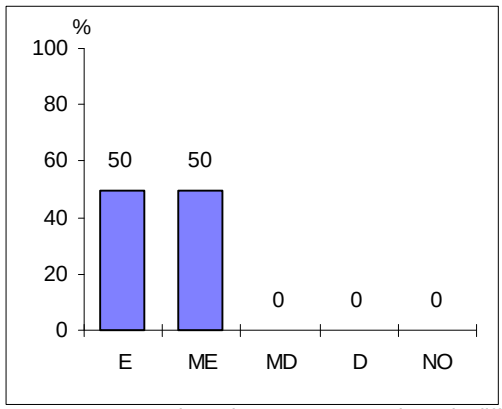


E - easy; ME - moderately easy; MD - moderately difficult; D - difficult; NO - no opinion

Interpretation

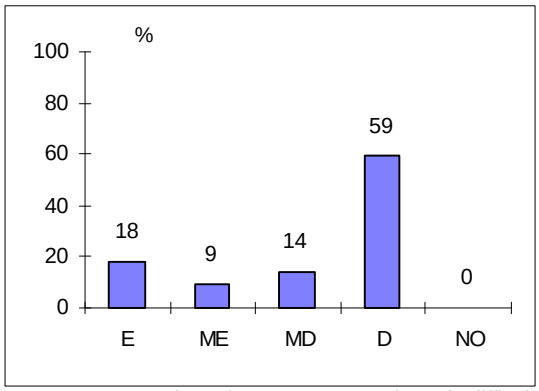


E - easy; ME - moderately easy; MD - moderately difficult; D - difficult; NO - no opinion

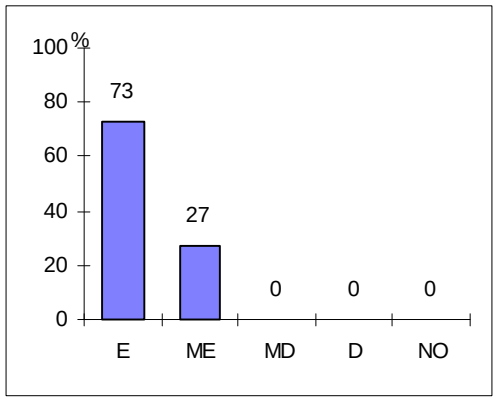


E - easy; ME - moderately easy; MD - moderately difficult; D - difficult; NO - no opinion

Transference



E - easy; ME - moderately easy; MD - moderately difficult; D - difficult; NO - no opinion



E - easy; ME - moderately easy; MD - moderately difficult; D - difficult; NO - no opinion

[1]**The same 22 interviewees were the respondents before and after.**

In some way to talk about the influence of the use of synthesis in terms of providing more perception is misleading; it may suggest or even promote an unconscious belief that the synthesis is an obvious agent that acts upon human perception. This, of course, is not strictly true, except in a very limited sense, as for example, in the context of ES State where in the absence of an alternative, the non-specialist user is forced to consult a large number of large extended individual original regional sources of information (See Table 11, about interviewee's spontaneous observations). The difference is that in order to do synthesis through a design of natural regional units, the physical and environmental data used were selected as a conventional representation of a natural condition but are now designed and tested within a format which was not accessible before. Although synthesis may be adjusted to relevant data, its effects do not have the same strengths in both users' contexts, being much less among specialists than among non-specialist users.

Even if the best possible description to display information is not achieved, the familiar terms in which the natural unit is based can be reflected in a relative gain in transference of information to the non-specialist users. One indicator of this is that interviewees would consult regional information from the map of natural units with higher frequency than the traditional sources (Figure 5). The map also retains immediate capability to re-access the original information. Thus the approach of the map of natural units makes information immediately available and this effect of giving accessibility for a set of relevant selected information provides a means for a gain in perception to non-specialists users.

In this research, the parametric approach was used as a complementary method of the physiographic approach or vice-versa. The natural unit denomination is a direct referral to their parametric approach. Because the natural units are retaining the benefits of double approaches, some advantages in relation to the "Microrregioes Geograficas" system (FUNDACAO IBGE, 1990), Itapemirim basin divisions (LANI, 1987) and river basin units can be observed. They are: (1) the immediate translation of their divisions to other idioms is feasible; (2) there is immediate linkage for re-accessing the parametric related information; (3) indicators can be immediately linked with main specific variables of the division.

For regional analysis, the basic problem is the determination of what gives any region its essential distinctive quality, and it is only on that basis that satisfactory regional lines can be drawn. Here we must be concerned with the physical framework, its functions, and also with the regional images which can be taken by the non-specialist users. The design of natural units is dealing in many ways with a pattern of factors that tend to operate as a unit, which is more than the simple sum of its parts. For example, the natural units Cold, Rainy and Poor Land are more meaningful than the separate totals of its temperature, "water" and nutrient components; that same original data soil unit conveyed as poor (nutrient component) in other context (e.g. Hot, Dry and Poor) does not have the same interpretation as in this one context of Cold, Rainy and Poor. Each aspect of an natural unit exists in context, is interrelated with other aspects, and cannot be understood completely unless it is seen in its total context, nor can the area as a whole be understood unless all of its interrelated aspects are seen. Users identify themselves with their own area and with its characteristics, including landscapes, seasons, and a host of other attributes which differ from region to region and this justifies the attention given to a design where the clustering process derives strength from the

consideration of biophysical relations. This information is not only described in an intelligible and tested format but also transparency is immediately shown in the way data from original sources come together to form the natural units division of the State.

It would be strange if such an obviously limiting or conditioning factor as climate and soils, one that varies so greatly from place to place in ES, did not have a discernible part in influencing the pattern of human society. But this does not mean that people who live under certain climatic and soil conditions are bound to think or live in a certain fixed way, or that climate and soil of some part of the State gives to its inhabitants a distinctly progressive or backward character. The environment usually operates as a whole. To isolate one of its factors and ignore the others is to misrepresent the actual situation, where there are a host of non-environmental factors operating as well, and where technological change is also taking place. The physical environment considered in the natural regional units is important as one of many influences on man acting in concert, not as a determinant. It is both difficult and misleading to examine the environmental influence without continual attention to other influences.

MURPHY (1972) claims that to make regional divisions intelligently, it is firstly necessary to understand as well as possible what gives the region its coherence and distinction, what its essential unifying or common qualities are, and secondly to determine the transition where these qualities significantly diminish and are replaced by another set of qualities belonging presumably to another region. He points out that usually there is a wide zone of transition and the line is difficult to draw. Both these characteristics of coherence and distinction were in the natural units successfully developed and users reacted optimistically to this quality presented (See Table 11 – presentation).

User response shows a positive reaction to the general application for field reconnaissance about what is shown on map. The design of the natural unit gave priority for the use of “all” that might be friendly, instructive-educational and accessible to immediate attention. The information science was re-arranged in a user-friendly communication and specific indicators for classes of each variable were studied. These indicators will work as a “track” or “finger print” of the natural units for a better field perception and as a consequence better dissemination and acceptance by the user. It is interesting to observe how at any moment attention may be directed to just one part of a situation and the result of such attention can be a regional perception. The perception consists of information obtained by any number of different senses from that part of the regional environment, which is being attended to. For example, for confirmation of a Dry region the mere observation of *Calotropis procera* presence, even though during the rainy season, would confirm or assure that zone designation. This indicator synthesizes in this way the expression of all complicated technical regional information for dry zones. All the senses may contribute to the perception, but for this example one of them alone is sufficient. The purpose of this study of natural units is to understand and explain, or at least to make available an important part of regional accumulated data which set man within the frame of the lands which he inhabits; this necessarily involves critical examination of man’s interrelations with his physical base, as well as the variety of other factors which influence him and which contribute to regional differences. In this way a set of indicators for the regional differences are discussed but development of studies for more indicators are still in need.

Self-critical judgements of this research and as a consequence characteristics of the natural regional units, its strengths and weaknesses were shown on Table 12.

Table 12. Strengths and weakness of the natural regional units of ES State, Brazil

Characteristics	Strengths	Weaknesses
- Intelligible format for natural unit divisions using unfamiliar observations from original data sources.	- Immediate user comprehension and fluency on its use feasible - All information at one map - The map makes clear the way information from original sources came together to form the natural units. - Immediate fluency on units denomination by users of different languages is feasible - Units can be read without legend referral - Two integrated legends are provided: (1) user-friendly and (2) technical - Many aspects of biophysical, economic and social importance and specific to ES can be related (meta-data) - The process for units denomination is logically linked to prominent factors and reproducible - It immediately shows how units differ from each other - It is designed to be used by non-specialist - It is physiographic and parametric - Retains capability to re-access specialised or original information sources - Available in both (1) digital and (2) hard copy format, providing areal references and location and also in (3) schematic format (decision tree).	- It does not show which is the one dominant factor and the other subsidiary ones - It's a man-perceived classification of a welter of areal differences which actually is a continuum of natural regions. - It can not assist demands other than those related to the variables considered - For some shortcomings detected in the original sources a new survey, reclassification or modification of original data were not carried out - Its methodological concept is imposed. - More indicators still need to be developed

In this research a balance between simplicity in the expression of natural units and simplicity of its relationships with some indicators seems to have been achieved. The natural unit expression itself can be easily mastered by non-specialist users. The study of technical organization of natural units and the use of re-accessibility of original information are greatly facilitated when both specialists and non-specialists are working together. The importance of this creation of assemblies of basic natural units in ES State

should eliminate the dilemma of ambiguous communication for expressing situations when some more ecological instructive-educational and enlightening location and description of regions.

6.1 Conclusion

The major findings for this investigation are:

- The natural units offered to users a sound basis for field reconnaissance of complicated environments in order to match regional program and planning decisions with the characteristics of each environmental regional unit.
- The spatial data and its system design was evaluated successfully for non-specialist users.
- The methodological stages in implementing the map of natural units have potential for application in other regions.

For the map of natural regional units the results are qualitatively useful for areal reference and indicative of apparent magnitude of regional quality and problems. Two distinct aspects are involved in the design of the map of natural units: 1) **preservation of original quality of information** and 2) **improvement in communication**.

Whether the information is presented as individual variables or as one integral map, the original **quality** of information must be preserved. Five situations in the preservation of quality were challenged:

1. The assembling of different key variables within one plane of information: this difficult process was feasible and in practice demonstrated.

2. The intelligibility for non-specialists requiring natural resource information: this accessing of needed information is enhanced, as evidenced through the user evaluation.

3. The flexibility to re-access original information sources: because the original data quality is preserved, this process is made possible for particular users who need to go back to original sources.

4. The employment of field indicators: many of the mapping units have easily-identified indicators, thus assisting the process of mental recognition and observation.

5. The clarity of the criteria in the construction of mapping units providing an immediate idea of the basic principles used (specialist information).

Data transference is at the heart of the process of information retrieval and **communication**. The objective is to enhance the presentation of the information in order to make it accessible to all users. In order to meet the needs of **communication**, the following attributes were important:

1. a logical and reproducible process for designation of natural units;

2. a legend and designation that provides an immediate understanding of the nature of the unit;

3. flexible output for units as area reference and schematic diagrams.

7. Further Developments

This research leads naturally to further developments in the use of information systems in ES State. Some of these developments help to fill gaps in the current research: others are a natural progression and further refinement of techniques and methodologies. Clearly indicated are needs to:

- disseminate the use of natural regional units,
- manage attribute data of natural regional units with GIS tools,
- increase the level of detail and develop further criteria for subsequent natural units.

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