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COST-EFFECTIVENESS ANALYSIS IN THE COASTAL WATER QUALITY SECTOR: A PRIORITY IN THE FRAME OF THE ICZM

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ABSTRACT

The Cost-Effectiveness Analysis (CEA) is the method most commonly used for the assessment of the costs and effectiveness of alternative policy options on the environment.
The objective of this paper is to describe the priority of the policy area "coastal water pollution control from land uses, in catchment area" in the frame of an Integrated Coastal Zone Management (ICZM).
The evaluation of related ICZM options is effected through use of the CEA; this policy area can be a distinct study, on which other seafront management ICZM policy areas can be based.
This is also based on the fact that the indicators used in the Coastal water pollution control from land uses policy area are different from the indicators for seafront management. The differences in ICZM indicators result to a lower number of variables, and consequently to a better development and use of all the data. In the present work the indicators needed for the application of the CEA in the water quality policy area are identified.

KEYWORDS: Integrated Coastal Zone Management, Indicators, Watershed pollution, Coastal water pollution.

INTRODUCTION

Integrated Coastal Zone Management (ICZM) "is a dynamic, continuous and iterative process designed to promote sustainable management in coastal zones" (E.C., 1999a).
As cited in FCR and GSES (2000) "From a pollution perspective a whole river catchment could be considered and from an economic perspective the coastal zone could be highly varied. There is no universal definition of the extent inland of 'the coast'". According to EUCC (2000) there is no formal definition for the boundaries of a coastal zone. They are decided upon on a case by case basis, usually at the municipality level, and are dependent upon local pressures and competing resource uses.

In each ICZM case study it is necessary to identify the main components of the seafront economies (sea dependent and sea enhanced uses[1]) in order to determine a fisheries and aquaculture policy, the sustainable levels of tourism, biodiversity protection measures, the appropriate transport networks, a coherent spatial planning-zoning, and the economic and social well-being of coastal zones in general.

[1] Uses, sea dependent: related to uses that require direct access to the sea to accomplish their primary function, Uses, sea enhanced: related to uses that do not require access to the sea, but are enhanced by a seafront location (adapted from Walker and Arnn, 1998).

Given the interdependence of the seafront policy areas, it is meaningless to propose management measures in one policy area without undertaking a parallel study of the indicators related to the others, e.g. for a sustainable tourism policy it is also necessary to study fisheries and aquaculture requirements, the plans for zoning regulations, the balance of the ecosystem, etc.

The participation of all interested and potentially affected parties, and the understanding of conflicts between stakeholders, are prerequisites for the design of successful sustainable management plans (E.C., 1999a, 2001a; UNEP/MAP/PAP, 2001). A coordinated effort is therefore needed for the effective collection and processing of all the relevant information and interconnected indicators, in order to define the sustainable levels of all seafront activities.

Furthermore, in the frame of an ICZM, the study of indicators for the control of existing coastal water pollution is also included, in addition to those pertaining to the support of the environmental, economic and societal objectives in the seafront area.

The UNEP/MAP/PAP (2001) report states that "programmes and projects have failed by attempting to cover too many areas at once, thus remaining superficial, and gradually rendered either irrelevant or restricted in their ability to resolve the problems faced by local authorities and their publics. It is essential to prioritize coastal problems and proceed to deal with the easiest first". The objective of this paper is to present the necessity of prioritizing obtaining information on current coastal water pollution from existing land uses in the corresponding catchment areas, as well as an assessment for the costs and the effectiveness of the relevant control measures (CEA), in designing suitable seafront management plans.

A synthesis of the indicators for the application of CEA in this pollution control policy area is also presented in this paper.

The report of FCR and GSES (2000) states that "not all the ICZM teams (Demonstration Programmes) appear to have ever assembled the basic data for their coastal zones and a degree of standardization could have benefits in terms of future inter-project comparisons" (p.7).

It should be noted that in the frame of an ICZM, the policy area "prevention of marine pollution" is considered different to the "Coastal water pollution control from land uses" policy area, taking into account that other indicators should be studied for its elaboration (Table 1).

COASTAL WATER POLLUTION CONTROL FROM LAND USES IN THE FRAME OF ICZM

In Table 1 a classification of ICZM thematic policy areas is presented, on the basis of: i) the actions needed in order to achieve their objectives, ii) the geographical area of data needed and iii) the method used for the evaluation of proposed management measures.

The indicators needed in the "PA-1" could be studied independently to those included in the other policy areas, in the frame of an ICZM. This aims at a better development and use of all the indicators required for the support and monitoring of ICZM policy responses, and is based on the following considerations:

a) The method of evaluation for proposed measures for land pollution control (PA-1, Table 1) is different from the evaluation methods used in the design of the other ICZM policy plans. Specifically:

According to the EU Water Framework Directive (WFD), the CEA is used for the assessment of the costs and the environmental effectiveness of the measures applied for the control of water pollution resulting mainly from land uses in a catchment area (E.C., 2003; Zanou *et al.*, 2003). Taking into account the pollutant sources, and their contribution to water pollution, a study is being carried out for the selection of the least-cost appropriate measures in each case study.

On the other hand, the Cost-Benefit Analysis (CBA), the Multicriteria Analysis (MCA) or other models with the capability to elaborate socio-economic and environmental impacts of future alternative development plans, are used for the "PA-2" (Table 1), where multisectoral economic and social benefits are interrelated.

Sometimes, the CEA is confused with the CBA. The basic difference between these two decision-support tools is that in a CEA the economic cost of a management measure is compared on the basis of its effectiveness in physical units (e.g. tons of N/nitrogen abatement per year), allowing a relevant rating of the examined measures, while the CBA evaluates measures absolutely by expressing all the effects in monetary terms. The problem with using the CBA is to reliably assign monetary values to the ecological consequences of emission reduction policies (Schleiniger, 1999; McAllister, 1995).

Table 1. ICZM thematic policy areas

ICZM Policy Areas (PA) Headline indicators	**Actions** – Group of indicators	**Data** *(Geographical area)*	**Evaluation of measures**
PA-1: Coastal water pollution control by land uses in catchment area	-Agro-environmental policy -Industrial waste management -Domestic waste treatment (sectoral analysis: integration of environmental principles per land use sector, environmental responsibility to users)	Data per municipality for all the catchment area (sub-catchments division)	Cost-Effectiveness Analysis (CEA)
The study of the hydro-morphological alterations (operation of land reclamation works, hydroelectric dams, etc) is also included in the assessment of the coastal water quality by land uses			
PA-2: Seafront management	-Zoning regulation[1] (land use categories changes, deforestation, decrease of areas covered by water, urbanization etc) -Tourism policy[1], carrying capacity assessment - Coastline and marine constructions -Fisheries policy (over-fishing, mooring sites, leisure navigation, etc[2]) - Aquaculture development (feasibility study[2]: site, forms of intensity etc.) -Preserve of wildlife habitat, historic resources, -Increase of public welfare (public access to coast, recreation opportunities etc.) - Second homes, sand extraction, - etc. *(multisectoral and cross sectoral economic growth with resolution of conflict uses and progress of social welfare)*	Determination of the geographic extent of coastal seafront area (inland length) with conflicting uses and overexploitation of natural resources: Data for coastline municipalities, or/and use of satellite images	Cost-Benefit Analysis (CBA) or Multicriteria Analysis (MCA) *or other models having the capability to elaborate socio-economic and environmental impacts of future alternative development plans*
PA-3: Prevention of marine pollution	Organization of marine transportation, of actions in marine accidents (oil slicks, chemical spills) and natural damages (storms, etc), monitoring, station of observation, anti-pollution ships etc.	Shoreline classification, biological resources, sensitivity of natural persistence of oil etc	

[1]Data for the agricultural holdings (hect.) and the industrial units in the seafront municipalities, as well as for the treatment of urban wastewaters, could be used from the PA-1 data base.

[2]Data for the control of polluted land use activities, which influence these sectors, is included in PA-1 data base

Another difference between these evaluation methods, in addition to their different results and cost variables, is the discount rate. In the CBA the social discount rate is used, while in CEA the financial discount rate is appropriate (Florio and Vignetti, 2003). Moreover, in the MCA a simultaneous consideration of multiple, often conflicting, objectives is realized. In the MCA alternative scenarios are ranked, including environmental and socio-economic values with different weights and points of view, in order to select the most preferable option (Nijkamp *et al.*, 1990; Hermanides and Nijkamp, 1997).

The data needed for the application of the CEA in the "PA-1" are therefore different from those required for other methods used for the evaluation of the measures in seafront policy areas.

b) For the planning of seafront activity-related policy options ("PA-2", Table 1), data on the cost-effectiveness of the pollution control measures ("PA-1") should be considered, and they should thus already be prescribed.
c) The control of land pollution, in addition to waste water control and the development of the existing agricultural and industrial

activities based on sound environmental principles, is a prerequisite for the success of seafront economic activities (tourism, fisheries, aquaculture) and the increase of social welfare.

d) The indicators used in the "PA-1" refer to the municipality level in a watershed area, while the indicators for the "PA-2" are related with data for the seafront municipalities only.

e) In the "PA-1" sea-dependent and sea-enhanced end-users are not involved (such as people involved in fisheries and aquaculture). Therefore, fewer people need to be coordinated in the management process.

HEADLINE INDICATOR "COASTAL WATER POLLUTION CONTROL BY LAND USES IN CATCHMENT AREA"

In order to decrease coastal water pollution by land use activities in a watershed studied ("PA-1") with the least cost, CEA indicators are needed, related to:

- the relevant pollutants and the environmental targets for these
- the support of the identification of policy measures, and their cost
- the monitoring of the application and effectiveness of policy response options and
- the support of the users in appreciatingthe impacts of their own actions (reflection of their actions in the indicator value).

In the following paragraphs the indicators that could be considered a basic reference for the application of the Cost-Effectiveness Analysis (CEA) in "PA-1" are presented:

Environmental Indicators in "PA-1"

According to the E.U. Water Framework Directive (WFD, 2000/60/E.C) in order to achieve the "good status of coastal water", biological indicators (aquatic flora and benthic fauna) should be identified. These indicators will be used for the assessment of the ecological quality, in an area studied, where reference conditions will be specified, the metrics will be selected and deviations from the references will be estimated. However, their use in the assessment of the environmental effectiveness of a measure should be tested once adequate data have become available. Nutrient conditions are currently used for the identification of water quality status and the determination of the environmental effectiveness of a policy option. As cited in WFD, these chemical elements will also used in the future for the support of the biological indicators. Thus, the environmental indicators used in "PA-1" are those concerning:

a) The pollutants (nutrients, BOD, heavy metals, etc) by source, i.e. emissions from:

(%) fertilizers
(%) pesticides
(%) erosion
(%) industrial units - sectors mostly responsible
(%) urban wastes
(%) atmospheric deposition
(%) groundwater

b) The set environmental targets. For example, if the target is the decrease of nitrogen loads (N) the following should be identified:

- • The total reduction of N emissions in coastal water (%)
- • The reduction of N emissions in coastal water from:

(%) fertilizers, pesticides
(%) erosion
(%) industrial units - sectors mostly responsible
(%) urban wastes
(%) atmospheric deposition
(%) groundwater

If another target is determined, relevant indicators will be used (e.g. if the target is the decrease of P loads, it is necessary to know the level of the reduction of P emissions etc).

This identification of the environmental targets is very important because if the target is the reduction of the phosphorus loads (P), pollution decrease by a large percentage can be achieved through cheap measures (e.g. wastewater treatments), compared to the application of measures for a corresponding reduction in nitrogen loads (N). Conversely, if the target is the reduction of N there are measures (e.g. restoration of wetlands, reduction of fertilizers etc) with lower effectiveness in the reduction of phosphorus (P). Furthermore, the greater the percentage by which pollutant loads decrease (e.g. 30% reduction of N or 40%, 50% etc.), the greater the requirement is for the application of measures, either in quantity or in geographical scale.

Indicators for the identification of policy options in "PA-1"

According to the environmental indicators, policy measures should be applied for the control of the agricultural run-off or/and the treatment of industrial and urban wastes. Furthermore, if hydro-morphological alterations have a negative

Table 2. Indicative list of agro-environmental management options in "PA-1"

New mode of cultivation	Reduction in the use of chemical fertilizers/pesticides
	New irrigation techniques (e.g. irrigation in drops)
	Recycling/ conservation of water use, Use of treated effluents, Crop residue use
	New tillage practices
	Reduction of manure use and changes in application practices
New crops	Organic farming
	Catch crops
	Winter crops
	Crop rotation
	Products with "name of origin"
Land use changes	Buffer zones
	Restoration or construction of wetlands
	Land under fallow
	Terraces
Land reclamation works	Dams-irrigation works, channels for the drainage of stagnant waters, flood control, etc. *(control of their operation)*
Education - consultation of farmers	Training, discussion meetings, advice in farm, travels to farms which already have implemented successful planning, etc
Increase of farmer' income through new activities	Agro-tourism etc.

Source: Zanou *et al.* (2004)

impact on water quality, measures for the control of the operation of land reclamation works, hydroelectric dams, and etc. should be also examined.

The socio-economic indicators needed for the identification of management measures are taken per municipality in a catchment area. Some indicators could be on a wider geographical area, such as the County level, but those often exceed the boundaries of the watershed.

Thus, taking into account that it is necessary to have a large amount of data on the municipality level and that a great number of municipalities are included in a catchment, particular attention should be given to collecting only the necessary data. For that reason, in the case of certain indicators only most recent data is needed, but for other indicators data from previous year is necessary for comparison (Tables 3, 5, 6). Furthermore, data for the Country average, as comparative data, could also be collected (e.g. the wheat productivity in "x" municipalities is greater than the Country average).

In the tables where the data is registered, the presentation of the municipalities in alphabetical order is not suitable,; instead, listing them according to their geographical position, in each sub-catchment, helps the definition of the zones of activity, and also makes finding them on the map easier.

Moreover, a serial number (S.No) could be assigned to each municipality in the process of their registration in the tables, as well as to their reference in the text, for their quick finding from one table to another and for their easy presentation in the text (e.g. the municipalities S.No: 7-15 concentrate more than 80% of the wheat production).

In the following paragraphs, the socio-economic indicators that could be considered principal for the application of the CEA to the main pollutant sources (agricultural run-off, domestic and industrial wastes) are described. In these indicators supplementary data are not included that could be required for the assessment of nitrogen surplus.

It is essential to note that in order to access the relevant requirements for the selection and application of the most appropriate management measures, in each case study, cooperation between all the relevant interested and affected parties is necessary during all planning and implementation steps, in order to have information about:

i) the national legal and administrative framework,
ii) the political planning (local development plans in progress or submitted proposals for financing),
iii) the available financial means and

Table 3. Indicators for the identification of agro-environmental options in "PA-1"

Indicators *(Data for all the municipalities in watershed studied)*			**Notes**
Indicators related to the importance of this activity in the area studied	(%) GDP of the primary sector to the total GDP *If there is no data available per region, data per County (NUTS 3 level) is used*		
	(%) of the economically active population in the primary sector		**Data also from previous years-trends**
	(%) of the cultivated areas in the total land use		**Data for the Country average (e.g. the wheat productivity in "x' municipalities is greater than the Country average)**
Indicators for the identification of the cultivations causing the water pollution	Arable crops area (hect.) and their percentage of all the cultures (vineyard, tree culture etc)		
	Irrigated areas and irrigation systems		
	Principal arable crops (area, production) and productivity indices (t/ha)		
	Used nitrogen fertilizers, pesticides		
Other indicators and data needed for the identification of the appropriate measures	- Organic farming - Agrotourism - Products with name of origin.		
	Size of farms		**e.g. if the agricultural holdings are small it is not possible to propose plough parallel to slopes or cultivation of catch crops in order to decrease the great leaching when it rains**
	Number of exploitations		**e.g. for the calculation of the cost of education programs for the heads of agricultural holdings**
	Percentage of young farmers (<35 age)		**In cases with a larger percentage of young farmers new practices are more easily accepted and education programs are more efficient**
	Stressing human activities in existing or drained wetlands		**Their restoration or preservation is considered a low cost option and is a first priority in many case studies**
	Length of the main river/sub-catchment		**e.g. for the calculation of the extent of buffer strips along the river**
Indicators for the productive livestock capital	**These indicators are needed in the case studies where, according to the environmental indicators, pollution from pig and cattle farming exist (intensive units, etc).**		
Hydro-morphological alterations	If there is water quality impact of the operation of land reclamation works, hydroelectric dams, etc.	**- Negative impacts on the ecosystem due to their malfunction** **- Their not operation due to lack of funds**	
Macro-economic indicators	For example, if the economy is in a recession period, it should be examined if an extension of the organic farming will have a positive response of the consumers, considering that the price level for the organic products is greater in comparison with the conventional. Another example is related to the enlargement of the European Union, which results in different competitiveness of the products, and probable changes in the crops should be studied, etc. (Zanou et al., 2004).		
Additional indicators	*If another measure which is not included in Table 2 is considered as appropriate for a case study an examination of possible added indicators should be realized.*		

iv) the factors influencing the users' acceptance of the proposed measures (Gilman, 2000; Morris and Potter, 1995; O'Connor *et al.*, 1999).

For the design of appropriate policy options the use of participatory processes and co-management principles are required. The alternative policy options related to "PA-1" (agro-environmental policy, industrial and domestic waste management) are described in the following sections.

Agro-environmental policy

In the framework of an agro-environmental policy, good agricultural practices should be adopted. An indicative list of these practices is

Table 4. Indicative list of policy responses in industrial wastes treatment (PA-1)

Designation of industrial zones or relocation of pollutant units in existing zone
Construction of wastewater plants
Recycling of wastes
Emission charges
Environmental agreements/voluntary approaches
New rules in granting operating license
Charges or fines for: a) industries operating without license and b) industries that do not make use of their anti-pollution equipment
Environmental Management Strategies (ISO 14000, EMAS, eco-label)
Training of personnel
Creation of an information network: up-to-date information for legislation, subsidies

Source: Zanou *et al.* (2004)

Table 5. Indicators for the identification of options for industrial wastes (PA-1)

Indicators *(Data for all the municipalities in watershed studied)*		**Notes**
Indicators related to the importance of this activity in the area studied	(%) GDP of the secondary sector to the total GDP *If there is no data available per region, data per County (NUTS 3 level) is used*	Data also from previous years-trends and data for the Country average
	(%) of the economically active population in the secondary sector	
Indicators for the identification of the industries-manufactures causing the water pollution	Industrial plants/branch *Location of the plants, because in some statistical bases there is no differentiation between office location and productive unit location*	
	Treatment of their water wastes	
	Solid wastes disposal (landfills, recycling, selling to other firms etc.)	
Other data needed for the identification of the appropriate measures	Industries with an environmental certificate (EMAS, ISO14000, eco-label)	
	Number of employees, turnover and number of working days	e.g. the small size manufacturing units or the units with seasonal operation (olive-oil plants, canneries etc) it is difficult to cover the cost of the treatment of their wastes or the purchase of an antipollution equipment. A common environmental station for the elaboration of their discharges could be examined, etc
	If another measure which is not included in Table 4 is considered as appropriate for a case study an examination of possible added indicators should be realized.	

presented in Table 2.For the selection of the most appropriate measures for each case study, indicators are required for the identification of a profile of the agricultural activities in the municipalities studied (Table 3).

Industrial waste management

For the decrease of water pollution caused by industrial activities, different management measures should be adopted (a broad outline of these actions is presented in Table 4). For the selection of the most appropriate of the different

Table 6. Indicators for the identification of options for domestic wastes treatment (PA-1)

Indicators *(Data for all the municipalities in watershed studied)*		**Notes**
Inhabitants and population density rate /municipality (inh./Km^2)		Data from previous years and Country data also
Hotel capacity and rented rooms (number of units and beds, coverage rate)		
Alternative forms of tourism (ecotourism, agrotourism, cultural tourism)		
Treatment of domestic waste waters	Existing wastewater conventional treatment plants (primary, secondary, tertiary treatment) and (%) of annual wastewater quantity treated	
	(%) population connected to these plants and population equivalents	
	(%) population connected to sewerage networks. *For the municipalities not connected it is necessary to examine if their wastes are transported to the treatment plants by trucks, or whether they end up in the sea without treatment*	
	Natural treatment systems (constructed wetlands) and (%) wastewater treated as well as (%) of population connected	
Elaboration of municipal solid wastes (landfills, recycling, etc.)		

Table 7. Cost components for the assessment of the total cost of a measure in "PA-1"

Probable profit reduction for the economic user (including the given subsidy)
Capital cost and maintenance-operation cost of a work-investment
Cost of options: • mutually dependent (e.g. planting + irrigation) • which must be implemented beforehand (e.g. construction of a drained ditch before the works needed in a wetland for its restoration) • the combination of which results in lower cost (e.g. some cost components are the same for two measures and they are calculated once)
Cost of required education programs/consultation of users for the application of the proposed measure
Cost of a control procedure (administrative control: cost for training of public servants or the employment of new personnel – or cost for satellite images, etc)
Cost of the measurement of the environmental effectiveness (cost for the selection of samples and their laboratory study)

available measures for each case study, indicators are required for the identification of the activity profile in the municipalities studied (Table 5).

Domestic waste management

In the case studies where, according to the environmental indicators, measures for the treatment of domestic waste are needed for the improvement of water quality, relevant indicators should be studied (Table 6).It is also noted that some of the above socio-economic indicators are used in the policy area "seafront management' (see: Table 1) for zoning regulation and tourism study (use of data concerning only the municipalities near to the coastal water).

Cost assessment

The above mentioned socio-economic indicators will give the information needed for the selection of the most appropriate measures in each studied area, according to the water quality target.

The cost of these measures should be also estimated, in order to carry out a CEA.

The lifetime of a measure, based on the nature of the investment (Bystrom, 1998; Ribaudo *et al.*, 2001) or on its legal-administrative nature (E.C. 2001b; Florio and Vignetti, 2003) and the financial discount rate used should be identified. It should also be noted that all costs should be expressed in the same year prices.

The cost components that should be considered for the calculation of the Present Value Total Cost (PVTC) and the Total Annual Economic Cost (TAEC) of a measure for the control of water pollution (PA-1, Table 1) are presented in Table 7.

Cost-effectiveness analysis

The environmental effectiveness of the alternative proposed management options in

"PA-1" is estimated by the results of the catchment-coastal zone simulation model. The different combinations of measures are examined in order to find those achieving the predetermined water quality objectives, with the lowest cost

The calculation of their incremental cost and the use of a sensitivity analysis are also included in the framework of the CEA in the water quality sector (Zanou *et al.*, 2004).

Particular attention needs to be given to the design of the hydrological model, for the watershed studied, in order to have the required spatial and temporal resolution for the nutrients at the outlet of each measure. In particular, the cost-effective allocation of measures in the agricultural sector (non-point source of pollution) involves spatial concerns with respect to knowledge of nutrient leaching and retention (weather conditions, pollutant transports, upstream measures, etc.).

CONCLUSION

In the frame of an ICZM a great number of socio-economic and environmental indicators are studied together, in order to understand the multisectoral economic and social objectives in a coastal area. Evaluation methods such as the Cost-Benefit Analysis (CBA), the Multicriteria Analysis (MCA), or other models that have a capability to elaborate all these interrelated indicators are used, in order to estimate the economic, social and ecological impacts of future alternative development plans.

For the design of these ICZM plans, knowledge of the existing coastal water pollution, attributed to land uses in the catchment area, is necessary; also, in case studies where a great level of such pollution exists, its control is the prerequisite factor for any other management plan. Furthermore, a priority in the water pollution decrease may also exist in cases where there are budget constraints and a classification of actions in the frame of ICZM is required.

For the assessment of the cost and the environmental effectiveness of proposed management measures, in order to decrease the water pollution from land uses and to reach the "good status of water" (WFD), the Cost-Effectiveness Analysis (CEA) is used.

The indicators needed for the application of the CEA in this policy area are not interrelated with those required in the other CZM policy areas.

Furthermore, the cost variables and the discount rate, as well as the results of the CEA are different in comparison with those corresponding in other evaluation methods (CBA, MCA, etc).

Therefore, the policy area "coastal water pollution control from land uses in catchment area" could be considered as a distinct study, supporting the decision making process for ICZM planning, and the indicators required in this policy area are not incorporated in the same procedure of elaboration with the other indicators. This study differentiation also contributes to a better elaboration of all the data included in an ICZM, since a lower number of them will be studied together.

The indicators included in this pollution control policy area are identified in this paper. Taking into account that many municipalities are included in a catchment area and consequently much data should be collected, particular attention was given in order to present only the indicators that could be considered a basic reference in the methodological framework for the application of the Cost-Effectiveness Analysis.

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