IT SYSTEM FOR MONITORING CLIMATIC CHANGES

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Abstract

The proposed system represents an integrated, complex IT system, through the creation of a support – digital map – where the environment related information is spatially represented, on which cadastral data is overlaid, along with data regarding the underground, with the specification of the geo-morphological structure and geological resources, data regarding the land's potential, through the pedological mapping of the soil, the environment with data related to climate, hydrography, etc. which allows the impact analysis of interfering climatic factors, soil, water, air pollution factors, allows the economic assessment of resources for the purpose of eradicating poverty, creating development opportunities and jobs, and encouraging development initiatives for the local economy, and, correlated with social data and information, the system can determine, through a specific zoning, the vulnerabilities to discrimination regarding the equality of chances, access to education, healthcare supply or the fight against poverty.

Keywords: *Earthquake prediction, magnitude, leveling.*

1 INTRODUCTION

The study of recent crustal movements is integrated in the overall research on the dynamics of the earth shell, which is a reflection of the phenomena taking place both in the earth shell and in depth. The results obtained by correlating the data provided by geological, geophysical and oceanographic sciences with the results obtained through geodetic measurement, concur to the clarification of the issues related to the earth's temporal evolution, the understanding of current processes and the attempt to foresee their future manifestation method. Besides from its fundamental nature, research in this field also displays an applied nature, concurring along with geology and geophysics to the highlighting of new sources of energy or useful minerals, the determination of the stability level of the soil in inhabited areas or areas where important industrial and urban sites are to be located. The understanding of the displacements affecting the upper layer of the earth's shell, movements which occur prior to, simultaneously or after earthquakes, also represents a current issue **(Nacu, 1998).**

2 MAP OF THE RECENT VERTICAL CRUSTAL MOVEMENTS – SHORT HISTORY

The creation of an IT system on GIS platform having as support the digital cadastral map, specialized in the spatial analysis of data and information regarding the monitoring of the climatic changes in a pilot area, and the integration in a rural center for sustainable development, for the purpose of getting the inhabitants involved in the process of reducing the effects of natural disasters, has targeted the following results:

- the execution of the area’s updated digital map
- the execution of the IT system for the monitoring of climatic changes
- the execution of the interface between the IT system and users, allowing the active and unmediated participation to the collection of meteorological data and information, their inclusion into the system and their processing by specialized software, for the zoning of the area, in order to obtain the following spatially represented information:
    - flood risk areas
    - landslide risk areas
    - polluted areas
    - areas affected by erosion
    - deforested areas
    - classification of lands according to usage categories and soil quality classes etc.
    - identification of actual options for removing “disparities”, by highlighting the area’s economic resources;

The project’s main feature is the involvement of the population, especially the representatives of the local administration, volunteers, to the collection of data and information related to climatic changes, by using the devices which are to be purchased: mobile weather stations, USB port weather stations, hydrometric gauges, pluviometers, topographic devices, and also by observing the way in which the data and information contributes to the zoning of the area, for the determination of land portions subject to the risk of floods, erosions, desertification etc. and can observe the occurred amendments, after each collection phase. The training of volunteers and the representatives of the local administration in the use of monitoring equipment for climatic changes develops specific competences and contributes to their awareness, developing the civic spirit, which can contribute to the population’s unmediated involvement in the habitat’s sustainable development.

In this context, the proposed project is perfectly integrated in the concept of sustainable development for insuring an adequate climate for the development and fertility of the habitat in this area, through the rational usage of natural resources, risk reduction and reduction of the effects of natural phenomena caused by climatic changes, in order to provide life and welfare conditions for the current inhabitants and future generations.

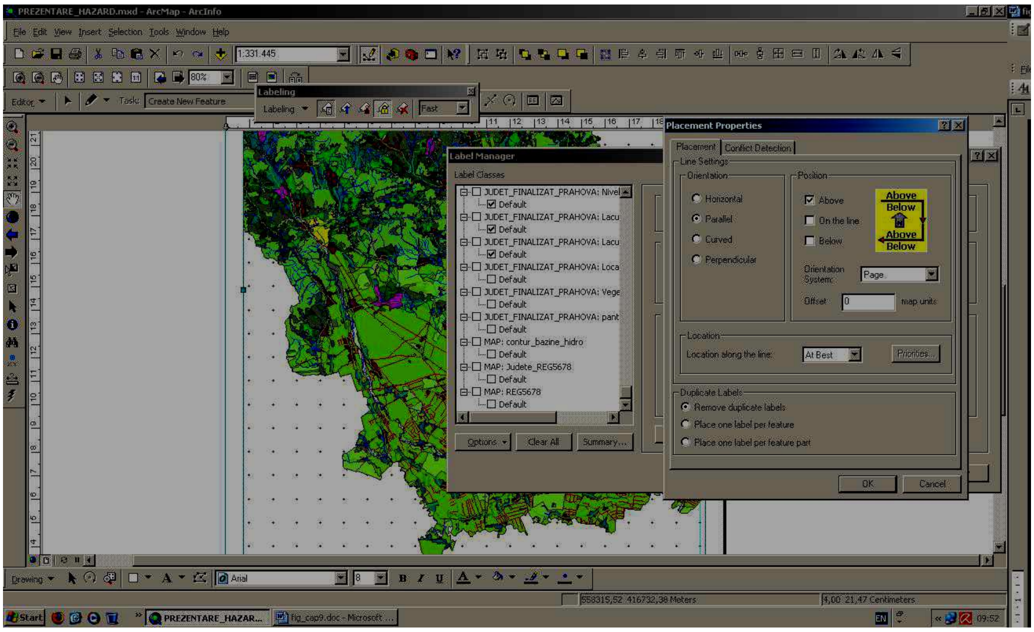

Fig. 1. Basic maps at county level and hazard monitoring databases

3 THE EXECUTION OF RISK MAPS FOR LANDSLIDES AS MEASURING SYSTEM FOR THE PHENOMENON, BASED ON PRECISION GEODETIC MEASUREMENTS

The issue of natural hazards is one that is intensely studied in specialized literature. Thus, we can mention the papers in the field of geographic consideration hazard monitoring by using various mathematic procedures, using „Data-Based Mechanistic" (DBM), neural - networks approaching (NNA), filter Kalman/ nonlinear time series analysis (NLTSA), for the purpose of obtaining a prediction mechanism for natural risks. The goal is to eventually integrate these prediction systems in GIS type systems.

During the past 20 years, a series of GIS type software was efficiently integrated in research and production as studies, articles, research agreements, grants, various applications requested by beneficiaries from various fields of activity, including the monitoring of earthquake, flood, landslide risks and hazards. A GIS software is not only a collection of buttons which, when pressed, provide, directly and trouble free, on an isoline map, a river's floodable area, the risk areas, the relief pattern, the transport network vulnerable to landslides, avalanche corridors etc. The execution of a GIS specialized in the monitoring of natural phenomena is technical and requires the use of specific functions, the alternative consultation of the graphic database and attribute base, the formalization of application at graphic primitive level: dot, line or polygon, raster structure calculations, selections, discretions, logical combinations, overlays etc. Thus, it must be shown how layers can be obtained, their features and correlation method, in order to achieve the desired result. The user's evolution from primary geographic data to the targeted result (digital map, statistic report, graphics, visual scenario) is highly technical, and the result usually hides a numeric approach.

In this project, we have approached the execution of risk maps, in order to build a pattern group for landslide monitoring. Through geodetic methods, the geometric parameters are determined accurately, allowing the spatial localization of the other parameters (physical and dynamic, conditioned by environmental factors, the area's geomorphological structure, rainfall etc.), influencing landslides.

First, we have studied the process of landslides, in order to determine the parameters according to the causes of these phenomena and to correlate these parameters with the land's topographic elements, for the purpose of creating maps which can be used in the decision making process regarding the measures for fighting the phenomenon and mitigating damages.

For instance, we have used the land's digital model for the calculation of the volumetric weight, physical parameter which is important in order to create the quasi-probability pattern of the landslide.

The creation of the land's digital model and digital map, through accurate planimetric and altimetric measurements can also be used for the calculation of:

- the thickness and volume of the landslide body,
- the length and width of the landslide body,
- the partitioning of the area's surface, by determining the sliding directions,
- the determination of the longitudinal and transversal sections etc.

The news in the execution of this model consists of the determination of a map, for each parameter intervening in the landslide process, the influence area, quantified by determining significant values, based on measurements, the correlation between parameters, allowing a systemic analysis (a dynamic system with several inputs and outputs). The observability and detectability of the system's instability areas are proven, along with the measurability of interfering factors. In this context, we have designed a system where geodetic measurements are combined with measurements performed by sensorial devices; this system has allowed the determination of the correlation between the parameters of interfering factors, their spatial distribution and zoning of their influence. This zoning has allowed the use of modern analysis methods, such as the finite element method, the use of neuronal networks in finding the most probable values of periodically repeated geodetic measures (considered time series here), in order to highlight landslides. Also, this zoning opens other complex and efficient analysis possibilities, through the application of the cluster method and execution of landslide simulation patterns.

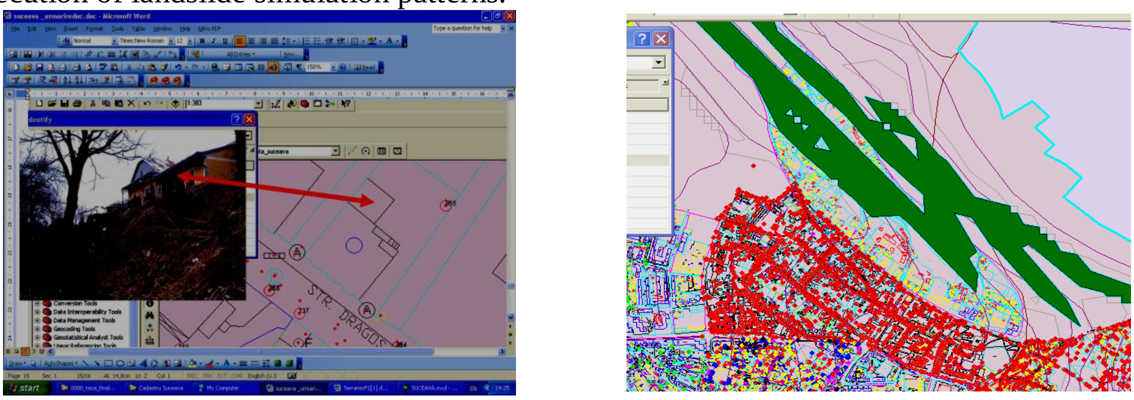

Fig. 2. Maps for highlighting landslides

Classic variation methods have proven incapable of solving a series of important current issues, which include those of landslides, thus, a parametric analysis is required; the most recommended modeling method for analysis of the structures in the landslide area and of the interfering factors is the finite element method. Based on periodical geodetic measurements – which can be characterized as time series – using the finite element method, changes in the coordinates of individual dots in the landslide area are highlighted, along with the input parameters describing the system's behavior under the action of interfering factors.

The processing of experimental and observation data involves the use of special analysis methods, which are the object of the following fields of mathematic statistics:

- descriptive statistics;
- correlation analysis;
- regression analysis;
- spectral analysis;
- verification of statistic hypotheses;
- modeling and prediction.

The aforementioned fields represent the same number of function classes, where software modules will be implemented and developed for the execution of a decision support system (DSS).

In order to follow-up the behavior of landslides, the deviation of a set of dots located in characteristic dots is studied.

In this field, an important role is held by the accurate determination of the spatial position of characteristic dots, on various objects, through contactless measurement methods and during a timespan as short as possible.

Most of the times, measurement results in the field of geodesy (i.e. direction and distance measurements) are included in subsequent calculations, in order to determine the coordinates of the dots. Since the individually measured values are affected by random deviations (random errors), represented by the standard deviations of the measured values, these deviations will impact the calculated function. The deviations of the measured values will spread throughout the calculated dimension (Law of error propagation).(COSARCA a.o. 2007).

Floor risk management means the implementation of policies, procedures and practices having as goals risk identification, analysis, assessment, approach, monitoring, reassessment, in order to mitigate risks, so that human communities, all citizens, can live, work and reach their goals in a sustainable physical and social environment.

In figure 3 the data sources for flood prediction are presented:

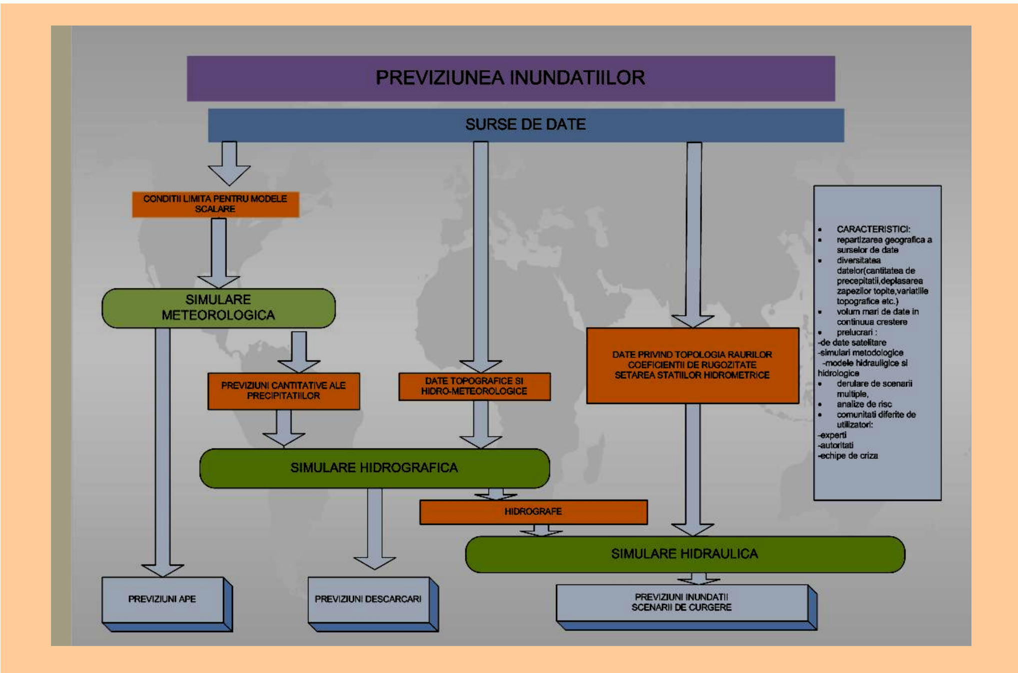

Fig. 3. Data sources for flood prediction

The flood risk is characterized through its occurrence nature and probability, exposure degree of the receptors (population and goods), predisposition to floods of the receptors and their value, thus resulting that for reducing the risk we need to act on its characteristics.

These actions focus on the prevention/reduction of the potential damages generated by floods through:

- avoiding building housings and social, cultural and/or economic objectives in the potentially floodable areas, with presenting in the urbanism documentations of the data regarding the effects of the previous floods; adapting the future developments to the flood risk conditions; promoting adequate utilization practices of the lands and of the agricultural and sylvan lands;
- implementing structural protection measures, also in the area of the bridges and footbridges;
- implementing non-structural measures (controlling the usage of the minor river beds, drafting basin plans for reducing the flood risk, and measure plans; implementing insurance systems etc.);
- detailed identification, geographic delimitation of the natural flood risk areas – fig. 4. on the territory of the municipality, registration of these areas in the general urbanism plans and providing in the urbanism regulations of the specific measures regarding the prevention and reduction of the flood risk, performing constructions and using lands;
- implementing of the prediction, warning and alerting systems in case of floods;
- maintenance of the existent protection infrastructures for floods, and of the river beds;

Fig. 4. The zoning of residential centers for flood risk management

- performing protection works for river bed scouring in the area of the existent bridges and footbridges;
- informing the population and educating it regarding the flood risk, and how to act in emergency situations.

b. Operational management activities (emergency situations management) to perform during the flood phaenomenon:

- detecting the occurrence possibility of flash floods and of probable floods;
- predicting the evolution and spread of the flash floods along the watercourses;
- warning the authorities and the population of the spread, severity and of the occurrence of floods;

- organising response actions of the authorities and of the population for emergency situations;
- providing resources (material, financial, human) on a county level for the operational intervention;
- activating operational institutions, mobilisation of resources etc.

c. Activities to perform after the flood phaenomenon:

- assistance for satisfying the immediate necessities of the population affected by the disaster and for resuming their normal life;
- reconstruction of damaged buildings, of infrastructures and of those from the flood protection system;
- reviewing the flood management activities for the purpose of improving the intervention's planning process in order to deal with future events in the affected area, and in other areas.

Evaluating the vulnerability of the exposed elements, material damages and human losses

The vulnerability refers to the capacity of an exposed element during the impact of a natural hazard. The definition of vulnerability to a natural hazard generally refers to the characteristics of an element exposed to the hazard – road, building, person, economic and social objective – which contributes to this element's capacity to withstand and to recover after the impact with the natural hazard.

Through GD 447/2003 vulnerability is defined, as and degree of affection of an element or of a group of elements from an area exposed to landslides. It is expressed on a scale from 0 (no losses) to 1 (total destruction). For the loss of human lives, vulnerability is the probability that a life registered in the area affected by the landslide, to be lost, if the landslide takes place.

The vulnerability of persons represents a subject which is hard to evaluate. It is normally the subject of extremely detailed social-economical-administrative investigations, which, are unfortunately not provided by the Romanian law and they were neither practices in Romania (to this day).

Social vulnerability, that which evaluates the person's ability to recover itself after the it was involved in a natural hazard, can be analysed on four distinct levels, as follows:

- individually in a household environment (it refers to the personal reaction attributes/abilities);
- community (it refers to the person's reaction method with the social environment in which it develops);
- regional/geographic (it refers to the distance to the employee's workplace);
- administrative/institutional (it refers to the funds assigned for disasters and prevention studies).

The four levels are presented in figure 5.

This simplification aims to present the fact that there are various factors which contribute to the social risk, as consequence of the natural hazards, including those regarding the hazard management method in the regional or household environment, up to the individual attributes. Social vulnerability, can mainly focus on the first level, as shown in the figure, and refers to the person and its household environment.

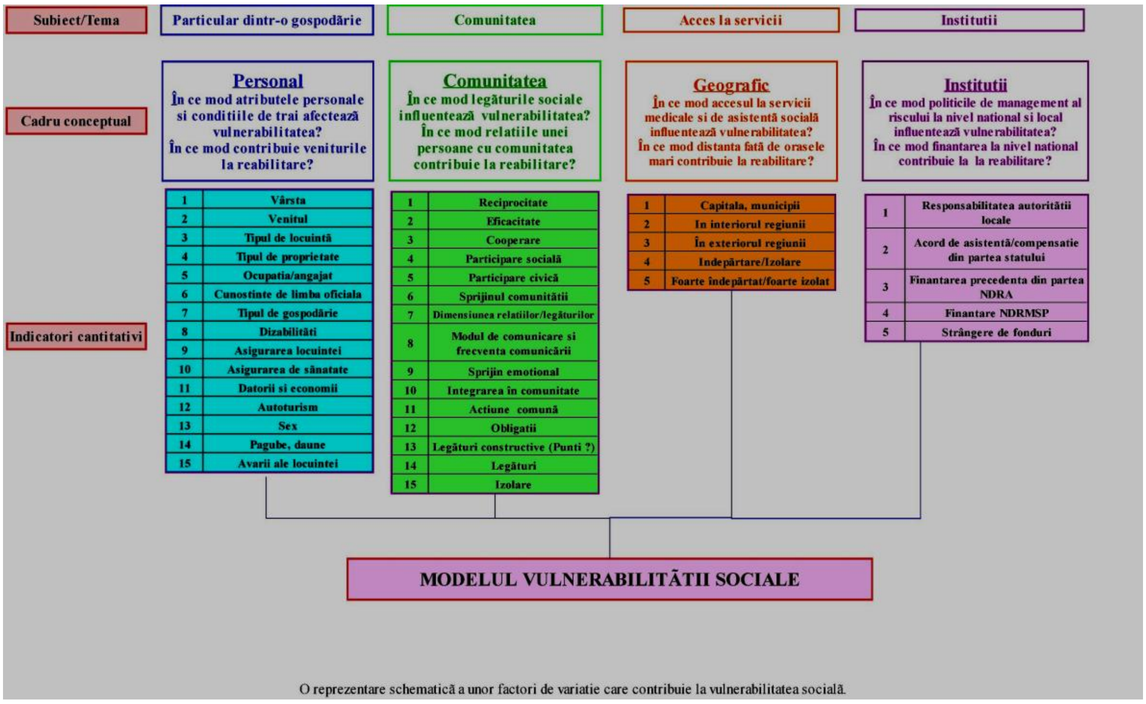

Fig. 5. Social vulnerability to natural phaenomenon hazards and risks: floods, landslides and earthquakes (by Dordea and others)

4.CONCLUSIONS

The aforementioned external causation factors, which constitute the inputs in the system – grouped in: climatology factors: factors of the human activity (anthropogenic); biotic factors; natural mechanical factors; other causation factors (currently they can be unknown), can be sorted and an index can be associated to them, so that the contribution to the destabilization of the versant system shall, and producing landslides. This analysis can be performed with assistance from the neuronal network models specific to the repeated measurements considered time series.

Performing measurements in different moments for determining the quantity characteristics of one observation unit or of an entire area, the data which we obtain in this way, form a time series or a dynamic series. This data is from the perspective of important statistics, both through values and through the order of appearance of these values.

The data are usually collected on equal intervals, other times (ex. for barometers) we have continuous recordings, from which we can extract data equidistant in time.

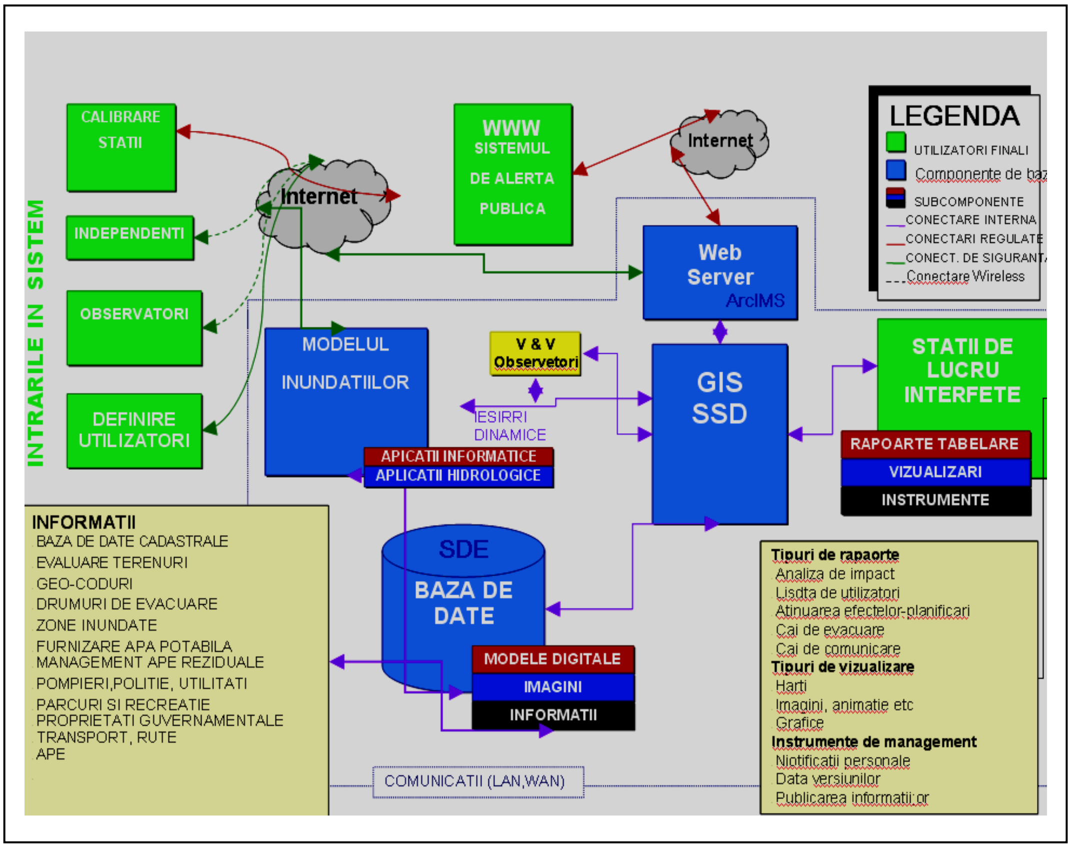

Fig. 6. The architecture of the risk and hazard monitoring system

The content of the hazard and risk maps for an efficient monitoring (fig. 6), needs to correspond to the following criteria for integration in an intelligent monitoring system of the hazard and risk factors of natural calamities: multifunction, compatibility, updating, realism.

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