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The need for energy savings in companies, especially in developing countries, encouraged the execution of this study, which presents an analysis of how the integration of free software and hardware with sensors can monitor and manage electric energy consumption in a responsive thermal system in a Data Center. In this way, the developed system can reduce energy input costs and improve the availability of the services offered by the Data Processing Center. The experiment was made using a temperature sensor, a non-invasive current sensor, Arduino Uno, Raspberry PI, and Zabbix. Therefore, using the proposed system, it was possible to save an average of 20% of energy in a monitored environment when compared to an uncontrolled environment.

GEOLOGY

Strength and Weakness in Geotourism: The case study of Irpinia (Campania, Italy).

The territory of Irpinia (Campania, Italy) has been largely preserved by the "Great Transformation" of the territory followed by the Second World War. Its environmental peculiarities and its historical-cultural aspects have integrated into the landscape; therefore they represent attractive places for the new directions of environmental and cultural tourism. The advantages derive from the proximity to the coast of Campania, where the global value of tourist attractions has been known for centuries. The strengths of these internal areas of our peninsula are represented by the numerous places capable of divulging the "geological culture" and therefore to highlight how around them have developed stories, cultures, and traditions of quality. However, there are weaknesses in the conservation and uses by tourists of these areas, as highlighted by the spread of certain geological and geomorphological hazards (landslides, floods, fumes, etc.). Geotourism would, therefore, be fundamental to recall the public interest on this internal area of Campania and to encourage protection and enhancement initiatives.

Peri-urban areas, morphological evolution and hazards: The case of Rio city, Northern Peloponnese, Greece.

Morphological evolution and its relationship with peri-urbanization is becoming an increasingly interesting and significant topic, due to the high impact that it has on highly sensitive areas. Our study area is the city of Rio in northern Peloponnese, located approximately 7 km far from the city of Patras. With a population of around 15.000 inhabitants, is considered to be a highly sensitive area, because of numerous and important infrastructures, such as the University of Patras, the local University hospital, two sports halls and the Ottoman era fortress located at the coast. The geology is characterized by the formation of Olonos – Pindos zone, including Pli-

ocene and Pleistocene sediments, covered by Quaternary and alluvial deposits and dislocated by faults with NE-SW and NW-SE direction. Geochronological and sedimentological studies of dated raised terraces found an average uplift rate of 0.4 to 6 mm/yr while the dating results indicate pre-Tyrrhenian to Tyrrhenian interglacial ages. Hydrologically, the area is characterized by ephemerous streams and rivers such as Charadros, Selemnos, Volinaios and Foinikas flowing into both the Gulf of Patras and Gulf of Corinth. The area combines sectors of mixed use. Green parts are also present in a currently developing area. During the years, the area has undergone a series of changes that can be developed into potential hazards. The construction of Patras University in the 1960s and the University hospital in the late 1980s led to the infilling of one branch of the Selemnos River, increasing the risk of flooding of the remaining river branch. The coastal area suffers erosion introducing risks to the port and coastal infrastructure. Some minor remediation works were unsuccessful. Combined with the high seismicity of the area, the extensive human intervention, high seismicity, and the local tectonics, introduce risks that have to be researched, analysed and controlled.

EDITORIAL

The challenge of climate change in the city

Alessio Valente

Climate change is a global phenomenon that is already affecting our cities, sometimes causing disastrous consequences. Beyond personal considerations on the causes of what is happening, in this editorial, I believe that to understand what is happening about climatic conditions of our planet it is necessary to rely on scientific thinking. More precisely, I will consider the recent IPPC report which took into account over 6000 scientific articles of the last few years. This report highlights above all "*the impacts of global warming of 1.5°C compared to the levels of the pre-industrial period and the related greenhouse gas emission paths, in the context of strengthening the global response to the threat of climate change, to sustainable development, and efforts to defeat poverty*" (IPPC, 2018).

In the absence of a reversal in the trend of greenhouse gas emissions (CO_2, methane, etc.), the increase in global temperatures will result in a highly probable change in weather conditions over the next few decades: greater frequency and intensity of extreme events, sudden floods with long dry periods, increased temperature and increasingly violent heat waves and, last but not least, a significant sea level rise. The scenarios envisaged by the IPPC report are at +1.5°C, but those with an increase of +2°C are also not neglected, which would be decidedly higher in terms of intensity and frequency. Consequently, the needs of defense / adaptation and the related costs would become exponential for increasing temperatures. Last year's Nobel Prize for Economics was awarded to William Nordhaus for this new emergency, who among the first studied the mutual influences between climate change and economy. He recently expressed himself for the urgent adjustment of the budgets for mitigation rather than finding himself facing the costs of impacts.

Cities are particularly vulnerable to IPPC scenarios, as they are considered "real" settlements. Buildings for housing and for different services, as well as infrastructures such as sewers, bridges, underground lines and roads, can represent the strengths of the place but at the same time become a liability if the local ecosystems on which they are based are not in able to adapt to climate-induced changes. Climate change poses serious threats to urban infrastructure, to the quality of life and to the entire urban system. Not only poor countries, but also rich ones will be increasingly influenced by anomalous climatic events and trends.

On the other hand, however, cities are also the cause of climate change, since urban-level activities are among the main sources of greenhouse gas emissions. In fact, already in 2006, urban areas were responsible for three-quarters of energy consumption and therefore a similar quantity of CO_2-related energy emissions, even if with significant geographical differences. In recent years, initiatives have been taken in many cities to tackle climate change with unexpected successes (less pollution, better infrastructure, greater attractiveness, and livability). However, the initiatives will be all the more effective if they are able to integrate the needs of the cities and their environmental management skills. As advocated by the IPPC, but also by the latest climate change conferences (i.e. COP21 in Paris, 2015), a positive result can only be achieved with a coordinated approach and actions at global, regional, national and local level.

However, according to the prestigious PNAS magazine, the awareness of the populations and consequently of those who manage public administrations with respect to climate change is held back by a series of factors (short temporality, expectations, memory, cognitive bias...). Such a brake leads to underestimating the analyzes on climate change that take as reference long-term periods. So far the changes in temperature and the average sea level have occurred gradually over time and therefore were not perceived significantly. Differently for some consequences of the changes manifested as extreme events (for example, cyclones, heat waves, and floods) that have been felt with dismay and concern. Therefore, there is probably a greater need to respond to such extreme events based on current experiences in disaster risk reduction rather than taking action to tackle the problem of climate change (Hansen et al., 2012).

For this reason, an aspect not to be overlooked for urban areas is the management of the approach and actions, as it must have as its object both the causes of climate change and the possible consequences deriving from them. In the first case it will be necessary to act on the planning and on the efficiency of the use of resources, to reduce greenhouse gas emissions, in the second case on increasing the capacity to withstand a city through more efficient rules and technologies to prevent or at least limit the damage that extreme events can cause (Rosenzweig et al, 2011). For both cases, it is necessary to increase scientific knowledge and experiment suitable innovative techniques in order to be able to act correctly. For the reduction of greenhouse gases the actions will find answers in the medium-long term, also considering that

the climate has inertia and, even if we immediately stop our emissions, the temperature would continue to rise a little. While increasing the resilience of the cities to the effects, immediate interventions are necessary, that give answers in the shorter term, also because often it is necessary to repair what has already happened. However, in this case, the actions are not exclusively oriented to the defense against climate change impacts. In fact, they could be directed to the advantage of hydrogeological instability or the protection of biodiversity and at the same time counteracts the effects of climate change. The significant investments that these actions entail generally prove to be a source of benefits rather than costs. However, nowadays, the choice towards conservation, recovery and restoration interventions of ecosystem services for sustainable management of the territory, compared to the so-called hard structures, allows not only an economic advantage. In fact, the so-called ecosystem-based measures aim at strengthening the resilience of ecosystems (Griscom et al., 2017).

Trying to decline some aspects of climate change, we realize that if the global trend predicts temperature increases of +1.5° or even +2°C, in the cities temperatures could reach up to +4°C with seasonal peaks even higher. This condition is derived from the spread of asphalt on the roads, the high density of buildings with conventional plants, the absence of green areas, motor vehicle traffic with fossil fuels, and so on that gave it the name of the urban heat island. The increase indicated above would disproportionately increase the number of hot days and heat waves. The main effects could be health risks for citizens, especially the most vulnerable ones, a further increase in air pollution, an increase in energy demand for seasonal heating/cooling and difficulty in water management. For example, for each centigrade degree of heating increase, a reduction in renewable water resources of at least 20% is expected.

To reduce emissions, water consumption, and heat gain, cities can increase the use of renewable sources. These sources could derive from plants that use the energy of the sun, the wind and the heat of the Earth. Currently, some of these technologies have made it possible to make important progress in the renewable energy sector, so as to be able to reach an advanced level of technical and economic maturity. In this sense, the buildings, which are responsible for about one-third of greenhouse gas emissions could be equipped with solar panels and green roofs, sensors that turn off lights in empty rooms, windows that retain heat and high energy efficiency air conditioning systems. One could even try to subtract "carbon" from the air, generating humidity and filtering the fine dust, creating the so-called "vertical woods", i.e. "turricular" buildings in which several tree species are distributed in the various facades. In addition to the benefits in terms of climate, they allow the creation of biological habitats. Examples of this kind are already present in Milan, Eindhoven, and Singapore. There are also cities where geothermal energy is exploited. Such energy is released by nuclear decay processes of some elements present within the earth, for heating and cooling of buildings and for some industrial processes. These systems are widespread in Sweden, Norway, Germany, and France, and now also in Bolzano, Italy. These could be some of the efforts to reverse the sources of global electricity needs, now covered by three-quarters of fossil fuels for the benefit of the renewable. The latter can lead to undoubted advantages for cities, for example in reducing the level of urban air pollution. In some cities of the world (i.e. New Delhi in India, Linfen in Cina, Tetovo in Macedonia...) the poor quality of air causes a spread of respiratory diseases and even a great number of deaths a year.

In this direction, there should be interventions to reduce transport emissions from transfers within the city. There are many actions that have been activated, but much remains to be done. In fact, while in some cities modal transport has been favored, in others due to the extensive urbanization in terms of surface area it has penalized it. The inhabitants of Hong Kong have such an efficient public transport network with 75% of stations located less than 1 km and half of them at 500 m: that is indicative! Obviously, beyond the coverage of public transport, many cities have opted for low-carbon vehicles. As for citizens who cannot use public transport, the best solution is to go on foot or by bicycle, which both do not create greenhouse gases. In Italy, for example, despite an improvement in the performance of the car fleet and the improvement of fuels, which has allowed for a 20% reduction in CO_2 in the last ten years and a significant reduction in the specific emissions of NOx and other pollutants, this was partly thwarted by the growth of traffic in the cities. The situation will change when the car fleet in Italy and in the world will switch from fossil fuels to electric power. Definitely advantageous are the traffic exclusion solutions in the so-called historical centers or the days in which parts of the city cannot be crossed by private cars. However, this is often a restrictive provision imposed by city administrations that to avoid violating the limits of pollutant concentrations, rather than a choice to improve the livability of one's city.

An urban problem that goes beyond the reduction of greenhouse gases, but that affects the efficiency of the use of resources in a city is represented by water management. Most climate change models predict a long-term decline in water availability in the western areas of North America and Asia and in areas of Africa and Europe washed by the Mediterranean Sea. Consequently, in the cities of those areas, but not only, it will also be necessary to dedicate proper attention to the conservation of water resources and the quality of the distribution plants. Currently, it is estimated that 150 million people live in cities with a perennial lack of water and this

condition probably in consideration of trends could reach one billion in 2050. In addition to avoiding waste, through a strong educational process, the challenge to be launched is to capture every drop that falls from the sky by conveying it in cisterns on the roofs and using it, for example, to irrigate. Another help could come from an improvement in the water infiltration process by creating the so-called "Rain Gardens", which absorb excess water and release it slowly. In the cities, in fact, the high density of structures and infrastructures alters the water cycle and favors the presence of water on the surface, contributing to the occurrence of hydrogeological instability during important meteorological events. To allow the drainage of water in some cities were made ramps and sidewalks in permeable materials, very similar to the natural sandy and gravelly soils. Strongly restrictive interventions to obviate the decrease in rainfall and guarantee a minimum of water to all may not be entirely advantageous. In fact, Melbourne health authorities in Australia have realized that the sharp decrease in the flow of wastewater, combined with rising temperatures, will make the discharges warmer and more concentrated, increasing the possibility of pipe corrosion. To compensate for this effect, they proposed to modify the sewerage inspection and maintenance programs.

So far we have devoted a large part of this editorial to some ways to reduce emissions and save water, protecting citizens, but the slow but steady aggravation of the effects of ongoing climate change requires urgent action and measures. We increasingly talk about adaptation, which involves the acceptance of change, but at the same time requires the adaptation of natural or anthropic systems in response to climate change and their effects, in order to reduce their damage, promote resilience and even generate benefits. For this reason, the first cities to be consulted are those located near rivers and oceans, traditionally that setting was for transport and connectivity purposes. However, this natural geographical advantage is now increasing the vulnerability of cities (i.e. Donadio in CSE, 2017), in fact, climate change involves an increase in sea level and therefore in the severity and frequency of storm surges. Global warming melts the land ice, especially that of the polar ice caps, and adds more water to the oceans. Since 1900 it has risen by about 20 cm, nowadays it increases by about 3 mm a year and is accelerating. According to the less pessimistic forecasts, therefore with an increase in global temperature to 1.5° C, an increase of about 65 cm would be reached in 2100. Faced with this rise, 70% of the largest cities in Europe would have serious difficulties being developed for the most less than 10 m above sea level. The port cities of many Asian countries, in the so-called developing countries, such as Kolkata, Shanghai, and Guangzhou, would also be vulnerable to an increase as well as those already technologically developed, as Rotterdam, Tokyo or New York, and imagine what it would be if the increase were greater! It is not just a question of economic loss, only in Italy the economies of many Adriatic and Tyrrhenian coastal cities are based on beach activities, but also of cultural assets loss. In Italy, the mind goes quickly to Venice, which would be submerged and together with it the monuments that made it famous.

In this context, planning interventions are possible, but it poses enormous uncertainty. Long-term infrastructures, such as flood protection works, major transport systems, large-scale power plants (which are often found near cooling water sources), are generally designed on certain conditions and durations, which today they would not be completely certain. Moreover, the degree of tolerability of some large urban infrastructures such as metros, sewers, bridges existing in many coastal cities is not known in the occurrence of extreme events with an increased sea level. Furthermore, according to these scenarios, the built of new infrastructures in Shanghai, Jakarta, Bangkok, Rio de Janeiro, and other cities adds further complexity to an already difficult setting. An even more difficult problem, and rarely mentioned in the literature, is the possibility (and the potential desirability) that national governments evaluate for some cities the need for relocation and potential abandonment of key infrastructures and areas prone to flooding. This would represent one of the largest losses of value in land and infrastructure and the greatest transfer of economic wealth in human history. This, for example, is what happened in New Orleans that was hit in 2005 by Kathrina, one of the five most serious hurricanes in American history. 80% of the city was flooded, as the flood prevention system turned out to be completely useless. The force of the hurricane and the consequent flooding caused the death of at least 1836 people and damages for 81.2 billion dollars. To avoid new catastrophes, most of the residents have moved to less vulnerable areas, leaving a large number of poor people in the city, in poor housing, at the risk of a new destructive event. This situation could multiply for other cities in view of the probable sea level rise and the consequent sea storms and floods.

The effects of climate change affect not only coastal cities; in fact, flooding after violent rains is becoming an increasingly common problem even for many cities in the hinterland. By the end of the 21st century, extreme conditions are considered to increase between 10 and 60%, with the risk of floods that include the collapse of sewage systems. The volume of sewage released into the environment by the blocked sewer system combined with spills and floods can be considerable, up to 40% in some cities. The construction of defensive works on the river banks can help to break down any abnormal and sudden floods, but also mitigation works upstream of the cities (such as compensating/balancing reservoirs) can guarantee a delay and a lowering of flood height.

The situation will be aggravated in cities where there is an

uncontrolled urban development, with buildings based on natural drainage canals and recent flood plains. In the absence of suitable drainages, the speed and volume of runoff will increase. Furthermore, this increase could have an effect on the less consolidated soils arranged along the slopes close to the new settlements which are not always properly constructed. In the world, there are numerous cases in which anomalous rain events have triggered floods and landslides with damage and victims in the houses that these sediment-laden flows have invaded. For example, in 2013 in India the same amount of rainfall in 6 months rained in just 5 hours, or in 2017 in Colombia and Peru it rained in less than three hours what happens in 24 hours and in 2018 in the Philippines, on a period of 6 months, a large number of tropical typhoons occurred with intense winds and heavy rains. In all these events there were floods from rivers and landslides from the slopes with heavy human losses, damage to property and infrastructure and economic interruptions, especially in the most important settlements. In Italy, there are over a hundred municipalities that in recent years have had significant impacts (flooding, landslides, damage to infrastructure and historical heritage, etc.) due to extreme weather conditions. In these areas, an estimated 7.6 billion euros have been estimated to deal with the emergence of the reported damages. Probably this estimate would have been different if one had acted in terms of prevention.

Both with respect to mitigation, which acts on the causes of climate change, and with respect to adaptation, which instead acts on the consequences, with the aim of reducing the vulnerability of environmental and socio-economic systems to the negative effects of climate change and limiting the damage, cities have a crucial role to play in order to manage what is inevitable and avoid what cannot be managed (Rosenzweig et al., 2015). If it is true that states have a power that individuals, cities, and businesses do not have, it is also true as Michael Bloomberg, a former mayor of New York, said that "*mayors must not wait for national governments or a new global climate agreement to take action. They can do it today, and more and more are those who do it*". Positive signals from local administrators, in fact, are beginning to be there in an increasingly widespread way, also because forms of collaboration have developed between local administrators whose goal is to combat climate change at a global level (Large Cities Climate Leadership Group, World Mayors Council on Climate Change) or continental (in Europe, Covenant of Mayors and Mayors Adapt). Scientists have urged politicians for years to tackle the problem of climate change, asking politicians for effective measures to prevent coordination between nations (see COP). Probably to the reluctance of states that do not perceive the influence of climate change on their territory, local administrators who have a more acute perception will respond. Cities, where the majority of the world's population resides, are key players in tackling climate change: it is in urban areas that the challenge to climate change will be won or lost.

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Energy Efficiency in Buildings and Districts

Temperature Responsive Monitoring System for Smarter Energy Consumption in Data Centers

Alexandre da Silva Rodrigues, Marcos Roberto dos Santos, Thaísa Leal da Silva, Lauro André Ribeiro

Keywords: Data Center, Energy Efficiency, Energy Savings, Thermal Monitoring

Abstract

The need for energy savings in companies, especially in developing countries, encouraged the execution of this study, which presents an analysis of how the integration of free software and hardware with sensors can monitor and manage electric energy consumption in a responsive thermal system in a Data Center. In this way, the developed system can reduce energy input costs and improve the availability of the services offered by the Data Processing Center. The experiment was made using a temperature sensor, a non-invasive current sensor, Arduino Uno, Raspberry PI and Zabbix. Therefore, using the proposed system, it was possible to save an average of 20% of energy in a monitored environment when compared to an uncontrolled environment.

1. Introduction

Nowadays many scientists and societies are concerned about environment degradation inflicted by men, with energy production and consumption being one of the main causes of this negative impact in ecosystems. In addition to environmental concerns, companies in many countries are also concerned about higher energy costs derived from rising energy consumptions.

Regarding technology and data processing, one of the greatest consumers of energy are Data Centers. According to Corrêa (2014), Data Centers are basically a physical structure that was designed to house a variety of resources that provide network equipment, servers and telecommunication storage and management.

The wide use of the Internet and the new ways of storing data generate large amounts of data, which in turn needs to be stored and processed in Data Centers, thus causing an increase in requirements related to these structures. According to Dayarathna et al. (2016), of all the energy consumed in a Data Center, 50% is due to its cooling systems, used for maintaining the equipment in certain preset temperatures.

Bottari (2014) states that Data Centers cooling systems are necessary because of the equipment sensitivity to high temperature and the need to dissipate heat is high. Higher temperatures can shorten the useful life of equipment and also lead to failures. Besides hardware damage, information technology (IT) service interruption can be extremely costly for the companies.

According to Brown (2008), "more than 70% of the Data Center operators have identified the cooling system as the main cause of installation management problems". Bottari (2014) also highlighted that the probability of failures due to higher temperatures entails an increase in Data Center's cooling capacity and results in additional energy expenditure. It is common that the cooling system is designed to withstand possible failures of the equipment responsible for temperature control, thus creating an exorbitant structure that ends up generating an increase in the energy expenditure in Data Centers.

On the other hand, companies are pressured to save energy, not only due to financial reasons but also to environmental impacts related to energy generation. Therefore, companies have the challenging task of worrying about the impact caused in nature and remaining competitive in the market, reducing the cost of operation.

These circumstances encouraged the execution of this study that aimed to integrate free software, free hardware and a set of sensors in order to obtain a responsive thermal monitoring system to manage consumption of electrical energy in a Data Center in order to reduce energy consumption. The following section will address how information technology can be more efficient and assist in meeting efficiency goals.

2. Sustainable Information Technology

Nowadays, awareness that societies must preserve the environment is increasing. The energy consumption is directly linked to the environment, because the more energy is consumed, the more CO_2 is released into the atmosphere generating problems such as greenhouse effect and human and animals related health issues.

According to Cavalcante et al. (2012), environmental and

economic aspects are leading corporations to think in more efficient and sustainable ways in relation to the use of IT resources. According to IBM (2007), "for most CEOs, whose sights are firmly fixed on business growth and expansion, energy consumption and environmental concerns can take on a whole new meaning when they begin to impede the company's ability to grow".

In this way, besides the financial benefits, "Green IT" practices also help companies improve their market image since companies with environmental concerns are better viewed by society (Vieira et al. 2009). In addition, international standards such as ISO 14001 encourage institutions to make their processes more efficient concerning environmental impacts. In this scenario, one of the first steps towards implementing more environmentally friendly processes is the reduction of energy consumption.

Just to highlight some successful cases, IBM started a behavioral environmental change in 2006 and managed to reduce 5.72% of electricity consumption and 14% of water by using simple attitudes such as turning off the lights and closing faucets. Also in that year the company was able to recycle 85% of its waste (Vieira, et al., 2009).

Real Bank (Brazil) won the Banker Technology Awards of 2008 due to the results achieved by its efficiency program. They replaced 180 conventional computers with 160 Blade PC, which obtained an estimated reduction of 62% in consumption of electric energy by computers and 50% reduction in the consumption of air conditioning used in the operating tables. Besides the reduction of costs, the project also improved the management and maintenance of these structures (Yuri, 2008). Real Bank also replaced four physical servers with virtualized servers and achieved estimated savings of 40% in the electric consumption of air conditioning in its Data Centers, in addition to the estimated space gain of over 70% (Renner, 2008).

The application of more sustainable IT focuses on some tools and technologies, as pointed out by Cavalcante et al. (2012): energy management, green data center projects, server virtualization, cloud computing, responsible disposal and recycling of electronic waste and the use of renewable energy sources.

Among these, virtualization procedure does not require large investments because it normally uses hardware resources already in place in the companies. The main goal of virtualization is to increase productivity, management and high availability (Silva & Júnior, 2013) without incurring additional energy expenses.

Server virtualization provides reduction in equipment acquisition, power and space. This operation allows a single server to store various operating systems and applications. The concept is basically the existence of several computers in one. These virtual computers do not differ in any aspect to real computers as far as performance is concerned; the only situation is that they do not exist in a physical form.

In turn, the application virtualization allows running an application and protects the operating system from potential problems that could compromise its performance. In this arrangement, applications do not have access to system information, such as registry keys, system libraries, etc. In application virtualization the resources used by applications are fully managed by the virtual machine (CITRIX, 2015).

With virtualization it is possible to provide remote access to applications and data from any device, and thus maintain the productivity of mobile users. It is also possible to highlight that security is enhanced with this technique, such as controlling and encrypting access to data and applications (CITRIX, 2015).

Another way for energy-saving and service automation is to use nano-computers and microcontrollers. Due to their small size and low power consumption, these technologies are often used in home automation, automotive and monitoring systems. They have become a great alternative to control environments and take actions, being possible to find these technologies present in thousands of devices like, washing machines, microwaves, telephones, keyboards, monitors, etc. (Rodrigues, et al. 2013).

Some of the most common usages for this type of IT equipment are network servers, where instead of using an appliance or dedicated server, generating higher costs, energy and maintenance, a nano-computer is allocated to accomplish this task, reducing costs, space and maintenance (Henes, et al. 2008).

In the next section, the methodology of this work is presented with the aim to show in details how the experiment was made.

3. Methodology

This research has an exploratory character. According to Yin (2005) an exploratory research aims to provide more information on a given subject. The exploratory nature of this study is confirmed due to the need to obtain more information about the real energy consumptions of the Data Center. This research presents a case study, which according to Yin (2005) is a unique experiment, planned and designed for an exclusive event. Since this survey has a sample and a unique environment, it meets these conditions. This study uses an appliance called Arduino and the data analysis collected by it in a real production company environment (Data Center).

This is an applied research in which "it aims to generate knowledge for immediate practical application in the solution of real problems" (Yin, 2005). Particularly in this case, in

which the application of the developed solution is supposed to reduce the energy expenditure of the Data Center.

In order to do so, the company studied in this paper is a Data Center of an information technology company based in the city of Passo Fundo in the state of Rio Grande do Sul, Brazil. The company operates on logistics software and Linux. In these two segments, the company has created advanced expertise and tools to support its clients from most varied branches and regions of the country.

The Data Center owns a 9000 Btus air conditioner, three HP servers (ML350-G6, ML310e - Gen 8 and ML310e - Gen8 V2), an OmniPcx telephone system, two modems (TG862 and V5471-002), two Switches (D-Link DES-1024A and Dell Powerconnect-2848), a Unifi AP router, two Storage IBM V7000, a Cyberoam CR35iNG and a T5700 router.

To contemplate the development of the appliance that aims to promote responsive thermal monitoring of electricity consumption in the Data Center, the steps made in this study are presented as follows. Data were collected by a temperature sensor (DHT11) and a non-invasive current sensor (100A SCT-013), as shown in figure 1 and figure 2, in which the temperature sensor is settled in the Data Center environment and the electric current sensor is connected to the electrical equipment power cable of the Data Center.

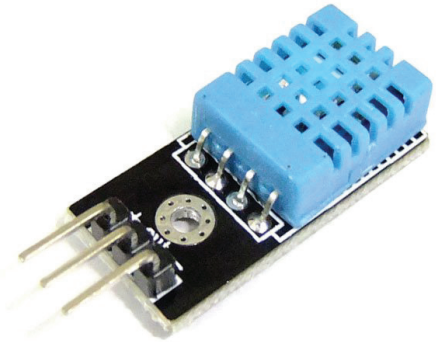

Figure 1 – Temperature sensor DHT11.

Figure 2 – Non-invasive current sensor 100A SCT-013.

The treatment of the information collected by the temperature sensor and the noninvasive current sensor was made by an Arduino Uno (figure 3), which sent the data using a serial port to communicate with the Raspberry PI (Figure 4). The data collected was processed by the Zabbix network administrative tool (Version 3.0.1) and the information generated by it was analyzed through its dashboard.

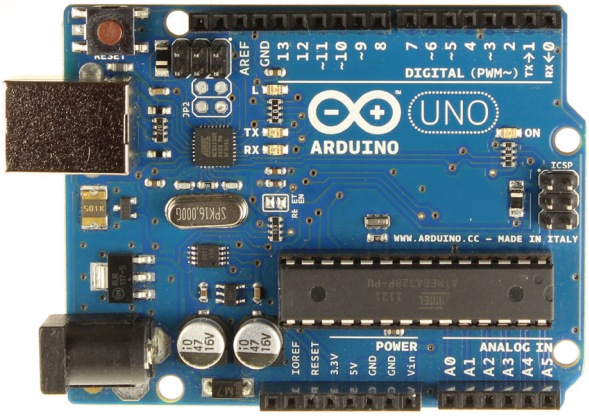

Figure 3 – Arduino Uno.

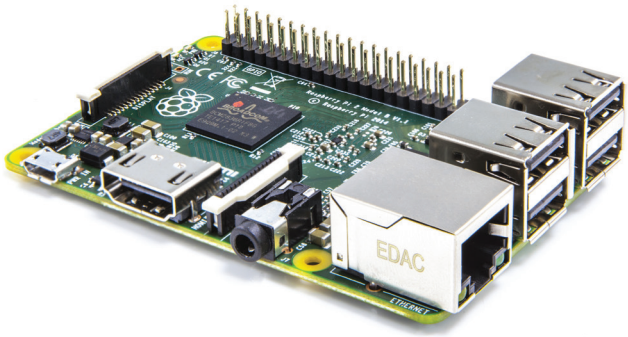

Figure 4 – Raspberry PI.

The Arduino Uno was responsible for the thermal responsiveness of the Data Center, which performed temperature control through the air conditioning via infrared. According to Geng (2014), to ensure the proper operation and durability of equipment at the Data Center's environment temperature, it should not exceed 25ºC. Additionally, according to Pereira (2015) good practices values for environmental temperature in a Data Centers must be between 18ºC and 22ºC. Thus, in this work, the Arduino will ensure that room temperature does not exceed 22°C. If for some reason the limit of 22ºC is exceeded, the Arduino will configure the air conditioner to operate at the minimum temperature (16ºC) to bring down the temperature and stabilize it between 18ºC and 22ºC. If the temperature is equal to or lower than 20ºC, it will turn off the air conditioning system to save energy, and under normal conditions the air conditioner will operate at 20ºC.

In order to analyze the results obtained by the implementation of the appliance, a comparison will be made with the energy consumption prior to the project implementation and the new consumption data after the project. Figure 5 shows the sensor collecting data from the Data Center. Figure 6 presents the developed system.

Figure 5 – Non-invasive current sensor (100A SCT-013) collecting data from the Data Center.

Figure 6 – Developed system collecting data from the Data Center.

During data collection, Zabbix monitored the temperature and power data readings hourly. In the following section, the data collected will be analyzed.

4. Results Discussion

In order to perform the data analysis, the data obtained by the collections made on two consecutive days were compared. The first day is the business as usual case, without the thermal response appliance and it is presented in table 1.

Table 1 – Hourly Temperature and Energy Consumption in the Business as Usual Scenario.

Time	Room Temperature (°C)	Energy consumption (watts)	AC status	AC temperature (°C)
0:30	17	1,325	On	16
1:30	17	1,333	On	16
2:30	17	1,335	On	16
3:30	17	1,329	On	16
4:30	17	1,335	On	16
5:30	17	1,337	On	16
6:30	17	1,570	On	16
7:30	19	1,572	On	16
8:30	19	1,569	On	16
9:30	17	1,456	On	16
10:30	17	1,369	On	16
11:30	17	1,356	On	16
12:30	17	1,370	On	16
13:30	17	1,315	On	16
14:30	17	1,377	On	16
15:30	17	1,379	On	16
16:30	17	1,357	On	16
17:30	17	1,367	On	16
18:30	17	1,379	On	16
19:30	17	1,355	On	16
20:30	17	1,326	On	16
21:30	17	1,297	On	16
22:30	17	1,300	On	16
23:30	17	1,365	On	16

In table 1, it is possible to verify that the air conditioning is always turned on in the minimum device temperature. Likewise, the room temperature suffers almost none variation. The energy consumed is always high.

In table 2, the new scenario with the system described and developed in the following day is presented. As it was described in the methods section, an automated smart management of the air-conditioning is made and the results are as follows.

In table 2 it is possible to witness that to maintain room temperature below 25 °C there are certain periods of the day that the air conditioning is not necessary to be turned on. Therefore, reduced electricity consumption can be attained.

Table 3 presents a comparison of energy consumption between the business as usual scenario and the proposed scenario.

Table 2 – Hourly Temperature and Energy Consumption in the Scenario Using the Developed System.

Time	Room Temperature (ºC)	Energy consumption (watts)	AC status	AC temperature (ºC)
0:30	20	715	Off	–
1:30	20	717	Off	–
2:30	20	725	Off	–
3:30	20	719	Off	–
4:30	20	723	Off	–
5:30	24	1,034	On	16
6:30	23	1,577	On	16
7:30	22	1,573	On	16
8:30	21	1,576	On	20
9:30	22	1,449	On	20
10:30	22	1,379	On	20
11:30	22	1,346	On	20
12:30	22	1,356	On	20
13:30	21	1,342	On	20
14:30	22	1,376	On	20
15:30	22	1,359	On	20
16:30	22	1,352	On	20
17:30	22	1,362	On	20
18:30	21	1,374	On	20
19:30	20	716	Off	–
20:30	19	721	Off	–
21:30	19	726	Off	–
22:30	19	727	Off	–
23:30	20	719	Off	–

Table 3 – Energy Consumption Comparison.

Time	Without Thermal Response (watts)	With Thermal Response (watts)	Difference (watts)
0:30	1,325	715	610
1:30	1,333	717	616
2:30	1,335	725	610
3:30	1,329	719	610
4:30	1,335	723	612
5:30	1,337	1,034	303
6:30	1,570	1,577	-7
7:30	1,572	1,573	-1
8:30	1,569	1,576	-7
9:30	1,456	1,449	7
10:30	1,369	1,379	-10
11:30	1,356	1,346	10
12:30	1,370	1,356	14
13:30	1,315	1,342	-27
14:30	1,377	1,376	1
15:30	1,379	1,359	20
16:30	1,357	1,352	5
17:30	1,367	1,362	5
18:30	1,379	1,374	5
19:30	1,355	716	639
20:30	1,326	721	605
21:30	1,297	726	571
22:30	1,300	727	573
23:30	1,365	719	646
Total	**33,073**	**26,663**	**6,410**

It is possible to verify that between 05:30 and 18:30 the energy consumption is higher, probably because that in these moments occurs a greater use of the servers and the temperature increase, which ends up requiring extra air-conditioning and consequently a greater consumption of energy. Still analyzing the values of table 3, with the use of thermal responsivity, it was possible to obtain savings of 6,410 watts in one single day. If it is considered a 30-day month, savings could easily reach 190,000 watts, providing significant financial savings for the company and resulting in an enhanced efficiency related to energy consumption.

5. Conclusion

The need for a more efficient and sustainable use of resources in developing countries motivated this research, which aimed to integrate free software, free hardware and a set of sensors in order to obtain a responsive thermal monitoring system to manage consumption of electrical energy in a Data Center. Using the proposed system, it is possible to verify that a simple automated system as described in this article is capable of saving an average of 20% more energy compared to an uncontrolled environment. In addition, it is possible to highlight a greater reliability of the services offered by the Data Center and the reduction of the problems generated by the lack of an active monitoring in the same one since the Zabbix software could alert real-time problems to company employees. Further experiments could be made to enhance energy efficiency of the system. Other preset temperature values could be tested in order to save even more energy and maintain the room temperature in the desired values.

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Geology

Strength and Weakness in Geotourism: The case study of Irpinia (Campania, Italy)

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Keywords: Geosites; Geotourism; Irpinia, Campania, Italy

Abstract

The territory of Irpinia (Campania, Italy) has been largely preserved by the "Great Transformation" of the territory followed by the Second World War. Its environmental peculiarities and its historical-cultural aspects have integrated into the landscape; therefore they represent attractive places for the new directions of environmental and cultural tourism. The advantages derive from the proximity to the coast of Campania, where the global value of tourist attractions has been known for centuries. The strengths of these internal areas of our peninsula are represented by the numerous places capable of divulging the "geological culture" and therefore to highlight how around them have developed stories, cultures and traditions of quality. However, there are weaknesses in the conservation and uses by tourists of these areas, as highlighted by the spread of certain geological and geomorphological hazards (landslides, floods, fumes, etc.). Geotourism would, therefore, be fundamental to recall the public interest on this internal area of Campania and to encourage protection and enhancement initiatives.

Introduction

In Italy, tourism is an important part of the economy, accounting for more than 13% of GDP, as reported for the year 2017 by the World Travel and Tourism Council, which analyses the economic impact of the travel and tourism sector in the world and in the individual countries (WTTC, 2018). Statistical data show an increase both in the presence in the hospitality establishments and in the arrivals in our peninsula with rates higher than the European average.

The southern regions, even if they are not yet in the very first places, show substantial increases in terms of presences, which in any case in the northern regions still absorb the majority (Veneto: 16.5%, Trentino Alto Adige: 11.9%, Tuscany: 10.9 %). Considering the revenue left on the territory by the tourists, instead, Campania succeeds among all those of the south in attracting a meaningful percentage that immediately puts it behind the Lazio, the Lombardy, Veneto, and Tuscany (ISTAT, 2018). Even going back in time the economic value of tourism in Campania and its provinces has always been fundamental, even if the statistics show that it is concentrated almost exclusively in coastal areas. In these areas, the tourist flows prefer not only the holidays at sea (Cilentan coast, Ischia Island, Capri Island and Sorrento Peninsula), the archaeological sites (Pompeii, Paestum, Herculaneum) and the cities of art (Naples with its museums and palaces, the Royal Palace of Caserta) (MiBAC, 2018). Each of these places, today chosen by the majority of tourists, both Italian and foreign, presents a seductive and sometimes almost uncontaminated landscape, or a geological context, unique and characteristic, like that of the Campania volcanoes (Vesuvius in the Campania coast, Mount Epomeo in Ischia, Campi Flegrei in Pozzuoli) or that of the coasts with its many evocative forms (the limestone cliffs of Capri, the terraces of the Sorrento Peninsula, the caves of Palinuro in the southern Cilento).

These choices testify to the approach of tourism toward new categories of value, such as the natural environment and culture. Through them the experience lived by the tourist can contribute to increasing his "sense of attachment" towards the place visited or the appropriation of the "identifying products and/or attributes" of that territory (Gross & Brown, 2008). This includes the flourishing development of cultural tourism and its varieties (sustainable tourism, ecotourism, geotourism, eno-gastronomic tourism, etc.), which as shown in various surveys conducted on samples of tourists from Veneto, Tuscany and Puglia, is associated to cultural heritage as well as to more identity-naturalistic aspects (trekking, crafts, wine and food production, etc.) (MiBAC, 2010). In this

direction, it is possible to consistently insert the need to enhance the internal areas of the peninsula, such as Irpinia (Bencardino & Marotta, 2004; Bencardino & Cresta, 2007; Cresta & Greco, 2010; Russo & Sisto, 2012). In the enhancement actions of a territory, it is evident how these can be developed around strengths represented by the spread of large uncontaminated natural areas and by a close relationship between the territory's resources and human activities. However, these actions cannot be ignored those situations of the danger inherent in the territory, which could prevent the promotion and enjoyment of these places.

Geotourism in Irpinia

Irpinia is a region of the southern Apennines, located in the eastern part of Campania (figure 1). It corresponds to the province of Avellino (2,792 km2, 440,000 inhabitants) and its territory is divided between mountain, which makes up most of it (67.9%), hill (25.1%) and plain (7.0%). Its sparsely inhabited landscapes are largely preserved by the "Great Transformation" (Turri, 2002) followed in the Second World War. They are characterized by their natural architectures and the singularities of the environment, which have received the imprint of many ancient civilizations.

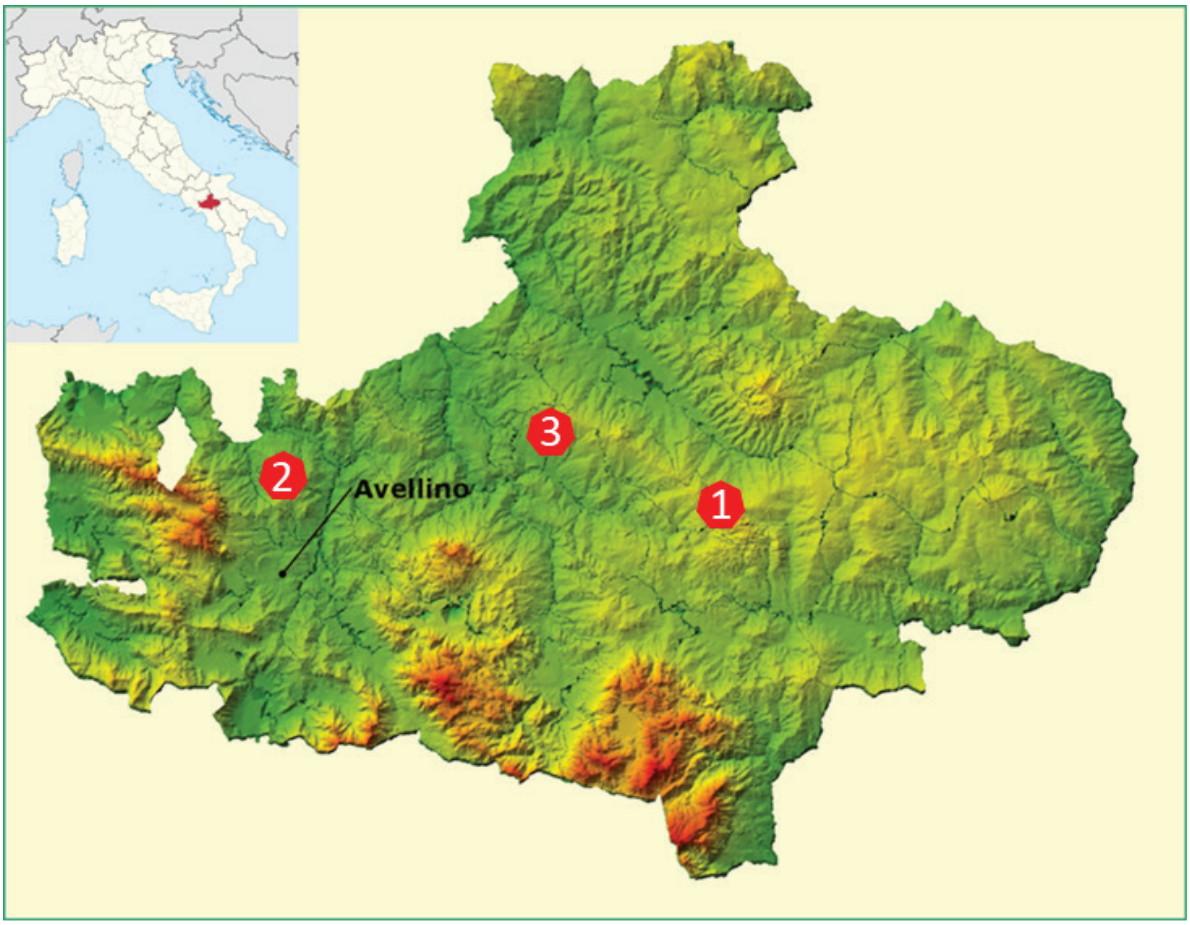

Figure 1 – DTM of Irpinia in Campania: from green (lower) to brown (higher) the altimetric range. Numbers in red polygons indicate representative geosites: 1. The Mephite in the Ansanto Valley; 2. The Mulino-garden of the sulphur mine; 3. The quarry of "Breccia Irpina" in Serro della Serpa.

To the west and south, there are the Mesozoic carbonate massifs (D'Argenio et al., 1973; Bonardi et al., 2009): thanks to their karst nature they have developed the largest underground water reserves in southern Italy and also show a wide range of landforms in the mountain landscape such as polje, uvala, dolines, lapiés. In the underground, an intricate system of fissures, connected to the surface forms, can open up in correspondence of caves with stalactites and stalagmites (Sestini, 1963). From their peaks, covered by dense forests, but also engraved by tectonics and shaped by erosion, you have the opportunity to have panoramic views at 360°. On other peaks, less elevated, we find medieval castles still surrounded by intact villages in their original configuration.
To the east, the Cenozoic clastic sediments form hills (Bonardi et al., 2009), whose slopes are frequently characterized by strong instability with landslides of all types and sizes. How-

ever, they have also developed valuable crops (vines, olives, hazel groves, etc.) increasingly growing in quality and quantity (Bencardino & Marotta, 2004; Cresta & Greco, 2010). These hills are crossed by a dendritic hydrographic network, which then flows in rivers with rather copious flow rates, such as Calore, Sabato, and Ofanto. However, the plains adjacent to these rivers, where they are slightly wider, have been filled with important thicknesses of alluvial deposits and pyroclastites during the Quaternary (Brancaccio & Cinque, 1988). The first sediments were deposited from the main rivers and the latter came from the Tyrrhenian volcanic centres of Somma-Vesuvius and Campi Flegrei.

This description is rather brief compared to the number of physiographic types that distinguish Irpinia. This assumes a greater value because the populations and their activities have respected these places for years, preserving their original appearance. In this effort even the secular traditions and flavours of food seem not to have been contaminated by modernity and sophistication. Moreover, the vegetation has taken advantage of these conditions so as to extend its naturalness with native species of value, which are protected by the Natura 2000 network (20 between SIC and SPA) and by two regional parks (Parco del Partenio and Parco dei Picentini). For these aspects, Irpinia is a privileged place for the development of environmental and cultural tourism (Regione Campania, 2008; Di Lisio et al., 2016a).

In fact, geodiversity, like biodiversity, is of primary importance for new tourism, based on the need for environmental protection and the concept of sustainable development (Baker, 2006). Milestones of its concepts are the Brundtland Report (1987), the European Landscape Convention (2000) and the Council of Europe's Recommendation on the conservation and enhancement of geological heritage (Council of Europe, 2004). Moreover, the action of the UN system on the Millennium Development Goals, by 2015, has set among the commitments of the Objective 15 of "Protect, restore and promote sustainable use of the terrestrial ecosystem, sustainably manage the forests, fight desertification, stop and reverse the degradation of the land, and stop the loss of biological diversity", and more "increase the capacity of local communities to pursue sustainable livelihood opportunities" (United Nations, 2013). Tourism in Irpinia has the opportunity to do so by choosing in the environment and in the culture the guidelines of the development. This territory can offer, in fact, very different landscapes, but also a rich cultural heritage (Panizza & Piacente 2003). It appears not contaminated, pleasant, not involved in criminal actions. That's why, in the last decade, arrivals and presences in all types of accommodation have recorded marked growth. Moreover, visiting the Irpinia villages, many tourists often buy holiday homes.

Along these routes, tourists are likely to feel attracted by the values and relationships of territory, but also by landscapes and forms capable of amazement for their beauty and at the same time to tell the story of the formation of those places (Cosgrove & Daniels, 1988; Poli, 1999). They are related to different aspects of geology, even if they then unfold popular traditions and dark mysteries. In these places, we find the typical landscapes of the inner areas of the Apennines (karst, terrigenous, fluvial, lacustrine, etc.), that have been the background to the secular historical events of these areas. Therefore, talking about geotourism in Irpinia means supporting and amplifying the "geographical character of a place, its environment, culture, aesthetics, heritage and well-being of its residents" (NGS, 2009). In these territories the trip allows you to visit places where winter sports and trekking are practiced, or to enjoy the wonders of architecture: from rock churches to castles and monastic complexes, or to taste typical gastronomic products with high-quality olive oil and wines, now exported all over the world. It should be noted that Irpinia has received the DOCG (Denomination of Controlled Origin and Guarantee) for three wines: Taurasi, Greco di Tufo, and Fiano di Avellino. This label demonstrates the achievement of quality and renowned product, with characteristics associated with the natural and anthropic environment (Bencardino & Greco, 2007; Cresta & Greco, 2010; Di Lisio et al., 2016b).

Strength

In a correct assessment of human actions, there is the need to highlight the resources that the system is equipped with. In this case, the strengths in geotourism in Irpinia are represented by the numerous geosites surveyed in the Regional Cadastre of Geosites since 2008 (figure 2). Such a registry was created by the Campania Region making a specific reflection on the value of geoconservation in its Territorial Strategic Plan (Regione Campania, 2008). Within it, a little more than 50 locations were included, surveyed on the basis of a prevailing geological-stratigraphic characterization. In the following years, thanks also to the reformulations of the concept of geosite (subjected to continuous revisions in a well-established specific literature), also extended to that of geomorphosite *sensu* Panizza (2005), the total of the deserving Irpinia geosites has been raised at 70 (Di Lisio et al., 2018).

The geosites to be considered as witnesses of time, according to a fortunate definition (Poli, 1999), are places, areas or territories in which it is possible to identify a geological or geomorphological interest for conservation (Wimbledon, 1996). Moreover, they are the basic prerequisite for discussing geoconservation strategies and developing products to disseminate the geological and geomorphological characteristics of the landscape to a wide public (Brilha, 2002). This assumes

Figure 2 – Excerpt from the Regional Cadastre of Geosites in Irpinia (fron Regione Campania, 2008).

more value since there is a growing interest in geosites (and related geotourism, a happily sustainable form of leisure/learning in the conceptual framework of the landscape): such interest is finally reflected in the planning acts of local authorities, regions, and states, and this not only in economically more advanced countries but also in developing countries.
In the case of Irpinia, many sites reach the definition of geomorphodiversity proposed by Panizza (2009) and the Principles of Geotourism (NGS, 2009), which refer to "the integrity of the places, the respect of the international codes, the participation of the community to the benefits, the satisfaction of tourists, the conservation and enhancement of resources, the planning and use of the territory, the educational / interactive fun, and finally the assessment procedures". Among those surveyed in Irpinia, in this work, three geosites are proposed as they are representative for scientific quality (Panizza, 2005) and for geological, historical and archaeological importance (Pereira et al., 2007).

The Mephite in the Ansanto Valley

This geoarchaeosite (sensu Lena, 2009) is one of the flagships of Irpinia's geological heritage (Di Lisio et al., 2010: Di Lisio et al., 2014), is known and frequented for millennia, so as to be worthy to receive important literary quotations. Over the centuries it has been variously interpreted as the mouth of Hell (Latin literature of the classical age), as an extinct volcano arranged on the Vulture-Vesuvius alignment (seven-nineteenth-century naturalistic literature), as a manifestation of resurgences of deep fluids enriched by contact with Messinian evaporites and/or as the epicentre of the 1980 earthquake (contemporary geological literature). The phenomenon has recently been linked to deep degassing processes, in the context of the articulated crustal subduction underway in the central Mediterranean. However, this *situ* shows the world's largest non-volcanic emission of CO_2 (Chiodini et al., 2010). The characteristic of the site (figure 3), located between the towns of Rocca San Felice, Frigento and Villamaina, is a pond of about 50 meters in diameter in which it boils grey and muddy water and from which violent poison gases are released (Duchi et al., 1995). Around the pond there are other small pools, mud banks and clayey slopes without vegetation from which crystals of gypsum and sulphur emerge (Di Lisio et al., 2011; Di Lisio et al., 2014). In the area a shrine to the Goddess Mefite was built around the seventh century BC, now completely destroyed, but the discovery of remains and findings (amphorae, terracotta, etc.) testifies its great attendance (Rainini et al., 1976; Mele, 2008). For this archaeological value, it is considered among the 101 archaeological sites of Italy, a place in which to go at least once in life (Ardito, 2013), however, the Mephites does not hide its intrinsic dangers (exhalations, active or quiescent landslides on the surrounding slopes) that may not favour the full enjoyment of this geosite. Despite this, it indirectly confers added value to all the crops and dairy production in the area, which have already obtained recognition and protections regarding typical local products. The happy union between the spectacular geological phenomenology, the high historical-archaeological value and the agro-food typicality make it a true

Figure 3 – The Mephite of the Ansanto Valley.

paradigmatic example of how a geosite can trigger virtuous paths of sustainable tourism, acting as a driving force for the economic growth of an entire territory (Di Lisio et al., 2014).

The Mulino-garden of the sulphur mines (figure 4)

The Altavilla and Tufo (AV) mines exploit sulphur deposits present in the arenaceous-clayey-chalky succession of the Upper Messinian (Altavilla Formation: Bonardi et al., 2009), approximately built up 5.5 million years ago. At that time the waters of the Mediterranean evaporated almost completely, due to the closure of the Strait of Gibraltar, for which the conditions of deposition of this mineral were created. Its discovery in these areas and its subsequent cultivation dates back to 1860, and since then this mining activity has played a role of great importance for the Irpinia economy (Di Lisio et al., 2014). The extraction of the mineral, taken from a man-power until then exclusively peasant, allowed the flourishing of an economy based on sulphur, so as to recall on the spot emigrants from Abruzzo, Molise, and Romagna: the precious resource was used both in commerce and in agriculture, with transport on cart or rail in all the neighbouring regions. In 1971 the crisis began and the number of workers was drastically reduced. At the beginning of the Nineties, the mining activity ended up leaving an industrial complex, which preserves the main elements of the factory from the milling and refining of the raw ore to the internal transport with trolleys to the storage and preparation for the shipment of the mineral ready for use (Del Prete, 2011). In recent years the public administrations of the area have started the recovery of the industrial and mining complex of the Mulino-Giardino di Tufo, also because in this area the lands are widely used for the rows of DOCG Greco and Fiano wines. For tourists visiting there is the opportunity to recover a close relationship between resources and human activity (Amato et al., 2010).

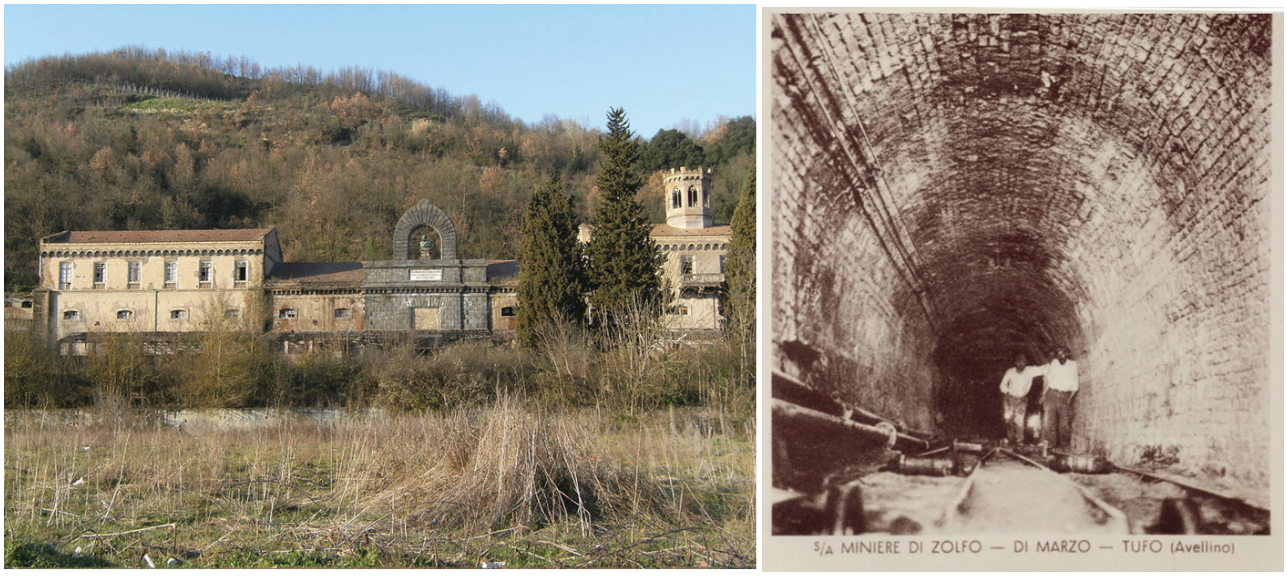

Figure 4 – The sulphur mines of Tufo (Avellino); on the left the monumental buildings before restoration and on the right the entrance to the underground galleries.

The quarry of "Breccia Irpina" in Serro della Serpa (figure 5)
The well-known lithotype commercially called "Breccia Irpina" has long been of considerable appeal, and not only locally (Allocca et al., 2010). Furthermore, for centuries it has constituted one of the most sought-after ornamental stone for the production of precious pieces and decorations, present in the most famous historical buildings and sacred buildings of Irpinia and outside it (Ciarcia et al., 2013). From the authorized quarries of Sant'Andrea di Conza and Pescopagano it is extracted in a compact form, with a granulometry typical of the breccias in carbonate matrix, whose market price is directly proportional to the size of the clasts and the variety of coloration. According to the sites, in fact, this material is identified as "favaccia, favaccino, brecciato, stone of Fontanarosa, stone of Gesualdo" (Ciarcia et al., 2013). More specifically, these are sedimentary deposits affecting a structurally complex formation, which is presented in layers and banks of ruditic limestone of varying thickness, sometimes crossed by laminated layers of clays (Flysch Rosso: Cretacico Inferiore – Oligocene, Bonardi et al., 2009). Today the extraction of this precious material proceeds at alternate rhythms, both because many quarries are about to run out, and because many are closed or difficult to open for reasons of environmental protection. However, there is the willingness of some of these workers to pass on this centuries-old ability of man to work an important stone resource in these lands through the promotion of their "shops". Its easy workability, its high wear resistance and sliding friction (Del Gaudio & Vallario, 2007), makes a stone widely used in construction and for the construction of internal and urban furnishings. Recognizing these geological materials in the historical heritage built in Irpinia contributes to establishing interdisciplinary approaches and even imagining prospects for social and economic re-evaluation.

Figure 5 – Example of a slab of Breccia Irpina (on the left) and a worker of the stone (on the right).

Weakness

If the structure of Irpinia with its geodiversity makes it possible to emphasize the nature of the trip and the visit to a place, it is equally true that there is a relationship between the geotourist use of a site and its natural or induced dangerousness human activity (Panizza, 2005; Brandolini et al., 2007; Reynard et al., 2016). This danger is linked to the conformation of the place, which can be accentuated by human behaviours not suitable for the natural processes that develop there, to the point of triggering or accelerating its occurrence. Therefore, even in a geosite, there is the probability that a potentially destructive event occurs in an area (e.g. crags collapse, poison fumes, etc.) with a certain intensity that can damage the user and/or the consistency of the place.
Recent and painful news stories have shown how the use of a geological and environmental asset can be risky, as evidenced by the Italian tragedies of the Solfatara di Pozzuoli (NA) and the Maccalube di Aragona (AG) occurred in 2017 and 2014, respectively. Such events are terrible testimonies of how the underestimation of intrinsic dangers can then be turned into manifest damage to people, to cultural/environmental asset or to natural resource (water, soil, forest, etc.), to property (land, buildings, etc.) and to the productive capacity of an activity (industry, farm, etc.).
The concept of risk has been repeatedly defined and is still the subject of reflection in various fields of application, not least those of technical regulations. But referring to the well-known proposal of the UNESCO report by Varnes D.J (1984), the risk is expressed by the relationship between different components, all probabilistically linked to the interaction between phenomenon/event and human society (people, buildings, infrastructures, economic activities).
According to this interaction, geotourism could be weakened

if it did not consider the nature of the possible risks to which a geosite or geomorphosite could be subjected. It could be damaged at the point of its complete destruction but, at the same time, the estimated risk could potentially compromise its own function in thr coincidence of a particular danger (for example, poisonous fumes, explosions, collapse, floods, etc.). Moreover, the lack of consideration of risks or observance of the safeguard rules would detract from the prestigious magazine National Geographic Traveler, which claims that geotourism represents the evolution of "sustainable tourism", that is to guarantee future generations to enjoy that environmental good (NGS, 2009).

To highlight these weaknesses in geotourism, the three Irpinia geosites, previously described, have been taken. These places of extreme geological interest are proposed among others for the particular combination created between natural and human resources, but also for their marked exposure to the dangers that are present in them.

In this choice, we wanted to investigate situations with levels of probability of occurrence more marked than relatively less critical situations. The identified risks have been distinguished in natural and anthropic types. For the natural risks, the various elements of danger have been highlighted, which for the various geosites can show common characters or peculiar characteristics (Table 1). For anthropic risks, a further distinction is proposed between risks connected to the commercial exploitation of the georesource available in the geosites and risks inherent to geotourist use of the same places (Table 2).

As it is possible to read the natural phenomena, which can determine a risk condition, they also develop around the site. For example, the Mefite is placed in an area at high risk of landslide due to the physical-mechanical conditions of the outcropping land (figure 6), while the sulphur mines of Tufo are on the right embankment of the river Sabato and therefore subjected to a possible flood (figure 7). In the latter case, it should be said that as the river in its engraving allowed the cultivation of the ore body in the same way it could remove the possibility of visiting these places where man has been able to extract a resource for more than a century. Also in the Sant'Andrea di Conza geosite the alteration of the calcareous breccias could determine instability conditions on unused walls. The degree of danger of these risks, as well as others, could find suitable mitigation if there was careful and responsible management of the site and of the territory.

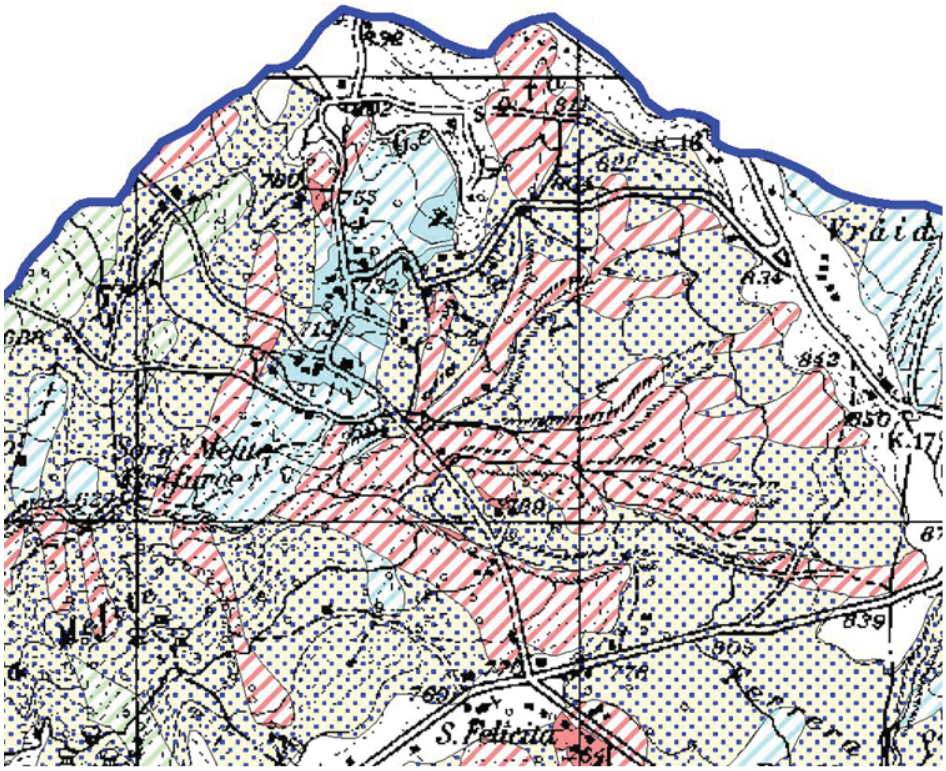

Figure 6 – Excerpt of the map of the Landslide Risk in the Mephite of the Ansanto Valley (from the Authority of the Liri Basin Garigliano Volturno, 2006). Note that the areas with pink diagonal lines are affected by triggering, transit and landslide invasions with the probability of maximum intensity; areas with celestial diagonal lines are areas that fall within quiescent landslides with the probability of medium intensity; the areas dotted on a yallow background are area of possible expansion of landslides.

Figure 7 – Planimetry of the external site of the sulphur mines of Tufo (AV) developed on the right bank of the Sabato River and therefore in an area at risk of flooding.

Figure 8 – Processing area of the Irpinia Breccia adjacent to the exhibition sites.

Table 1 – Natural Risks

Geosite	Municipality	Risks related to various dangers.
The Mephites in the Ansanto Valley	Rocca San Felice (Avellino)	• potentially deadly exhalations; • landslides due to high instability of terrigenous deposits around the site (damage to access roads, inadequate settlement of the surrounding slopes).
The Mulino-garden of the sulphur mines	Tufo (Avellino)	• falls in the tunnels; • exhalations in the mines area; • sudden explosions in the mines area; • Sabato river floods.
The quarry of "Breccia Irpina" in Serro della Serpa	Sant'Andrea di Conza (Avellino)	• stone elements falls on abrupt and unequipped walls; • alteration phenomena in the quarry area.

Another category of risks concerns the anthropic action that takes place on the site and in its immediate surroundings, as illustrated in Tab. 2. In order to better intervene on the anthropic risk, as already mentioned, it has been preferred to distinguish it in that linked to the exploitation of the geo-resources available on the sites (i.e. stone processing in the quarry), and the one connected to the geotourist use of the same places (i.e. visit to the "exhibition shop" of the stones annex to the quarry) (figure 8).

In the three geosites, it is possible to underline how the anthropic action has modified the natural order of the places. For example, in the sulphur mines of Tufo, now inactive, the construction of tunnels in the underground for four levels and 3 km in length, all armed with timber due to the construction of the extraction routes, may have led to a "loosening" of the compactness of the rock mass. On the other hand, in the narrow valley of the Mefite sulphur, mud, and gypsum sulphate, even if now ceased for a few decades, has certainly partially altered the morphological profile triggering the instability phenomena highlighted. For the active quarry of Serro della Serpa (figure 8), the cultivation takes place on a limited stone body of "breccia irpina", likely with the current withdrawal rates will result in the disappearance of the lithotype and, jointly, the disfigurement of the area, in absence of adequate environmental restoration measures.

As far as geotourist use is concerned, all the sites considered could be subject to unsustainable behaviour, if not subject to monitoring and surveillance, as well as to documentary information, containing rules aimed at safeguarding the site. In particular, in the case of the Mefite one could even imagine predators of archaeological material, or improper disposal or guilty of waste of any kind. In the other two sites, since the entire area has not been visited, it will be better to avoid access to the former gypsum mine or near the working area.

Table 2 – Anthropic Risks

Geosite	Municipality	Risk types	
		linked to commercial exploitation	linked to geotourist use
The Mephites in the Ansanto Valley	Rocca San Felice (Avellino)	• quiescent risk for previous quarry exploitation; • triggerable risk for unsuitable maintenance and site protection.	• unsustainable and / or predatory behaviour (removal of archaeological and numismatic heritage, abandonment of waste, etc.)
The Mulino-garden of the sulphur mines	Tufo (Avellino)	• quiescent risk for previous mines exploitation; • triggerable risk for unsuitable maintenance and site protection.	• collapse of the underground extraction system; • risk deriving from the rests of the extraction plants still present in the area • unsustainable behaviour.
The quarry of "Breccia Irpina" in Serro della Serpa	Sant'Andrea di Conza (Avellino)	• exhaustion of the outcropping lithotype; • landscape degradation of the area.	• incompatibility with extractive use still active; • unsustainable behaviour.

The knowledge and estimation of the risk linked to that phenomenon, however, makes it possible to identify the priorities of intervention to be implemented to reduce the likelihood that the risk will turn into damage. This mitigating action is strictly fitting with the use of an environmental resource, as a geosite, which preserves intact its geological and geomorphological characteristics more than any other place. The managing assets of the environmental resource should keep in mind this priority, so that it can be enjoyed in safety, without underestimating for incapacity or worse, for bad faith, the possible consequences of its fruition, more or less massive.

Finally, possible standard proposals have been made to mitigate the risks identified in the specific areas of study, but which can be adopted in any context in order to avoid dangerous situations that could lead to probable damage.

Discussion and Conclusion

Geoturism in Irpinia would allow the dissemination of the "geological culture", highlighting the values and relations of territory and highlighting the criticalities and vulnerabilities for its protection. The knowledge of the elements constituting the geological heritage is the starting point, as it would make it possible to present to the curiosity of tourists the different lithological and morphological forms of the territory, as well as their formation (Poli, 1999; Dowling & Newsome, 2008; Alberts & Hazen, 2010). This informative and documental aspect, perhaps with the installation of particular panels and visual supports, becomes essential for the promotion of geotourism. Immediately afterwards the connections with the other natural and anthropic aspects that make up the territory are to be considered. This will allow us to discover the relationships that bind living beings with the features of the Earth, even using pre-established routes or taking advantage of celebratory manifestations (Panizza & Piacente, 2003; Russo & Sisto, 2012; Di Lisio et al 2016a).

These considerations can be applied in Irpinia for three essential conditions: a) the growth of cultural demand and tourist flows, even beyond financial availability; (b) the presence of millions of tourists on the coast of Campania, and therefore the possibility of reaching the internal areas of the Apennines with a short trip; c) the existence of a large number of qualified geosites near other high quality attractions (biodiversity, castles and monumental palaces, DOCG and DOC wines, DOP gastronomic products, etc.) (figure 9).

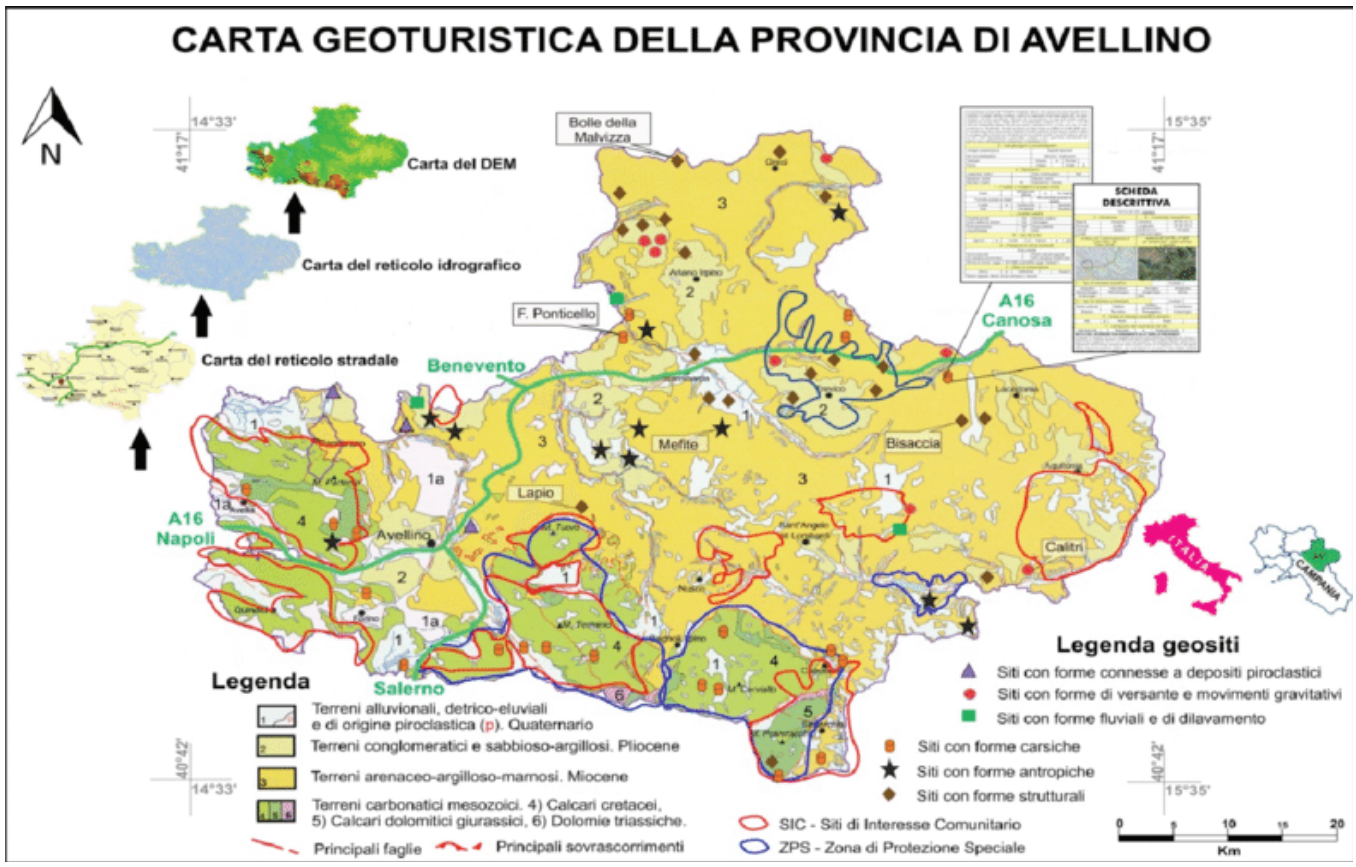

Figure 9 – Geotourism map of the province of Avellino (proposed in Di Lisio et al., 2014) in which are identified geosites close to other high-quality attractions of the territory.

However, in order to achieve significant feedback in geotourism, there is a need to develop cultural and tourism marketing, which satisfies the demand of tourists through an adequate and sustainable offer. An approximate or incorrect promotion of these itineraries and an absent or complex use of these resources cannot guarantee the result and not even the protection from possible risks (Brandolini et al., 2007; Alberts & Hazen, 2010).

For this reason, in the management of geosites, it is strategically useful to consider measures or interventions aimed at mitigating the reported risks. If for all the sites it seems obvious a protection of the area, to be implemented in the forms provided for by law to protect natural and landscape assets, we also propose installations of video surveillance systems and fence areas, with appropriate reporting of existing risks and boundary of equipment for tourism purposes (Dowling, 2008).

More burdensome but strictly necessary interventions are also those concerning the regulation of the outflow rods, adoption of containment systems with naturalistic engineering techniques (in particular the Mefite) and the removal, where possible, of pylons (visual pollution/landscape). At the same time, in the Apennine areas, already unfortunately largely subject to this type of installation, it would be to propose a total prohibition of further wind power plants, so widespread on these Apennine reliefs.

For the sulphur mines, in part already providentially implemented, the recovery and restoration of the entire industrial and mining complex would be accelerated, with the creation of a centre for tourism and, in the vicinity, a museum of eno-gastronomy. In fact, a very high-quality wine like, as the Greco di Tufo DOCG, could be developed from the characteristics of the land. Such interventions could be accompanied, as in many examples of similar geosites, by partial recoveries of the mining tunnels, as well as partly looted furniture and machinery, to create a Museum of industrial archaeology (figure 10).

Finally, for the active quarry of Serro della Serpa, it is suggested a partial halt of the extraction activity or, as a safeguard measure, an isolation for geo-tourism purposes of a more or less extensive part of the quarry areas, as a testimony in situ of the outcrop of the known stone material extracted therein.

The above descriptions are only proposals to make the three representative geosites of Irpinia more accessible and safer to the "general public". However, giving space to the geological culture also means diversifying the offer, including various activities suitable for schools, families, sports enthusiasts, lovers of traditions and so on. To this end it will be good to produce information material suitable for the public to which it is addressed, giving priority to the graphics part (Di Lisio et al., 2016b). Alongside this promotion of knowledge with scientific criteria, it will be possible to develop geo-tourist-cultural itineraries aimed at enhancing the resources of the territory through educational-educational paths. This type of tourism generally requires longer stays, because the times of the discovery of the mountain and hilly landscape are slower, as indicated by research by CENSIS (2003). Therefore, this consideration could also incentivize accommodation businesses and allow travel agents to find new job opportunities (Bencardino & Marotta, 2004; Cresta & Greco, 2010). All this will make Irpinia become a tourist reference pole, and consequently a flywheel for the entire economic system, but it is necessary that the territory should not be found unprepared (Baker, 2006; Raynard et al., 2016).

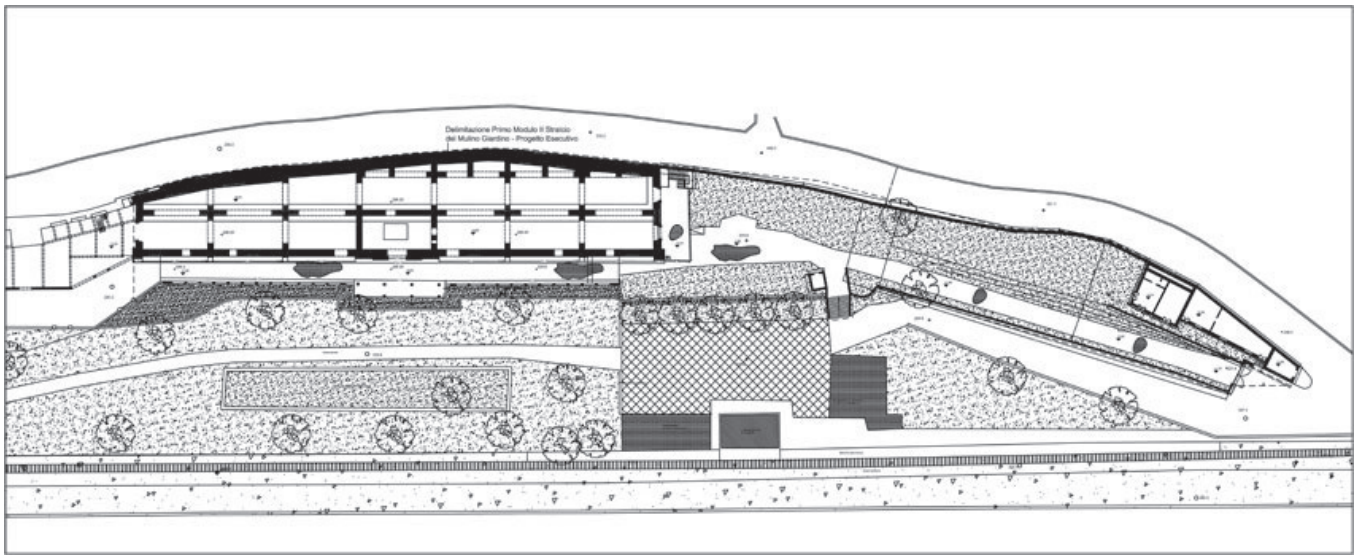

Figure 10 – Example of restoration project of the Mulino Giardino of the sulphur mines in Tufo (Avellino).

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Peri-urban areas, morphological evolution and hazards: The case of Rio city, Northern Peloponnese, Greece

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Keywords: Peri-urban areas, Rio, Peloponnese, hazards, morphology, evolution

Abstract

Morphological evolution and its relationship with peri-urbanization is becoming an increasingly interesting and significant topic, due to the high impact that it has on highly sensitive areas.

Our study area is the city of Rio in northern Peloponnese, located approximately 7 km far from the city of Patras. With a population of around 15.000 inhabitants, is considered to be a highly sensitive area, because of numerous and important infrastructures, such as the University of Patras, the local University hospital, two sports halls and the Ottoman era fortress located at the coast.

The geology is characterized by the formation of Olonos – Pindos zone, including Pliocene and Pleistocene sediments, covered by Quaternary and alluvial deposits and dislocated by faults with NE-SW and NW-SE direction.

Geochronological and sedimentological studies of dated raised terraces found an average uplift rate of 0.4 to 6 mm/yr while the dating results indicate pre-Tyrrhenian to Tyrrhenian interglacial ages.

Hydrologically, the area is characterized by ephemerous streams and rivers such as Charadros, Selemnos, Volinaios and Foinikas flowing into both the Gulf of Patras and Gulf of Corinth. The area combines sectors of mixed use. Green parts are also present in a currently developing area.

During the years, the area has undergone a series of changes that can be developed into potential hazards. The construction of Patras University in the 1960's and the University hospital in the late 1980's led to the infilling of one branch of the Selemnos River, increasing the risk of flooding of the remaining river branch.

The coastal area suffers erosion introducing risks to the port and coastal infrastructure. Some minor remediation works were unsuccessful. Combined with the high seismicity of the area, the extensive human intervention, high seismicity, and the local tectonics, introduce risks that have to be researched, analysed and controlled.

Introduction

Landscape morphology in the field of geomorphology has the meaning of the form and spatial structure of the landscape. Landscape morphology has a direct influence on water movements, soil, physical and chemical properties, and on the productivity of the vegetation cover.

It is used in human geography as the material formation of the landscape, its shaping and reshaping, in which social structures and cultural worlds are enfolded. In other words, it is directly connected with human activity and it is greatly affected by it in an undivided, through the years, way.

Morphological evolution and its relationship with peri-urbanization is becoming an increasingly interesting and significant topic. This is due to the always increasing, but also already high, impact that it has on highly sensitive areas. It can affect infrastructure, touristic areas, zones of high cultural interest, the environment and it can also have an effect on human lives.

In our case, we examine the city of Rio in western Peloponnese. It is located approximately 7 km far from the city of Patras. The municipal unit has an area of around 100,000 km^2 (figures 1a-b).

a b

Figure 1 – The study area (a) in western Peloponnese (b), Greece.

Rio city has a population of around 15,000 inhabitants and is of high interest and a highly sensitive area, because of numerous and important infrastructures, such as the University of Patras, the local University hospital, sports hall and the Ottoman era fortress which is located on the coast and the Rio-Antirio bridge connecting Peloponnese with the mainland (figures 2a-d).

Figure 2(a) – View of infrastructures and sensitive areas in Rio city.

Figure 2b – View of infrastructure and sensitive area in Rio city.

Figure 2(c) – View of infrastructure and sensitive area in Rio city.

Figure 2 (d) – View of infrastructure and sensitive area in Rio city.

Geological Setting

The Patraikos Gulf lies about 100 km east from the Hellenic trench, immediately behind the Plio-Quaternary fold belt, which runs parallel to the coast of western Greece. It is a Plio-Quaternary subsidence area of great structural complexity and crosses the Pindos-Gavrovo and Ionian isopic zones of the western Hellenides. The margin of the graben is marked by numerous faults that have been active in the Holocene.

Rio is the northernmost municipal unit of the Peloponnese. The study area lies in the southern coast of the Patraikos Gulf, surrounded by the pre-Neogene folded rocks of Cape Araxos to the west, of Mt. Panachaikon to the east and of Mt. Skolis to the south. It comprises a thick Upper Tertiary clastic sequence, which overlies unconformably the pre-Neogene basement. The geology is characterized by the formation of Olonos–Pindos zone, including Pliocene and Pleistocene sediments. Most of them are covered by Quaternary and alluvial deposits (Tsiambaos et al., 1997; Rozoset al., 2006).

The study area has an altitude that ranges from 0 (sea level) to 500 m and mainly consists of semi-consolidated Neogene sediments or Quaternary fluvial, alluvial and over bank deposits. It is also characterized by uplifted terraced Quaternary sediments where the Rion-Patras graben and the northeastern part of the Ellis graben are found. From a tectonic point of view the area is characterised by two sets of faults, one of NE-SW and one of NW-SE direction. The Patraikos Gulf area consists the western part of a major East/West graben system, behind the Plio-Quaternary fold belt. This graben system extends from the boundary of a marginal compressional zone associated with the subducting Western Hellenic arc, to the center of the Aegean Sea.

The NW-SE trending grabens of this system (Gulf of Corinth and Megara Basin) are associated with listric normal faulting with the same orientation, and are associated with shallow earthquakes. The NW-trending subsiding areas in the immediate vicinity, like the Preveza Gulf, Lake Trihonis and the Corinthian Gulf are also associated with NE-trending faults.

Urban development

People, urbanization and risk are interconnected factors which are deemed to be very important and have a decisive influence on the population. The growing rate of urbanization and the increase in population density can lead to the creation of risk, especially when urbanization is rapid and poorly planned. The city of Rio, just like the city of Patras, especially from the 1960's, faced a population influx due to inland and refugee migration and earthquakes. The city started to grow significantly and created the need for human intervention on areas that were deemed to be at risk or had to serve the public.

There are numerous characteristics of current urban planning and development that drive vulnerability including the

fact that disaster risk is rarely taken into account in investment decisions. Weak regulation, for instance the lack of enforcement of building codes, planning permission, and regulatory investment lead to the irregular and many times dangerous urban development, especially when combined with the fact that the area is highly seismogenic.

The area is also characterized by a number of active landslides and a number of houses have been built on these active landslides.

Finally, the coastline or Rio is widely exposed to erosion which has created many problems in the past especially to the coastal roads, local port and the foundations of businesses and houses nearby. A few remediating measures are taken, like the use of debris on the coast adjacent to the road and the construction of groins in order to decrease the erosional action of waves were not effective (figures 3a-b). Sediment accumulation was not improved, and the land still retreats.

Figures 3 (a) and (b) – Partial view of a coastal road in Rio city. The signs of erosion and coastal retreat are evident.

Discussion

The landscape morphology in the study area was shaped as a result of the interaction and interconnection between the intense human presence along with fluvial, tectonic and morphoclimatic factors.

Geochronological and sedimentological studies of dated raised terraces (Doutsos et al., 1988; Stamatopoulos et al., 1994, 1998, 2004; Frydas et al., 1995) found an average uplift rate of 0.4 to 6 mm/yr (Stamatopoulos et al., 1994; Kontopoulos & Zelilidis, 1997; Stamatopoulos et al., 1998, 2004) while the dating results indicate pre-Tyrrhenian to Tyrrhenian interglacial ages.

An important point regarding the interpretation of these ages is their geomorphic and stratigraphic context. High rates of coastal uplift have resulted in the intense erosion that has distorted a large part of the marine terraces of the studied area.

Hydrologically, the area is characterized by ephemerous streams and rivers such as Charadros, Selemnos and Volinaios, flowing into both the Gulf of Patras and Gulf of Corinth. The area combines sectors of mixed use (agricultural and urban). Green parts are also present and generally the area is currently developing.

During the years, it has undergone a series of changes that can be developed into potential hazards. The construction of the University of Patras in the 1960's and the University hospital in the late 1980's led to the infilling of one branch of Selemnos river, heightening the risk of flooding of the remaining river branch.

Additionally, as it was foretold, the area is characterized by active landslides. Houses and roads had been built on some of these landslides and as a result, especially in times of prolonged wet periods, the landslides create severe problems. A local road has already fellen, retaining walls and fences used on fields break and a number of houses have been classified as inhabitable (figures 4a-d).

Figure 4 (a) – Infrastructure and building problems in broader Rio area due to landslides, coastal erosion and poor development design.

Figure 4(b) – Infrastructure and building problems in broader Rio area due to landslides, coastal erosion and poor development design.

Figure 4 (c) – Infrastructure and building problems in broader Rio area due to landslides, coastal erosion and poor development design.

Figure 4(d) – Infrastructure and building problems in broader Rio area due to landslides, coastal erosion and poor development design.

Conclusions

The construction of general infrastructures such as roads, homes, shops, and ports completely replace natural habitats with manmade structures. Alluvial fans, deltas and their rivers, coasts and beaches are often modified in order to serve the public needs or suffer the consequences of the poor design of any kind of human intervention.

These interventions to the natural environment have to be executed with the help of appropriate planning practices and the raised environmental awareness of the people in charge. The interaction between urban development, risks, hazards, and the environment is complex and often determines the magnitude of the problems to be created.

In our case, the peri-urban and mostly coastal area of the city of Rio, in many cases these practices have not been followed. As a result, these man-made interventions are not in harmony with the natural environment. Many hazards have been created during the development of the area. Public roads (figures 5a-b), the port, residential and public areas, face the results of the dynamic, diverse but also disordered development.

The complete remediation of the already existent problems is in most instances complex and requires a big budget and this is the way in many cases simple maintenance is preferred to a large-scale remediation project.

The decisive point to take into account the results of the human intervention of any kind to the environment is before any construction. It will produce better results with less cost and less disturbance to the population.

This dictates us that a development assessment model regarding the impact of any intervention on the natural environment is of high importance. It will shape the development policy accordingly in each case and help to appropriately remediate the already existent problems.

It will also let us handle in the best way, the increasing trend of conversion of the peri-urban agriculture lands and fields into residential areas and will minimize the risks involved.

Figure 5(a) – Maintenance and signage is preferred to a large-scale remediation project on the coastal area.

Figure 5(b) – Old sign next to a road build on an active landslide. The road was repaved, but the sign indicates that the landslide is still active.

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