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From Knowledge to Wisdom

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Use of Polypropylene Non-woven as Sorbent of Oil Small

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Abstract: In this work, the mechanical tensile and elongation properties and the non-woven polypropylene flammability were evaluated, with variations of gratings, compared to non-woven fabrics prepared with thermo film and TNT (fabric non-fabric), for applications such as geotextile sorption of oil spills. The results showed high values of tensile strength for non-woven fabric prepared for application as geotextile, improving the mechanical properties of rupture.

Key words: Stretch, non-woven, polypropylene, sorption, traction.

1. Introduction

Barriers are used to inhibit the spread of oil in larger areas and prevent oil from reaching sensitive coastal areas as shown in Fig. 1. Some models absorb the oil in a mechanical effort to contain it. In other cases, controlled fires burn the water oil, although this creates another pollutant, or chemical dispersants are added to the water to accelerate the decomposition of the oil components [1].

Oil spills are critical because they are urgent and unexpected because of the enormous damage they cause to aquatic environments and marine life, so they must be contained quickly before they cause long-term disasters. Techniques to contain and recover the spilled oil are readily available in the form of barriers that collect it, but these seldom completely correct the problem [2].

Polypropylene (PP) is a branched polymer obtained by stereospecific polymerization via catalysis of the propene using the Ziegler-Natta catalyst [3, 4]. Melt spinning is one of the methods used to make non-woven PP blankets, where the polymer is melted and pumped through a matrix called spinneret with numerous small round holes. The melted fibers are cooled, solidified and collected in a take-up wheel, as shown in Fig. 2. The elongation of the fibers in both the liquid and solid favors the orientation of the PP chains along the fiber axis [4-6].

In the applications of sorbent materials with polypropylene (PP) non-woven, the mechanical properties of rupture and fatigue can be reinforced using thicker product or the compressibility of the blanket in the placement of thermo film and TNT [7, 8].

The adequate application of synthetic blankets used as sorbents in barriers to inhibit the propagation of oil leaks requires knowledge of the mechanical properties and flamability to characterize their behavior in industrial applications [9]. Thus, the behavior to the burning, traction and elongation of the hydrophobic material, shows that it is important to characterize the non-woven as a function of its weight [10]. The objective of this work was to analyze the mechanical properties of traction and elongation, and of flammability in non-woven PP with 300, 540 and 880 g/m^2 and compare with 740 g/m^2 blanket with thermo film and TNT, product used for spillage in oil spills.

The mechanical test of traction and elongation in non-woven was performed in the longitudinal and transverse directions, according to norm NBR

Corresponding author: Luciano Peske Ceron, Ph.D., main research fields: environmental engineering.

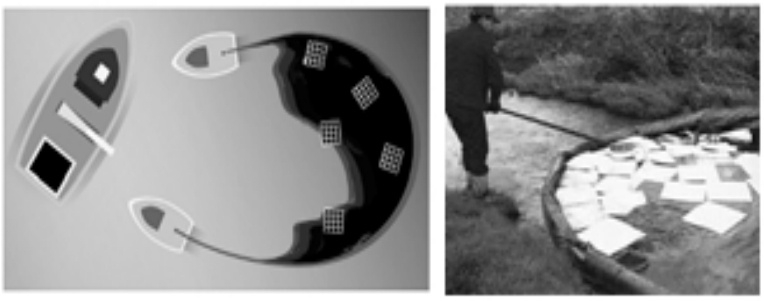

Fig. 1 The towed non-woven barrier, boats and oil catch.

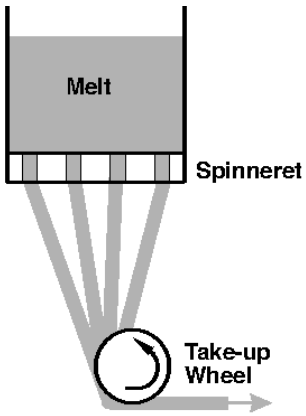

Fig. 2 Melt-spinning process.

13041:2004——Determination of tensile strength and elongation [12], which consist of applying the load until the body of evidence. The materials were conditioned for 24 h at 23 ± 2 ºC and 50 ± 5% humidity before carrying out the test. Five specimens were used for each weight in each tensile test. The dimensions of the specimens in rectangular strip format were 50 × 350 mm, as shown in Fig. 4.

2. Experimental Setup

The tests were carried out on non-wovens of PP produced by melt-spinning [11], provided by Ebios Tecnologia Ltda, located in Caxias do Sul, Rio Grande do Sul, Brazil. Four different types of mantas com 300, 540 and 880 g/m^2 and another with 740 g/m^2 with term film and TNT.

2.1 Fiber Characterization

The characterization of the PP fiber used in the blankets (Fig. 3) was performed at the PUCRS Electronic Microscopy Center in a Philips scanning electron microscope device, model XL 30, with an acceleration voltage of 20 kV. The initial preparation of the specimens was performed in Bal-Tec Metallizer, Model SCD 005, by metallization with gold in the samples of non-woven fibers.

2.2 Rechanical Resistance

The equipment used for the non-woven mechanical tensile test was a universal test machine-Frank 81565 IV dynamometer, shown in Fig. 5. A constant vertical clearance velocity in the 100 mm/min claw was applied with a load cell The results were obtained by a computer-linked NationalInstruments SC-2345 Series data system, which recorded the mechanical properties of traction and elongation.

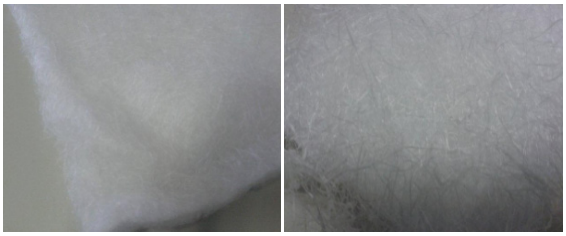

Fig. 3 PP blanket.

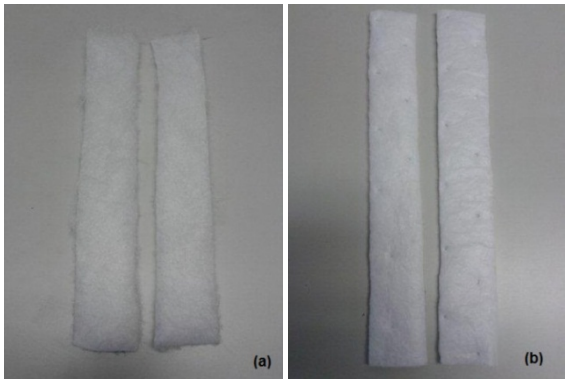

Fig. 4 PP non-woven test bodies.

Fig. 5 Frank dynamometer.

2.3 Flammability

The principle of the test is to affix a sample to an appropriate U-shaped fastener inside a chamber (Fig. 6). The sample is exposed to the action of a flame defined as having a low energy content, and the flame must act on one of the free ends of the sample. The flame should come from a Bunsen burner, placed in the center of the lower corner of the sample opening, using LPG gas for burning (calorific value of approximately 38 MJ/m^3).

The method follows NBR 14892: 2002-Non-woven-Flammability, which establishes as test condition the time of flame propagation in a certain area and sample weight, after exposure to a small flame, the area rate being determined.

3. Results

3.1 Scanning Electron Miscroscopy

The SEM micrograph (Fig. 7), identifies a disordered fiber interweaving, as well as the presence of individual fibers forming aggregates. Another consideration refers to the diameter of the fibers with many variations, which has a circular shape. These observations are a result of the method of production of the blanket, since more porous blankets siphon the oil faster, as shown by Wei, Q. F., ea al. [13].

Surface morphology varies from fiber to fiber, but generally exhibits a rough visual appearance surface. This detail is important because the more irregular the surface of a sorbent, the greater its surface area, which translates into a greater number of active sites for oil deposition [14].

3.2 Traction and Stretching Test

Table 1 and Fig. 8 show the mean values of the mechanical properties extracted from the tensile tests carried out on test bodies in the longitudinal and transverse directions.

Fig. 6 Flammability test.

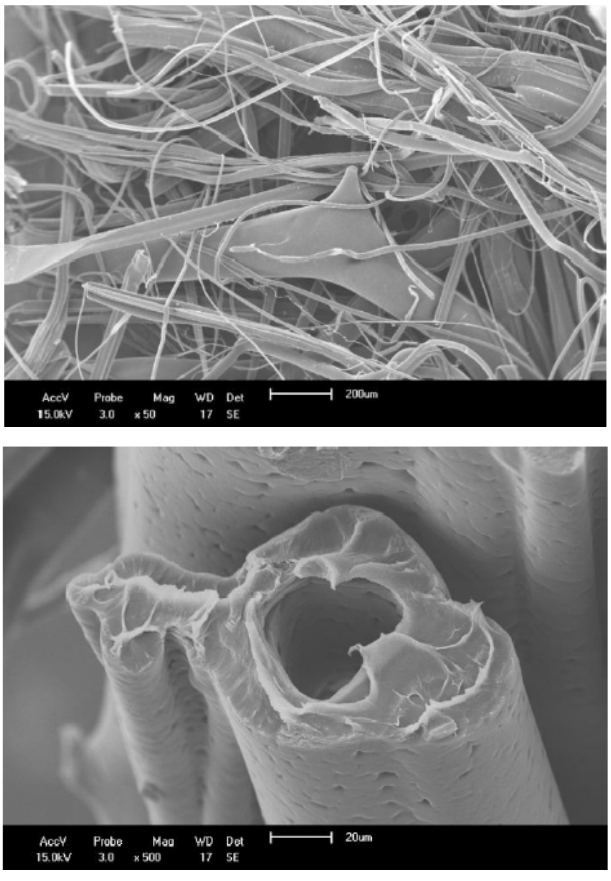

Fig. 7 SEM micrograph of PP fibers.

Table 1 Results of mechanical properties of the tensile test.

Proof bodies	Traction (N) longitudinal	Traction (N) transverse	Streth (%) longitudinal	Streth (%) transverse
300 g/m^2	26.4 ± 2.5	20.2 ± 1.2	23.9 ± 3.7	22.8 ± 2.8
540 g/m^2	58.6 ± 3.3	56.1 ± 3.5	55.9 ± 3.3	29.3 ± 3.1
880 g/m^2	65.8 ± 3.4	61.8 ± 4.1	59.8 ± 3.4	35.4 ± 3.6
740 g/m^2 (term film and TNT)	187.8 ± 5.7	88.0 ± 4.8	30.8 ± 2.7	27.3 ± 4.3

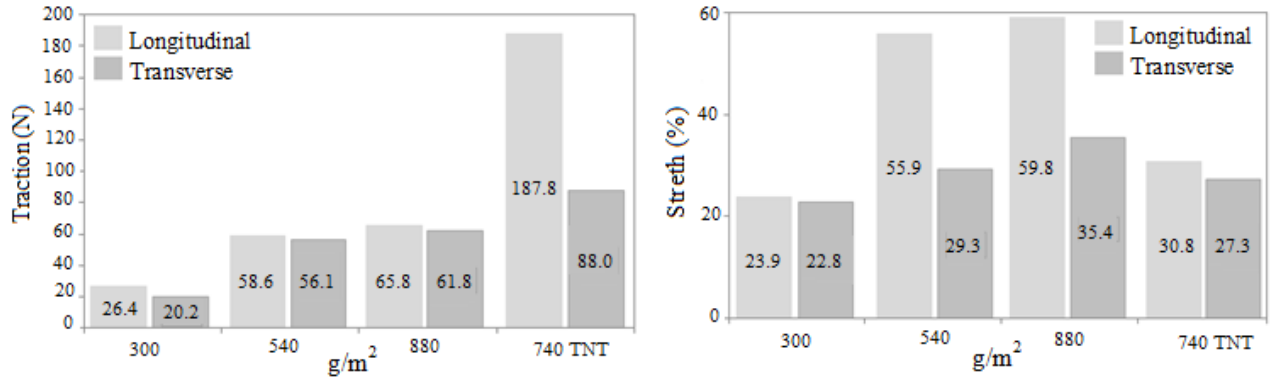

Fig. 8 Results of tensile strength and elongation (longitudinal and transverse directions).

There was a gradual increase in tensile strength as the weight rise from 300 to 880 g/m^2. Through the data, it is possible to justify the increase of the traction by the greater random distribution of fibers in the construction of the non-woven with a larger weight. As for the condition of higher traction results in the longitudinal direction, it is due to the non-woven production process, melt-spinning method, since the fibers are collected in the take-up wheel and thrown in this longitudinal preferred direction.

For the 740 g/m^2 composite film and TNT, material applied to the sorption of oils, there was a significant increase in traction in the longitudinal direction (187.8 N), practically three times in relation to the material of 880 g/m^2 (61.8 N). This increase occurred due to the compactness of the non-woven fibers, because in the placement of term film and TNT, material is fixed with folds to support the blanket in the application. Therefore, it is a significant reinforcement due to ruptures and fatigue in the material. In the transverse direction, the tensile increase occurred in the same proportion of elevation of the weight in the material, except for 740 g/m^2, where higher results were obtained as a function of the same conditions already mentioned above.

As in traction, the elongation at break is a property extremely dependent on the adhesion of the fibers in the construction of the non-woven. If adhesion is not perfect, voids occur and the material ruptures in the voids interface during the tensile test [15]. In this sense, in Fig. 8, there was a gradual increase of the elongation between 300 and 880 g/m^2 (in both dimensions—longitudinal and transverse), confirming the good compaction of the PP fibers during the production of the product. However, for 740 g/m^2, the value decreased due to the joining of different types of materials (PP fibers, thermofilm and TNT), occurring to the formation of voids in the joints of these materials.

3.3 Flammability

The results of the non-woven flammability tests of PP are presented in Table 2, with their respective area rates destroyed.

The rates of area destroyed by burning are practically constant close to 11.5 cm^2/s, so the weight of the PP blanket is not an impact factor, in case the material is burned in the application.

Table 2 Flammability of PP.

Proof bodies	Rate (cm^2/s)
300 g/m^2	11.46 ± 0.55
540 g/m^2	11.80 ± 0.45
880 g/m^2	11.75 ± 0.51
740 g/m^2 (term film and TNT)	11.33 ± 0.39

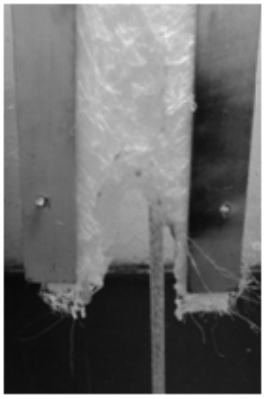

Fig. 9 Burned PP.

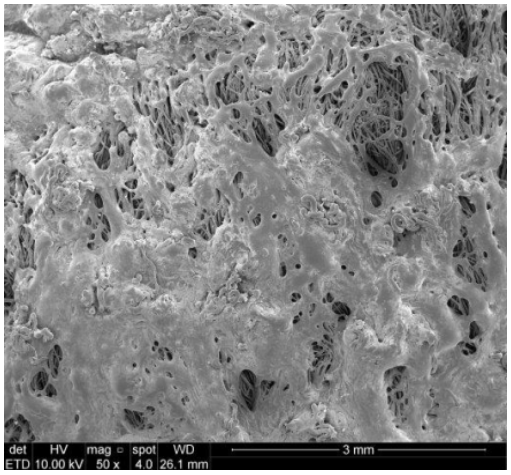

Fig. 10 Melt fiber SEM.

The non-woven PP obtained after the flammability test is shown in Fig. 9 and the scanning electron microscopy image of the PP fibers with characteristic of a plastic melt is shown in Fig. 10.

4. Conclusion

From the results obtained as a product in the oil sorption, it was found that application of thermofilmand TNT to the non-woven significantly improved the conditions of tensile strength of the material. In this context, increasing the useful life of the product in sorption applications for oils.

The elongation results for the same material weight evaluated in the longitudinal and transverse directions showed the greatest differences due to the non-woven production method with longitudinal preferential direction.

The firing rates are practically constant with respect to the various weights of the non-woven; it is not an impact factor in the application.

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Design and Construction of a Forest Village in Greece

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Abstract: The aim of this paper is the study for the construction of a forest village in the area of Souvardo in Kalavrita in the prefecture of Achaia. This paper presents the history and purpose of forest villages, as well as the laws that govern them. The methodology of the paper is analyzed and the particular characteristics of the study area are examined with the accompaniment of the general characteristics related to the formation of the space. Further, aerial photographs are listed with the help of Google Earth program, giving emphasis to the general plan of the study area. The reception building and the host installation of the forest village are described, as well as the building and topographic plans are designed with the use of AutoCAD and Photoshop programs. Furthermore, the cost of the development project is analyzed. Finally, the conclusions of the study and recommendations to the visitor of the area about sights, natural landscapes and archaeological sites are given. Criteria for intervention and promotion of tourism and proposals for tourism development in the area, such as ideas for the development of cultural tourism and ecotourism in the region, are suggested.

Key words: Recreational activities, cultural tourism, ecotourism, stonework, AutoCAD, Photoshop.

1. Introduction

Human progress and the development of civilization, as well as its growth and spread to ever-wider regions of the world, have resulted in the destruction of pre-existing flora, fauna and natural ecosystems. The primitive man was a balanced member of the natural bio-community, living like most animals by planting and hunting. As is well known, the objective and goal of our life is quality, a word derived from ancient Greek quality. In our everyday life, we are more easily aware of quality than its absence, despite its existence. But the concept of quality is not limited only to life, but also to constructions. Even in ancient Greece, the theoretical sciences, namely poetry and philosophy, have not emerged on their own, but in conjunction with the study, research and the achievements of the positive sciences in the construction sector [1].

Corresponding author: Sarantis-Angelos Liampas, Ph.D., main research fields: forest roads, forest operation, forest construction, forest opening up and forest fires.

Today, the quality of construction in relation to the natural environment is a prerequisite for the development and survival of a modern society. Technological development at the hands of the manufacturer is an instrument for improving or destroying, canceling or developing the relationship between human and nature. Particularly this dilemma is evident in cases where the natural environment is sacrificed for a construction. Citizens have been consciously aware of the fact that environmentally friendly construction and rehabilitation measures are "costly" in the long run less in the community. For the above reasons, in this paper, special attention is paid to the work's compatibility with the natural environment with measured characteristics (criteria). Thus, it is currently studying the construction of the forest village in the area of Souvardo of the Municipality of Kalavrita in the prefecture of Achaia where it is located on the outskirts of the Helmos forest according to the conditions that were mentioned.

The forest villages in the broadest sense are included in the forest recreation projects which aim to

offer, in urban populations in particular, a healthy environment, tranquility of isolation, aesthetic enjoyment of the landscape, and acquaintance with the natural environment from which they have been cut off [2].

A forest village, by its very nature, works at least partly in terms of tourist accommodation. It requires some infrastructure (access, communications, water, electricity, power supply). It requires a significant installation cost and above all an operating cost. It is a kind of activity that must in principle be driven in accordance with the principles and rules of supply and demand for a product, which in this case is recreation. This product—recreation—must be competitive with all uses of the forest (logs, grazing) and other recreation in the wider area. Otherwise, this activity will not be demanded. The basic requirement is therefore that the wider area has a number of natural attractions (beautiful paths with alternating scenery, impressive vegetation, springs, lakes, waterfalls, spectacular views, animal populations, etc.). These attractive natural elements must be made accessible to the visitor with relative ease and safety. In order to better approach the issue, it is useful to look at the experience of other countries in similar constructions and operations, the efforts in Greece as well as the experience of the Greek mountaineering shelters that is suited to the forest villages. Forest villages serving mountain tourism were created in the USA. In mountainous remote areas that could not be served by existing settlements. Forest villages in mountainous areas of the Carpathian Mountains (Romania) serve warders, hunters and travelers. They are the so-called "bells" in remote high altitude areas that sleep in large rooms with many beds and food. Approach to them is by train and cable car for the most part of the journey and on foot, by footpaths, to the last part of the route [3].

Similar facilities exist in the mountains of Bulgaria, ranging from organized hotels to simple accommodations and visiting organized groups of students, employees during their summer holidays or even individual visitors and hunters. There are specially trained guides-guides and printed information material. In general, continental European countries have developed their tourism in mountain areas.

Although Greece is one of the most mountainous countries in Europe (mountainous areas cover 60% of the country's land area), classical tourism was developed almost exclusively in coastal and island regions where significant sums were invested. Today, however, global tourism focuses on alternative forms of tourism (ecotourism, agrotourism and forest tourism) and thus opens opportunities for alternative tourism. The concept of Forest Village is a set of simple lodgings in mountainous, remote forests, intended for visitors to the mountain and the forest, and provide simple facilities to those who want to experience the mountainous area with great forests and excellent scenery [4].

The term forest village has been used in the past, but in the sense of a set of simple buildings in remote productive forests, intended to serve forest workers (loggers, forestry officers, guards, etc.). Such resilient wood-burning or permanent stone-made forest facilities were made in several Greek forests, smaller or larger depending on the extent and the cycle of forestry work in each forest complex. Such a forest village with permanent facilities was constructed in the 1970s in Elatia of Drama, at the "Central Construction Site", but it did not work with the prospect that was built. It was recently maintained and used by forest employees as well as students from the Orestiada Forestry and Management of the Environment and Natural Resources Forestry School who practice their summer practice. Also the Forest Village was used for the permanent buildings in the University Forest of Pertouli, designed by the great architect Dimitrios Pikionis, and are still used for the residence of students of Forestry and Natural Environment of Thessaloniki practiced during the summer period.

1.1 Laws Governing Forest Villages [1]

1. The provisions of the Law. 86/1969, as amended, were replaced and supplemented with the relevant provisions of the Law no. 996/1971 and 177/1975.

2. The provisions of Law 998/1979 and in particular Article 48 par. 4.

3. The number 156057/1317/1985 circular order of the Ministry of Agriculture.

4. The provisions of Law 2040/1992 and in particular paragraph 7d of Article 31.

5. Decision No. 66102/970/23.2.1995 of the Deputy Minister of Agriculture, as amended and supplemented by the Ministry of Agriculture's decision 99278/5712/8.2.1997, on the "regulation of issues related to the creation of day-care and outdoor recreation areas in forests and forests of the country".

6. The decisions of the Ministry of Agriculture issued on a case-by-case basis on the "approval of the study and construction of forestry villages".

7. The fact that six Forest Villages have already been built on the above provisions.

8. The provisions of Law 3208/2003, in particular paragraph 7 of article 1, replacing Article 21 par. 5 of Law 998/1979 as added par 10 of article 40 of Law 3105/2003, repealed respectively in paragraph 10 of article 40 of Law 3105/2003.

9. The need to organize the management of the Forestry Village for the better fulfillment of their aims.

10. The PD. 121/2004 "Appointment of Ministers and Deputy Ministers".

11. The PD. 202/2004 "Appointment of the Minister of Rural Development and Food".

12. The number Y131/11.10.2004 Joint decision of the Prime Minister and the Minister of Rural Development and Food "Delegation of responsibilities to the Deputy Minister of Rural Development and Food Alexandros Kontos".

13. The PD. 122/2004 "Reconstruction of the Ministry of Tourism".

14. The PD. 123/2004 "Appointment of Minister, Deputy Minister and Deputy Ministers".

15. The number 1153/20.4.2004 joint decision of the Prime Minister and the Minister of Tourism "Assignment of responsibilities to the Deputy Minister of Tourism Anastasios Liakos".

16. Law 3270/2004 "Competences of the Ministry of Tourism Development and Tourism Issues".

The aim of this paper is the study for the construction of a forest village in the area of Souvardo in Kalavrita in the prefecture of Achaia.

2. Materials and Methods

2.1 Research Area

Mount Helmos is located in the Northern Peloponnese and is characterized by a variety of geological substrates and soil types (limestones of the geological zone of Olonos-Pindos, flysch and conglomerate rocks. More specifically, Helmos occupies the central part of the northern wall of the Peloponnese and stretches between Krathi and Vouraikos River and from the Aoranios River to the sea. The main features of the Helmos Mountains landscape include well-forested slopes of the Meso and Hyper-Mediterranean vegetation floors with Abies Cephalonica forests and Pinus Nigrapallasiana, rugged limestone rocks, Mavrolimni Lake (2,050 m, the only "alpine" lake of the Peloponnese) and the impressive ravine of Styga (Water Stygos), which is framed by the most important mountain slopes and is associated with a small wet cave and a waterfall at its base. The name Helmos or Aroania Mountains is distinguished by a rich hydrographic network. It consists of numerous natural springs, rivers, tributaries and lakes. The sources of the Helmos peaks (Water Stygos, Kokkinovrisi, Kalithari, Pitsi, Aspro Lithari) owe their existence to the thin layer of the flysch that spreads over a thick and strongly calcified layer of limestone. Debris and erosion of the limestone substrate have contributed decisively to the formation of a sharp relief with precipitous limestone rocks and carvings. The enclosed, shady, "shaved"

meadows with trifolion parnassi and participate in the formation of a modern mosaic vegetation that clearly differentiates into four main types of vegetation (open rock formations, limestone cliffs, calcareous limestone and closed dense "shaved" meadows). Trees of particularly good structure are present on the eastern slopes of Mount Helmos and are characterized by a more diverse flora than the northern slopes of the mountain [5]. The area studied (Fig. 1) at Luka Souvardou is located on the northeastern side of the Municipality of Kalavrita at a distance of 8 km. It lies at an altitude of 1,220 meters with coordinates of 38°3'0'' N 22°10'29'' E. The total area of Helmos Public Forest (Municipality of Kalavrita) amounts to 8,856.9 Ha, and is the result of the most accurate measurement of the area (GIS) on a 1:5,000 scale map and is divided into various land uses formations as shown in Table 1 [6]. Souvardo is a lively destination with a history of evolution. Unlike many mountainous villages in Greece, who have flourished in the past and have almost deserted today, Souvardo was never abandoned. It has been constantly developing since the beginning of its creation; it retains an important permanent population and eliminates significant tourist activity. The relief of the soil has contributed to a relatively sparse construction because, due to the

Fig. 1 Picture from the Google Earth of the region.

Table 1 Land uses of Helmos Public Forest.

Land use	**Area (Ha)**	**Percentage (%)**
Forest area	4,290.9	48.45
Partly forested area	1,412.2	15.94
Agricultural lands	1,863.2	21.03
Bare lands	1,094.3	12.36
Barren, settlements, roads	196.3	2.22
Total	8,856.9	100.00

absence of intense slopes, the need for dense construction and full utilization of the sloping land is not a common characteristic of many mountainous villages. In addition, because of this feature, Souvardo has large open-plan surface areas, the largest area of which is untapped and unused. Souvardo is located on Mount Helmos and has an exceptionally rich natural land-scape. It is surrounded by dense fir forests and a healthy and rare ecosystem particularly diverse in flora and fauna. Within walking distance of the forest village, there are rivers and the water abounds in the area [7].

The studied flat is located about 2 km north of Souvardo at an altitude of 1,220 meters and an area of 24 acres with a very small slope not exceeding 30 degrees across its surface. It could be characterized by the most ideal of the fact that it is "bathed" by sunshine most of the day in combination with the unique scenery of the rich stands of the Abies Chephalonica stretch around the village.

2.2 Methodology

For this research is used:

1. GPS type GARMIN 60 that provides with a lot of useful information such as:

- Altitude indicator;
- Destination time;
- Hours of sunset and sunrise hours;
- Direction and orientation of the plateau.

2. Photoshop since it is a very extensive software was designed with the best image processing, thus helping in all necessary design corrections.

3. The AutoCAD of the Autodesk Company is one of the best for forest engineering applications which are available on the market, the most widespread and is of general purpose, to wit, can be applied to architecture, statics, topography, hydraulics, road construction and generally to every forest engineering field.

The main materials of the construction are selected based on the climatic conditions of the area and taking into account the local character of the constructions so that it is consistent with the architecture and with the environment in general. The means of construction are stone, wood and reinforced concrete. Other basic materials [8]:

Rockwool for better protection as non-flammable material;

- Gypsum board;
- Asphalt tiles (Roof chalet);
- Tar.

The question of building a forest village with basic raw material stone is a much more difficult case than a more conventional material. The peculiarities of the stone and the way of building are not easy and standardized. The type and quality of the materials has been chosen with the logic that in a stone forest "settlement", it is important to have a consistent luxury.

3. Results

Two types of buildings were designed with a total of 23 buildings that bind to the surrounding area as materials from the wider region of the Peloponnese have been used. These settlements will be able to accommodate a large number of visitors, research groups, pupils during educational trips, etc.. So the forest village is designed to accommodate up to 85-90 people along with staff who will be responsible for meeting the needs of the guests (Fig. 2).

A landmark at the entrance of the village is the first impression, its first image. It can attract a passerby or leave him indifferent, sometimes to repel him. The goal was not the creation of a loose construction. The place was again a source of inspiration. The aim was to synthesize primary local materials in a configuration of space, as if born of him. For the creation of an accessible natural sculpture it is needed experience. Moreover, it was the aim of the new shaped space-place to be neat, modest, simple and beautiful, as it is appropriate to the principles of traditionally built mountainous landscape.

Fig. 2 Picture from the Google Earth with the layout of the buildings.

Fig. 3 Facade of the united building.

3.1 Reception Building—Chalet

It is the main service and management building, measuring 15.55 × 8.15 meters, divided into 2 floors, providing all the facilities of staff and tourists while being divided into various areas. The main entrance leading to the reception from which all the instructions for stay will be provided through brochures informing about the proposed activities, hours of breakfast and evening and special reference to the treatment of emergency medical care needs. Therefore, in order to avoid unpleasant situations, the reception also has a special storage area for medicines [1].

- A large living room with a lounge and a bar that completes a large dining room for 12 people where lunch or drinks will be offered, respectively, with the local traditional music mix and the warm atmosphere that will give the traditional stone fireplace of the living room.
- The 2 large toilets are located a short distance from the dining room and designed to cater for the disabled.
- An important piece is the small but elegant office where it serves as a conference room, a study with a large projector.
- Finally, there is the central, large ground floor kitchen where cooks will take care of maximizing enjoyment by creating original flavors with a distinctly local character.
- Leaving the ground floor, follows the next floor with 2 indoor circular stairs facing each other, consisting of 2 bedrooms of 2 people each, exclusive staff area including 2 sitting rooms.

3.2 Wood Frame

The forest village will consist of 22 wooden residences with capacity of 4 individuals each. The residences have been designed based on the bioclimatic design, in order to exert the least effect on the natural environment and respond to the inhabitants' needs for a comfortable and relaxing living. The residences will be per two joined, so as with the opening of the interior door at the center of the residence, they increase their capacity from 4 to 8 individuals, satisfying the needs of more inhabitants (Fig. 3).

3.3 Costing

Estimate cost of forest village [1]:

(A) Wood frames:

(1) Total area of a wood frame:

(i) Ground floor:

$Ea = 6.35 * 6.35 + 2.72 * 3.2 = 49.03$ m^2

(ii) Floor: $Eb = 6.35 * 6.35 = 40.32$ m^2

(iii) Total area of a wood frame:

$E1 = 49.03 + 40.32 = 89.35$ m^2

(2) Total area of wood frames: $22 * E1 = 22 * 89.35 = 1{,}965.7$ m^2

(B) Chalet:

(i) Ground and 1st floor:

$Ea = 2 * (15.54 * 8.14 - 6.16 * 3.6) = 208.64$ m^2

(ii) 2nd floor: $Eb = 2 * 6.35 * 4.69 = 57.69$ m^2

(iii) Total Chalet Area = $Ea + Eb = 208.64 + 57.69 = 266.33$ m²

(C) Total area of forest village = $T1 + T2 = 1965.7 + 266.33 = 2232$ m^2

(D) Total village cost:

(a) Estimated cost of $1\ sqm = 500\ €/sqm$

(b) Total cost: $K = 2232 * 500 = 1.116.000\ €$

Incidental expenses = 40.000 €

4. Analysis and Discussion

The mountainous areas and the forest villages of Greece have undergone the price of a developmental process without the design and effective protection of their built environment. Fatal many have lost the privilege of constant development and intense tourist activity, resulting in isolation and abandonment.

Survardo, on the contrary, has retained all those features in terms of the physiognomy of the

environment and traditional architecture, so that it is still an important attraction of tourist interest, highlighting its lively history, the authenticity and the unspoiled beauty of the natural landscape. The stages of development of the area, often in difficult economic conditions of the local population, did not alter the local characteristics of the structured area. It was therefore necessary to create a forest settlement to keep up with the successive alternations of the modern era, giving even more glamor to a place that combines culture with a modern way of life. Consequently, the highly aesthetic constructions that will gather positive criticism will provide solutions to the unstoppable needs of the local population that despite the difficulties was held in the place, struggled to survive in him and certainly did not have the means or the ability to create a high aesthetic built an environment that will greatly improve living conditions and create the desire to seek adventure, guided tours and reconciliation with nature and history. The construction of the Forest Village will contribute to the regeneration of the nature of the natural environment and any approach in this direction requires in-depth knowledge and study of the characteristics of the area such as soil, hydrological, climatic and property as well as the delicate handling of the construction of a traditional village combined with the latest amenities. In order to meet this expectation, it was somehow required that the cost of the investment be greater than expected, expecting the future benefits that will emerge. These responsible work aims to create a center of environmental, tourist and cultural interest, respecting the nature and tradition of the region.

5. Conclusion

It is out of the question the creating of a visitor guide with natural landscapes and archaeological sites. The mountainous mass of Helmos and the surrounding area over millions of years with the action of not only water but also other factors of nature (wind, temperature etc.) gave many characteristic forms, such as the imposing gorge of the Vouraikos River, the beautiful cave of the lakes, the cool springs of the Aroani River, the mythical waters of Stygos, the Tsivlos and the Daxas lakes and many more. The E4 European long distance path and a network of other paths link these interesting natural monuments to geological heritage and enable the visitor to combine recreation with adventure and initiation into nature, history and traditions.

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The Opportunity Cost as a Critical Determinant Factor of the Cultural Heritage Monuments' Valuation: A Modified Contingent Valuation Method

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Abstract: The subject of this study, which involves two surveys, is to estimate externalities created round a cultural heritage preservation site by means of a CVM (Contingent Valuation Method). The first survey was conducted for the ruins of ancient "Diolkos" located in Isthmus of Corinth, Greece using a sample of 200 soldiers. The second survey was conducted for the ancient theater of Lefkada, using a sample of 100 tourists and locals. The results have been analyzed with Logit model regression. The findings show that willingness to pay (or participate) is strongly affected by opportunity cost and awareness of the site's history. Further, income level and education level play a critical role in developing volunteering activity.

Key words: CVM (Contingent Valuation Method), WTP (Willingness To Pay), WTA (Willingness To Accept), externalities, cultural heritage, Diolkos.

1. Introduction

The economic valuation of cultural heritage remains a scientific challenge. Most studies estimate the economic effect as an external benefit or as a source of tourist attraction. The first application of the CVM (Contingent Valuation Method) in the field of cultural (non-market) goods dates back to the 1980s (Throsby and Withers, 1983). Since then many studies in literature applied, validated and optimized the CVM for historical buildings [1], museums [2], archaeological sites [3], tourism economics [4] and cultural goods [5].

Although the CVM is based basically on subjective opinions, the main attempting is to acquire objectivity by extracting attitude and information from a stratified representative sample of interviewees. Participants are asked by means of a questionnaire to assign a value on a non-marketable good or an externality (considered as "transaction spillover" by laissez-faire economists like Milton Friedman and Friedrich Hayek).

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The evaluation of a benefit or a cost is not related to market values. The aim of the CVM is two-fold. Firstly, the CVM tries to create a hypothetical market in which participants may state their maximum WTP (Willingness To Pay) for a group of special public goods, through responses to the questionnaires. Secondly, the CMV applies to correspond to the minimum monetary amount which an individual would accept as compensation in order to deny any use of this special public good/service—WTA (Willingness To Accept) [6]. A single direct link to personal income may not reflect adequately the value of a monument; in many societies, for instance, cultural heritage of global significance (e.g., Acropolis in Athens, Greece) is traditionally linked to higher management levels, such as the state. In other cases, the interviewees might not agree with the questionnaire statements. Lo and Jim [7] have recently addressed these issues that are usually manifest as protest responses, i.e., zero or low WTP.

In effect, opportunity cost could be a multifaceted variable that adds complexity to a survey and could yield inconclusive results. When replaced with

voluntary work, the main answer that a researcher has to extract from questionnaires is the level of the opportunity cost of a day of a voluntary work for every single participant. In present study, the authors used a different WTP approach: the interviewees were asked for voluntary participation in a restoration of Diolkos monuments in ancient Corinth in order to estimate the maximum time (measured in labor days) which volunteers are willing to spend. The main advantage of the present study is that the opportunity cost of all interviewees tends to be zero because they are fulfilling their military obligation[1]. Trough a sample selection from this population, the ceteris paribus condition tends to fulfill completely. Thus, this survey is not a formal application of the WTP method but it is actually a Willingness To Participate "WTPar" research. The results have been compared with a traditional WTP survey, regarding the excavation and restoration of the ancient theatre of Lefkada island in Greece. Although this study firstly looks not comparable, in fact they are able to lead to important results. More specificly, participants in both samples come from different areas of Greece since they are soldiers (Diolkos survey) and mostly tourists (Lefkada survey).

The objective aim of this paper is to examine the effect of opportunity cost in indirect economic valuation of these special public goods through the supply of voluntary labor. In addition, the main purpose of this study is to reveal useful information about a research area with no scientific activity which is the economic valuation of a monument of cultural heritage in population with almost zero opportunity cost. Moreover, this study is in the area of CVM, volunteering activity and cultural heritage. Consequently, in this paper, an effort of economic valuation of a monument of cultural heritage through a modified CVM, in order to extract the function of the volunteering supply of labor has been made. This study structures as follows. In Section 2, some brief information is presented for each involved monument of cultural heritage. In Section 3, methodology, data collection approaches and information about each treatment are presented.

2. Study Areas

It is common knowledge that the history of a monument is the main motivation of the volunteering aiming to its restoration/excavation. The volunteering activity is a part of the social capital and as a result, the history of a monument of cultural heritage benefits the whole society. In Sub-sections 2.1 and 2.2, some historical information about the two involved monuments is given.

2.1 "Diolkos" Survey

"Diolkos" was an ancient paved pathway which connects Corinthian and Saronic gulfs in Greece (Fig. 1). The construction of "Diolkos" dates back to 7th century B.C. by a tyrant of Corinth named Periandros in order to save transportation cost and time. For approximately 1,500 years many thousands of ships avoided the dangerous circumnavigation of Peloponnese and at the same time, the Corinthians earned huge income by tolls of passing. Diolkos was buried for many years until 1956 while the excavation was started [8]. A long part of "Diolkos" is passing through a military area which was the main motivation for the present study, since the sample selection would be effective.

Lefkada was founded as a colony of the Corinthians at the end of the 7th century B.C. Thanks to its strategic position on the north-eastern coast of the island, which allowed it to control the sea routes in the Ionian Sea, it became a major commercial and economic center of the ancient world. Plenty of ancient buildings and materials are visible in the area of Koulmos. Knowledge of the ancient theater of Lefkada was non-existent, because it has never been

[1] Military service is an obligation for every man in Greece, where they are trained for nine months. During this period they are not allowed to work or to participate in other profitable activities.

Fig. 1 Ancient Corinthian Diolkos.

Fig. 2 The wall of the ancient theatre of Lefkada.

noted by ancient sources. In the early part of the 20th century, minimal excavation had taken place under the direction of the German archaeologist E. Kruger, who was a colleague and partner of the archaeologist W. Dörpfeld. The early excavation data were not published, but the excavation diaries and drawings that are available to us today indicate the identification of the ancient theater of Lefkada [7, 9].

3. Methodological Framework and Data

3.1 Methodology

WTP method is a part of CVM. It is presented an explicitly dynamic methodology of the formation of WTP and WTA and commitment costs under uncertainty and future learning. In this section, authors modify that model to the setting of the special market experiments [10, 11].

Consider an interviewee who formulates his WTP or WTA facing a trading opportunity in an experiment, knowing that the same good can be traded in the marketplace [12, 13]. To add structure, assume that a WTP (WTA) interviewee is one who must state a WTP (WTA) value in an incentive compatible institution. Let v be interviewee's (uncertain) valuation of the good, and let R be his information about the market price of the good. Because $'v'$ or $'R'$ are not known with certainty, but their distributions are known, it is assumed that the interviewee can learn both $'v'$ and $'R'$ with certainty later (e.g., after the experiment). So, his WTP is a function of his own valuation about the good, $'v'$ and his information about the same good, $'R'$.

$$WTP = F(v, R, d_1) \quad (1)$$

where d_1 denotes a group of other deterministic

variables which can affect the WTP, like age, education level, etc..

Interviewee's valuation about the good v is directly affected by the opportunity cost OC_M of the monetary units.

$$v = F(OC_M, d_2) \quad (2)$$

where d_2 denotes a group of other deterministic variables which can affect v.

It has to be mentioned that the deterministic variables which are included in d_1 and d_2 are not the same and actually, they have no variable in common.

A combination of Eqs. (1) and (2) will lead to the fact that WTP is a function of OC_M , R and other deterministic parameters with Eq. (3):

$$WTP = F(OC_M, R, d) \quad (3)$$

where $= d_1 + d_2$.

The CVM can also be applied to a hypothetical economy with no monetary units, where the trade for goods is time. By asking the interviewees for their WTPar in the restoration of the archaeological site, it is tried to measure the willingness for voluntary participation. So, the opportunity cost of monetary units instantly transforms into opportunity cost of time units OC_T and the WTPar function has the following form ceteris paribus.

$$WTPar = F(OC_T, R, d) \quad (4)$$

In present study, the interviewees are soldiers and their opportunity costs of time units are equal to zero due to forbidding of social and paid work by the soldiers.

In order to estimate the Eq. (4) , Eq. (5) multi-linear regression is estimated:

$$z = \beta_0 + \beta_1 X_1 + \cdots + \beta_k X_k \quad (5)$$

where the variable z is the dependent variable, while β_0 is the constant term of the regression and $\beta_1, \dots, \beta_k$ are the regression coefficients of $X_1, \dots, X_k$, respectively. Moreover, the independent variables $X_j, j = 1,2, \dots ,8$ stand for respondents' income, age, living distance from the monument, real estate ownership in the vicinity, membership in organization with cultural activities (volunteering), extent to which the interviewee is informed about the history of the site (information), coming in the site as visitors/tourists before (previous visit) and education level, respectively.

After the multi-linear analysis, authors examine the effect of information to WTPar, ceteris paribus. In order to do this, authors firstly applied a Kolomogorov-Smirnov test to secure that authors' data are normally distributed and then authors applied a *t*-test for dependent sample to compare means. In last step of authors' analysis, authors compare WTPar of the interviewees of the present study against the interviewees of a similar study to examine the effect of opportunity cost of their time and information at the same time.

Both researches took place by questionnaires. In first research (about ancient theatre of Lefkada) 100 interviewees were asked to fill a questionnaire about the 8 variables which authors would use and independent variables and about their WTP in order to contribute to the restoration of the theatre. Subsequently, an informative text was given to the same interviewees and they were asked to fill it again. Relative method of data collection was followed to the second research too (about Diolkos). The crucial question authors tried to answer in both researches is if there is a change between the WTP of the interviewees before and after the reading of the informative text, as well as the amount of money they are able to pay.

3.2 Data Collection and Treatment

3.2.1 Diolkos Survey

In order to collect the data for authors' analysis, authors get a random sample of 100 Greek soldiers who were in the military camp of Corinthos and ask them to complete a questionnaire before they get informed about the monument and the same questionnaire after they read an attached informative text. Authors collect the 100 pairs of questionnaires

and the above analysis was followed. The same method was followed to collect the pairs of 100 questionnaires about the survey of ancient theatre of Lefkada. In that case, local population and random tourists were asked to fill the questionnaires before and after the reading of an informative text.

The empirical analysis of data from the Diolkos questionnaires was divided into two parts. In the first part, the analysis of variance (AN.O.VA.) and the multi-linear regression model were studied. In the second part, two new variables WTPar1, WTPar2 have been created. WTPar1 represents the soldiers' willingness to participate in the restoration of the monument before they received any information about it. Following the first response, an informative text about the history of the monument was distributed to soldiers and they were asked again about their willingness to participate (WTPar2). Using a *t*-test for paired samples author examine the differentiation between their willingness to participate.

In the first step of analysis author create the WTPar regression which has the Eq. (6):

$$WTPar = a + b_1X_1 + \cdots + b_8X_8 + u \qquad (6)$$

where $X_1, \ldots X_8$ represent the independent variables which were determined in Section 3.

Subsequently, author examine the influence of the independent variables to the dependent one as a group, using the AN.O.VA. approach.

3.2.2 Lefkada Survey

In order to complete the research of ancient theatre of Lefkada, authors also asked 100 randomly selected local people to fill a questionnaire before and after the read of an informative test about the benefits of a restoration of a monument of cultural heritage. The following empirical analysis has exactly the same structure with the research of Corinthian Diolkos. The crucial difference between these researches is the existence of opportunity cost of people who participate in Lefkada's research and the absence of opportunity cost of soldiers who participate in Diolko's research.

4. Results

4.1 Diolkos Survey

People who were asked to fill the questionnaires in Diolkos survey were soldiers, which means that their age was around 18 years. Specifically, 73 soldiers (not only men) were to the age group of 18-26 and the rest 27 soldiers were above 26 years old. Moreover, 21 soldiers declared that they have primary education, 75 soldiers declared that they are holders of graduation or post-graduation degree and only 4 soldiers declared that they are PhD candidates.

After the estimation of the simple descriptive statistics authors examined the well-fitting of the model to the theoretical parameters. Specifically, the AN.O.VA. procedure was used for that purpose. The results can be observed in Table 1.

The *F*-statistic was found equal to 54.152 and also, statistically significant to the 5% significance level (while the *p*-value is equal to 0.001). According to this result, authors can assume that authors' model is well-structured and the independent variables are appropriate to determine the behavior of the dependent variable. In the next part, Eq. (6) was estimated using a multi-linear regression model. The results of the regression can be seen in Table 2.

The estimated expression of Eq. (6) has the Eq. (7):

$$WTPar = 68.2 - 0.013X_1 + 0.010X_2 + 0.036X_3 + 0.011X_4 + 0.031X_5 + 0.023X_6 + 0.013X_7 + 0.043X_8 \qquad (7)$$

As it is observed in Table 2 and Eq. (7), all variables have a statistically significant effect on the WTPar variable. More specifically, it is shown that volunteering, age, living distance, ownership, information, previous visit and education level have a positive influence on the soldiers' willingness to

Table 1 Analysis of variance for dependent variable WTPar (AN.O.VA).

Source of variance	Sum of squares	df	Average sum of squares	F-statistic (p-value)
Regression	48.521	8	6.065	54.152 (0.001)
Residuals	10.192	91	0.112	
Total	58.713	99	–	

Table 2 Coefficients of multi-linear regression.

Variable	Coefficient (p-value)
X_1 (Income)	−0.013 (0.008)*
X_2 (Age)	0.010 (0.037)*
X_3 (Living Distance)	0.036 (0.018)*
X_4 (Ownership)	0.011 (0.022)*
X_5 (Volunteering)	0.031 (0.007)*
X_6 (Information)	0.023 (0.000)*
X_7 (Previous Visit)	0.013 (0.014)*
X_8 (Education Level)	0.043 (0.002)*

* denotes statistical significance at 5%.

participate in the restoration of "Diolkos", while the income effect on same variable seems to be negative. Despite the fact that the effect of each variable seems to be low enough to change the maximum time of voluntary supply work of soldiers on its own, the aggregate effect of all variables seems to be able to cause a statistically significant change on WTPar time of soldiers.

In the second part, WTPar1 and WTPar2 were created according to the procedure presented in the section of methodology. The descriptive statistics and a bar-chart of these two variables can be observed in Table 3, Fig. 2 and Fig. 3 respectively.

The mean of WTPar1 is equal to 1.50, while the mean of WTPar2 is more than three times higher and equal to 4.58. This result can also be visualized by the bar-chart. Consequently, it can be seen that there is a significant difference between these variables. To validate this, *t*-test for paired samples was used to compare the means of WTPar1 and WTPar2 time of soldiers before and after they received some information about Diolkos monument. In order to choose a proper parametric or non-parametric test, a Kolmogorv-Smirnov test was first applied in order to examine if data are normally distributed. The test was positive, and allowed the use of a *t*-test for dependent samples to compare means of WTPar1 and WTPar2. The results of this test are given below in Table 4.

The results of the analysis show statistical significant difference between WTPar1 and WTPar2 while the *t*-statistic was found equal to -57.146 with respective *p*-value equal to 0.000. So, there is significant difference between the time soldiers are available to spend on the restoration before and after information supply. This result is an indication of soldiers' sensitization to restore monuments of Greek cultural heritage if they are aware about the history of the monuments.

4.2 Lefkada Survey

A sample of 100 interviewees were selected and their willingness to participate in the excavation of the

Table 3 Descriptive statistics for WTPar1, WTPar2.

Variable	*N*	Mean	*SD*	SE mean	Min.	Max.
WTPar1	100	1.50	0.89	0.150	0.00	10.00
WTPar2	100	4.58	0.12	0.430	1.00	12.00

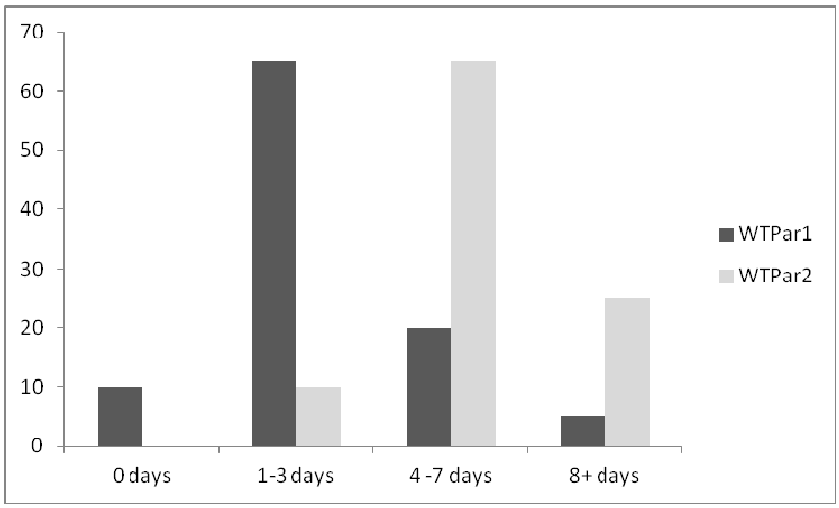

Fig. 3 Comparing WTPar1 and WTPar2 after grouping them in appropriate classes.

Table 4 *t*-test for paired samples.

Pair of variables	Mean	Standard deviation	*t*-statistic	*p*-value	Decision
WTPar1 - WTPar2	−0.97	0.170	−57.146	0.000	Significant difference before and after information

Table 5 Descriptive statistics of WTPar in two monuments.

WTPar1—Before information					
Monument	N	Mean	SD	Min.	Max.
Lefkada's Theatre	100	0.50	1.451	0.00	6.00
Corinthian Diolkos	100	1.50	0.89	0.00	10.00
WTPar2—After information					
Lefkada's Theatre	100	4.13	2.899	1.00	9.00
Corinthian Diolkos	100	4.58	0.12	1.00	12.00

Table 6 *t*-test for independent samples for WTPar for two monuments before and after information.

Before information					
Pair of variables	Mean	Standard deviation	*t*-statistic	*p*-value	Decision
WTPar1 (Theatre) - WTPar1 (Diolkos)	−1.00	0.567	−19.111	0.001	Significant difference
After information					
WTPar2 (Theatre) - WTPar2 (Diolkos)	−0.45	0.037	0.713	0.219	No significant difference

ancient theatre of Lefkada Island in Greece is estimated before and after reading of an informative text about this monument. The main difference between the two studies is the existence (Lefkada) and the absence (Diolkos) of opportunity cost of the interviewees. So, a comparison between both ancient cultural heritage monuments would be interesting. In Table 5, the descriptive statistics of both studies are compared.

The important effect of opportunity cost in WTPar is obvious according to the above descriptive statistics.

People with opportunity cost are able to spend an average of half a day on the restoration of the monument against an average of 1.5 days by people without opportunity cost of labor before information.

A significant increase of these averages can be observed after the information, with 4.13 days and 4.58 days respectively. To examine if there are significant differences between the WTPar of interviewees of each group, *t*-test was performed for independent samples before and after information supply. The results can be seen in Table 6.

Table 6 provides evidence for significant difference between WTPar1 for each monument which declares that the existence of opportunity cost of labor affects the willingness of interviewees to participate in restoration of these cultural heritage monuments. It also provides evidence for no difference between WTPar2 for each monument which is a very interesting finding because it allows assuming that the effect of information to WTPar is much stronger than the effect of opportunity cost.

5. Conclusion and Discussion

The effect of opportunity cost to the validity of CVM for cultural heritage has been studied herein using an ancient Greek monument called "Diolkos" and interviewees serving in a near-by military camp. The survey used two runs: one questionnaire without providing any information for monument and one after the distribution of information leaflets.

The soldiers' willingness to participate in the restoration of "Diolkos" is influenced by several parameters: income, age, educational level, living distance, ownership, volunteering, information and previous visiting. Soldiers with higher education level showed greater willingness to participate than those with lower education level. Moreover, the older the soldier was the greater willingness to participate he stated. In addition, the distance of permanent residence from the monument, the previous visits to the monument and the ownership of any kind of land around the monument had a positive influence on the willingness of soldiers. An extremely interesting result is the positive effect of information on the soldiers' willingness. A significant increase of their willingness was observed after they had been informed about the history of "Diolkos". The negative income effect to the soldiers' willingness to participate is another interesting result of authors' analysis. The summary of results above can be seen in Table 5 and Table 7.

The fact of negative income effect is explained through the refusing of soldiers with higher family income to participate in the restoration of "Diolkos". It seems that the higher income a person has, the less willing is to get personally involved. An absolute opposite effect is seen in the volunteers and informed. A person with previous volunteering activity seems to be more concerned and sensitized to cultural heritage monuments. The awareness of this population about the level of usefulness of voluntary work drives them to continuously try to offer more and more voluntary work. An extremely interesting and positive effect on the willingness is coming from the awareness of the participants. The more knowledge a person has about a monument the higher his willingness to participate in its restoration. In effect, knowledge raises the value of the monument manifold. Consequently, the main result of Diolko's research is that information and personal interest are two great "powers" of nowadays. The higher education level and study about a crucial subject a person has, the higher sensitivity he has.

Table 7 Effect of several parameters to the willingness to participate.

Parameter	Effect
Income	−
Education level	+
Information	+
Volunteering	+
Ownership	+
Age	+
Previous visit	+
Living distance	+

In comparison, the willingness of interviewees to participate in the restoration of the ancient theatre of Lefkada Island in Greece was estimated with the traditional method. The difference between the two studies is the existence of opportunity cost in the first study and its absence in the second. According to the Lefkada survey, the 58% of interviewees have previously volunteered in similar works, whereas 42% have not; the 36% of the interviewees had visited the site, while 64% had not; the 31.5%, 41% and 27.5% of the interviewees were aged between 18-22, 23-47 and 28-31 years old, respectively. The 3%, 22%, 31.5%, 22% and 21.5% of the interviewees have completed primary school, high school (1-3 class), high school (4-6 class), university or technological institution or postgraduate studies respectively.

The difference between the willingness to participate in voluntary work seems to be higher before the distribution of the information leaflet. Similarly to the Diolkos survey, the willingness to volunteer is substantially increased after the interviewees learnt the history of the monument. Evidently, the effect of the opportunity cost is counterbalanced by the information effect.

The output of the WTP approach is the demand curve of a non-marketable good. The methodological modification presented herein leads to the extraction of a supply curve for voluntary work. This is particularly interesting and quite straightforward because the participants have no opportunity cost and no income during their military service. Moreover, there is not a transportation cost to consider, because the interviewees are located at the site. The outcome of this method might be inconclusive when these variables, i.e., opportunity cost of time and transportation cost, have to be considered.

The depreciation of antiquities caused by humans is an external economy, which is not corrected through any institution or market. From the statistical analysis provided herein, a path is clearly drawn to stabilize the social costs of depreciation of cultural goods. External effects are observed when supply or demand impose costs or confer a benefit to others. The external effect is the impact of the behaviour of a producer or consumer well-being of another, which is not reflected in market transactions. The external effect of the deterioration of cultural monuments is universal and appears as an external benefit borne by all of humanity through time.

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The Environmental Democracy under Political Siege in Turkey

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Abstract: On June 24th, 2018, President Tayyip Erdogan, along with his pro-Islamic party, the Justice and Development Party, AKP, won the general election in Turkey, which will enable Mr. Erdogan to be a one-man ruler of the Republic of Turkey in the foreseeable future. Now, invested with infinite executive-presidential power, coupled with having complete control of the military, cabinet, judiciary and legislative branches, enables Mr. Erdogan to pursue his ambition to be a "nuclear power leader" in the Sunni Islamic world. The scientific denialism in general and environmental science, in particular, will reach a whole new level of insanity in Turkey where any conceivable environmental democracy will be abolished. The new government will further change the education establishment in every level and implement its anti-science political doctrines in which logic is an enemy and scientific truth is a menace. The last fifteen years of experience show that the AKP's politicians have become anti-science zealots who preach a dangerously new political cultism that is devoid of actual facts, if it does not fit their religious aberration narrative. Thus, virtually every aspect of the nuclear power program in Turkey will be a state secret under the control of one religiously motivated and driven ruler and this, should certainly sound alarm bells across the globe.

Key words: Environmental democracy, Turkish Nuclear Energy Project.

1. Introduction

On June 24th, 2018, President Tayyip Erdogan, along with his pro-Islamic party, the Justice and Development Party, AKP, won the general election in Turkey, opening a new chapter in the Turkish civilian and military nuclear saga which has been declining for the last 40 years. In July 2010, Mr. Erdogan, who was then the Prime Minister, concluded an intergovernmental agreement with Russia involving the transfer of nuclear energy technology to Turkey. A 20-billion-dollar contract was signed with the Russian company: Rosatom, to build a nuclear power plant and a nuclear fuel fabrication complex at the Akkuyu-Mersin site located on Turkey's eastern Mediterranean coastline. Under this agreement, the Russian company would develop a 4,800 MW nuclear power plant, consisting of four VVER-1200 reactors, on a BOO (Build-Own-Operate) basis. The Akkuyu power plant site is near the Goksu delta which has the status of a nature reserve and is protected by Ramsar Convention.

Two years later, on May 3rd, 2013, a similar intergovernmental agreement, was finalized with the Japanese Government to establish another 4,800 MW nuclear power plant, consisting of four ATMEA1 reactors and a nuclear fuel reprocessing facility, in Sinop providence located on the southern shore of the Black Sea. A consortium comprising Mitsubishi Heavy Industry Ltd and Itochu of Japan, Areva and GDF Suez of France, would build a nuclear complex, based on BOO also, with an initial estimate of $22 billion (US). The power plant site is within the Sarikum Lagoon and protected by the Ramsar Convention, as well as by the 1994 Black Sea Convention (Bucharest Convention).

However, in April of 2018, the Japanese trading house Itochu, which is major global financer of the nuclear weapon industry, was a contributor of 30% of this project's overall cost, withdrew from the joint

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Turkish Japanese nuclear power project, claiming that their decision was based on unforeseen cost overruns and stricter safety regulations. It is said that the Japan Bank of International Cooperation may cancel its 70% present contribution at any time, which will in turn create a temporary halt in the Sinop project until China or South Korea makes a deal with Mr. Erdogan who can overrule any existing environmental restrictions.

A third nuclear power plant, again by the Black Sea, is now being planned in Inceburun-Igneada, approximately 150 km west of Istanbul and only 10 km from the Bulgarian border. This power plant will be built in one of the protected territories under the Ramsar Convention and Bucharest Convention, namely, the Igneada Sakha Longozu. It includes several small lakes, a river delta and undisturbed sand dunes with their characteristic unique xerophytic vegetation. There are questions as to whether China or South Korea will be the winning bidder to construct and operate this facility.

When complete, the Akkuyu and Sinop nuclear site will be the first and only nuclear power complex in the world under the control of an operator that is a subsidiary of a foreign, rather than sovereign, State, from construction through to the end of an undetermined decommissioning process. Furthermore, both cooperation agreements also include the promising establishment of foreign owned and operated nuclear fuel cycle programs, more specifically nuclear fuel reprocessing and fuel fabrication facilities in Turkey. According to article 2 of the Turkish Japanese agreement: “Technology and equipment for Uranium enrichment, spent nuclear fuel reprocessing, conversion of Plutonium and production of material including those items listed in part C of Annex A, as well as Plutonium may be transferred under this agreement only when this agreement is amended for that purpose in accordance with pyrograph 1 of Article 14” [1]. And so, the very real possibility arises of weapon grade nuclear material being manufactured by Russia or Japan within the borders of a member of the NATO alliance.

A sobering fact is that there is no technical demarcation between a military and civilian reactor nuclear program. “Commercial nuclear power is the foundation for nuclear weapons. If we had any chance to slow the spread of nuclear weapons, we needed to establish a control regime concerning the spread of commercial nuclear technology”, said John J. Hamre, US Deputy Secretary of Defense 1997-1999, and US Undersecretary of Defense 1993-1997, President and Chief Executive Officer Center for Strategic and International Studies Washington, D.C..

Both, Turkish-Russian and Turkish-Japanese agreements include several clauses that permit the Turkish government to extract plutonium from spent fuel and to enrich Uranium. Simply, Turkey is embarking upon “weapon sensitive” technology. Therefore, there can be no clearer indication that these intergovernmental projects are geopolitically motivated and will provide a new breeding ground for nuclear weapon programs thinly disguised as “Nuclear Technology Transfer Agreements”. The latest attempts by Turkey, the Arab Emirates and Jordan to embark on vigorous nuclear programs collectively show that the proliferation of nuclear power in the Middle East is now the greatest challenge [2].

2. Rights of Access to Information, Public Participation in Decision-Making and Access to Justice for Akkuyu and Sinop Nuclear Power Project

On December 11, 2013, the Turkish Ministry of Environment and Urban Planning issued a three thousand page, literally a cut and paste, EIA (Environmental Impact Assessment) report for the Akkuyu nuclear power plant project, and at this time, a similar EIA being prepared for the Sinop project. The EIA is supposedly subject to independent public hearings and approval of regional residence before it will be finalized. The AKP government brought

members of their party from nearby cities by bus to be present in several public meetings in Mersin and Sinop Province. They provided accommodation and free lunches to the party members who attended. But local NGOs (Non-Governmental Organizations) and hundreds of people living in the in Mersin and Sinop who are opposed to the nuclear power plant projects were prevented by police from participating in the public hearings. After 30 days of a largely superficial review process, Mr. Erdogan sent a letter to every governmental institution involved in producing EIA report asking them to expedite their final approval of the EIA. A revised version of the EIA was approved by the AK government in December 2014.

Since then, for the Akkuyu project, 13 different complaints have already been filed against the Ministry of Environment and Urban Planning in the Mersin High Court. Numerous NGOs along with the UCTEA (Union of Chambers of Turkish Engineers and Architects), the Turkish Bar Association, Turkish Medical Association played a vital role in preparing technical and judicial arguments of the complaints. These complaints seek to challenge the scientific integrity of the EIA report and invalidate it on the following grounds; misrepresentation of or failure to itemize the radioactive inventory and projected releases into the environment; incomplete information about the toxic chemicals which will be injected into the cooling system throughout the nuclear complex; misleading information about the cooling water's temporal and chemical effects on marine life; lack of details on an emergency evacuation plan in case of a sewer accident; lack of a comprehensive waste management plan; unspecified insurance coverage for the nuclear complex as well as noncompliance with third party liability requirements. Coupled with these complaints are allegations that signatures on some sensitive reports contained or referred to in the EIA have been falsified.

After two years of appealing producers, the case reached to the Republic of Turkey Presidency of the Council of State, DANISTAY, a Superme Consultative and Appelative Court, accept to review this case. Before rendering their final oponion for this case, the court had to rewiew the final certification of EIA which was produced by 15 lower court assigned experts to evaluate arguments that were filed against the approved EIA. According to rules and regulations these experts must be independent-impartial indivuals, however, they happened to be working in goverment universities. In spite of clear scientific evidence presented in the complaints, unfortniuatly, these academicians have relactend endorsed-certified the incomplete and ill-advised IEA.

The first and the last instance court of the Turkey, in March 2017, the Councel of State rendered its final descsion in which they admitted that, "After reviewing the arguments of complaints against to EIA which is endorsed by goverment assigned expert findings, the court recignizes that the EIA report before the court is inded incomplete imperfect and inadequate. However, in the court oponion, the deficiencies that are argued by plantaif did not arise to the level of in invalidating or cancelling the EIA for the Akkuyu Nuclear power Plant, and further, the court accepts the goverment assertion that all possible defisits that will be determined and fixed during the implimantation of the project in the future", which marks the beging of the end of existing envorimental laws and regulations in Turkey.

3. Japan and France—Global Financial Involvement in Nuclear Weapons Program

From the onset of the Cold War, the financial institutions that are directly or indirectly sponsored by governments have provided various types of financial services to nuclear-energy-weapon companies including loans, investment banking and asset management. Since January 2014, seven financial institutions in Japan made an estimated USD$18,555 million available to 20 nuclear weapon producing companies in the USA and Europe. In France, 14

financial institutions made an estimated USD$29.8 billion available to nuclear weapon producing companies since January, 2014. The following Japanese banks, which are involved in the Sinop Project, are known to have significant involvement in providing loans, investment banking or holdings shares.

The Chiba Bank: US$20 million; Mitsubishi UFJ Financial: US$8.470 million; Mizuho Financial: US$5.172 million; Nomura: US$3 million; Orix Corporation: US$610 million; Sumitomo Mitsui Financial US$4.246 million; Sumitomo Mitsui Trust: US$35 million [3]. The Japanese financial institution which is most significantly involved in the financing of one or more nuclear weapon companies in France is: The Ariane Group, which includes the Safran and Airbus of France.

4. Inexorable Nuclear Power Program of Turkey

If this proliferation of nuclear development was not sufficient cause for concern on its own, right after the presidential elections in June 2018, a new NRC (Nuclear Regulatory Commission) of Turkey, by a Presidential Degree, directly controlled and staffed by the president Erdogan, was established in July 2018 to oversee all future nuclear activities in Turkey. Worryingly, the budget, plans and programs of the NRC cannot be questioned or challenged, without the consent of the president Erdogan.

The new NRC is also charged to govern the TAEK (Turkish Atomic Authority) programs, which in turn are both the promoter and safety regulator of the nuclear energy industry in Turkey. In fact, both organizations are politically subordinate to the president's office and have no effective organizational power, scientific expertise or capacity to make independent rules, enforce compliance or impose international safety measures during both the construction and operational phases of the nuclear complex in Akkuyu and Sinop.

5. Is Turkey Ready for a Nuclear Energy Program?

Within the frame work of the IAEA (International Atomic Energy Agency), there is a committee known as the INIR (Integrated Nuclear Infrastructure Review) formed in 2009. It consists of IAEA staff and international experts that provide a comprehensive assessment of all facets of a nuclear power program upon the request of a member country.

The INIR mission is to guide the member country on everything from the creation of regulations to the necessary infrastructure, materials and technical expertise required for building a nuclear power program. At the reluctant request of the Turkish government, the INIR prepared a report concerning the Akkuyu project in general and the integrity of the EIA report in particular. The INIR report was delivered to the Turkish TAEK on February 20th, 2014.

The INIR report includes 24 major recommendations and 15 suggestions to assist the Turkish authorities and institutions to prepare the necessary infrastructure for the Akkuyu and Sinop projects. The main recommendations of the INIR report are that Turkey enacts a compressive law on nuclear energy; establishes an independent regulatory body; firmly adheres to international conventions and treaties relating to nuclear power in any shape or form, and, conducts an impartial EIA report free from political influence or pressure.

Without sayings as much, the report's findings were clear that the Turkish Government, with its existing inadequate legal and technological infrastructure, is far from capable or prepared to implement a safe and properly managed nuclear power program. Perhaps unsurprisingly, the report was kept secret by the Turkish government and was not revealed to the public until it was leaked to the media in June, 2015.

This structure of control and regulation of the nuclear energy, along with the passing of strict secrecy laws, similar to the 2015 Japanese Secrecy

Laws, is an almost carbon copy of the Russian Nuclear Regulatory System and completely different from the accepted "norms" in the western part of the world. The Sinop Nuclear Complex will be a new extension of these obscured organizations under the personal protection of Mr. Erdogan.

6. The Russian, Japanese and Turkish Nuclear Energy Authorities; No Safety Culture and Corruption Remain Endemic

Turkey, Japan and Russia did not sign the convention on "Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters" known as AARHUS Convention. Russia is a developed state with the world's most inefficient economy, and the Russian nuclear industry and regulatory authority lacks transparency. They have neither the capacity nor the willingness to enforce the rules and regulations set out in their own nuclear safety codes.

The report of the Eco Defense and Transparency International Russia organization published in November 2010, showed that the corruption has "deeply imbedded" into almost every branch of Rosatom. Rosatom is, in essence, a "state within a state" operating under no one's control but its own. The Russian nuclear industry remains under almost no external control. The lack of transparency, widespread corruption, failure to demonstrate high levels of safety, and, the unresolved waste and decommissioning issues must be of high concern to any potential customer of Rosatom's on the international market. According to governmental sources, about 500 million tons of radioactive waste has accumulated at various facilities across Russia.

Corruption in Japan is arguably worse, a fact that Chiari Naito, the former vice president of Kansai Electric Power Co. (KEPCO-Japan), admitted when he disclosed secretly paying seven of Japan's prime ministers approximately $200,000 per year, for 18 years (Mashable UK, July 28th, 2014). From the beginning of the peaceful use of nuclear energy, hundreds of nuclear industry executives and regulators in Japan and Russia have been arrested on the grounds of corruption. According to the US National Academy of Science report, titled Committee on Lessons Learned the Fukushima Nuclear Accident for Improving Safety and Security of U.S. Nuclear Plants. National Academy of Sciences [4] "Japan's safety rulemaking is deeply flawed. Because NISA lacks full-time technical experts to draw up comprehensive regulations, it depended largely on retired or active engineers from nuclear-industry-related companies to set rulemaking. While the Government of Japan acknowledged the need for a strong nuclear safety culture prior to the Fukushima Daiichi accident, TEPCO and its nuclear regulators were deficient in establishing, implementing, and maintaining such a culture. Examinations of the Japanese nuclear regulatory system following the Fukushima Daiichi accident concluded that regulatory agencies were not independent and were subject to regulatory capture."

7. Environmental Concerns

Ecological effects of a nuclear power plant on local marine life as well as the long-term geopolitical consequences have been generally overlooked and the Turkish EIA is no exception to this. Every use of the sea and its coastal areas has the potential to affect the well-being of neighboring countries. Even point-source pollution restricted to the vicinity of a nuclear power plant, may affect the economic development of another country by killing juvenile fish which would have otherwise migrated to its coasts. The Turkish commercial fishing industry, annually catches around 300,000 tons of anchovies alone—this will be the first "victim". Within 10 years, the Sinop and Igneada nuclear power plant's cooling system will severely deplete most of the marine life around the Black Sea Basin.

For thousands of years, the Mediterranean and Black Sea Basin inhabited by unique form of flora and

fauna. Both Seas connect three continents, 27 nations, and, more than 700 million people. And both basins have been the cradle of most of the civilizations in our planet; the human population of the coastal countries heavily dependent of their needs for food, transport and recreation uses this marine ecosystem.

The Akkuyu and Sinop nuclear complex, from the onset of the construction, during the operations and possible unforeseen accidents, will have adverse impact on ecology, biogeography, economy and livelihood of people who thrive on the marine-ecosystem and tourism industry around the Mediterranean and Black Sea. These ill-conceived agreements also ignore vigorous adherence to the Barcelona and Basel Convention to protect the Mediterranean Basin, as well as the 1994 Black Sea Convention (Bucharest Convention).

In addition to chronic radioactive gas released every day, enormous quantities of water (10 billion litres per day) will be circulated throughout the Akkuyu and Sinop nuclear complex destroying billions of larva and other marine creatures, including planktonic organisms. Discharge water will also increase the temperature and change the chemical composition of the sea water.

The biological diversity and peculiarities of the Black Sea and Mediterranean Sea are well documented: “The Mediterranean Sea comprises less than 1% of the world’s oceans, but it contains about 7% of all known marine species, including 357 species of reptiles, 115 amphibian species, 400 species of fresh water fish and 22,500 endemic vascular plants species”. In the Black Sea, a total of 3,774 species have been identified, including: 1,619 fungi, algae and higher plants; 1,983 species of invertebrates; 168 species of fishes, and 4 species of mammals.

According to a detail United Nations report in Ref. [5], “The biologically rich regions are only limited to only oxygen rich shelf zones, with depths of up to 50-100 m in the southern coast line, and in the northern Black Sea shallow-water areas with depths of up to 5-10 meters. This water body, bordering the hydrogen sulphide zone, is approximately 200-300 meters wide and averages 5-50-metres-deep, in which high concentrations of fish eggs and larvae strive, and circulate counter clock wise along 4,340 km coastline of the Black Sea”.

The high and low tides are practically non-existent in the Black Sea, which is why there are no typical estuaries-inlets-sounds in the Turkish coastline. Therefore, oxygen rich coastal water will be used as cooling water for both Sinop and Igneada nuclear power complexes. As a result, if the water-balance-boundary between lifeless Hydrogen Sulphide and biologically creative/productive regions of the Black Sea is disturbed and mixed that will be the beginning of the end of marine life in the Black Sea.

8. Conclusion

The founder of the Justice and Development Party, president Erdogan, is ambitious to create Turkey as a nuclear power leader in the Sunni Islamic world which is happening at any cost and, with little care for the environmental consequences. This should be a matter of global concern. Their willingness to adopt the lowest Russian-Japanese nuclear technology rather than the highest western standards of nuclear technology and regulations, the least rather than the most transparent of environmental impact procedures and the riskiest rather than the safest partners is contrary to all conventions and the best interests of the Turkish people.

In addition to existing Turkish energy dependence on Russian oil and natural gas, which can be supplied from different sources, the electrical energy produced at the Akkuyu and Sinop nuclear power plant will be at the mercy of the Mitsubishi and Rosatom companies. It is not, however, too late to draw back from the abyss. Even if cancelling the agreement with Russia and Japan involves payment of significant compensation it would be money well spent for the

wellbeing of the Turkish people and the rest of the world.

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Establishing the Method for Assessing Flood Vulnerability in Ho Chi Minh City, Vietnam—A Case Study in District 6

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Abstract: Urban flooding has impacted significantly on people's living: economic development, environmental pollution, etc.. It has been the serious problem of many cities in the world, especially in urban areas in developing countries because urbanization is too fast but lack of adaptive management planning and infrastructure. In Vietnam, the big cities, such as HCM (Ho Chi Minh) City, Hanoi, etc. have also been influenced severely by floods. By early 2017, HCM City has 171 flooded sites assigned by the district level; 40 submergence points assigned by Steering Center of Flooding Control Program, and 9 tidal flooded points. The paper will establish a suitable method for assessing flood vulnerability in HCM City from natural, social and environmental aspects. The results of a case study in District 6 show that there are four wards with high vulnerability and 10 wards with average vulnerability.

Key words: Vulnerability, flooding, District 6, HCM City.

1. Introduction

1.1 Natural Condition

1.1.1 Geography

Located in the transition zone between the southeast and the southwest, the city covers an area of 2,095.06 km², consisting of 24 districts.

HCM (Ho Chi Minh) City is located at 10°10'-10°38' north and 106°22'-106°54' east. The city borders Binh Duong Province to the North, Tay Ninh Province to the northwest, Dong Nai Province to the east and northeast, Ba Ria-Vung Tau Province to the southeast and Long An and Tien Giang Province to the west and northwest (Fig. 1) [1].

Thanks to its ideal location as the central of South East Asia region, HCM City is a critical transport hub of not only road transportation but also water and air transportation. The city is also the biggest international hub welcoming countless international airlines to and from Vietnam [1].

The city's terrain descends from north to south and from west to east. The uplands are in the north-northeast and partly northwest, with an average of 10 to 25 m. Alternatively, there are some hills, up to 32 m high, such as Long Binh hill in District 9. In contrast, the low areas are in the south-southwest and southeast cities, with an average height of about 1 m and the lowest area 0.5 m high. The central areas, the part of Thu Duc District, District 2 and the whole of Hoc Mon and District 12 have the average height of about 5 to 10 m [1, 2].

1.1.2 Hydrology

Located in the downstream of the Dong Nai River system—Saigon, HCM City has a very diverse network of rivers and canals. Dong Nai River which originates from Lam Vien Highland and connects to many other rivers, is a large basin, about 45,000 km².

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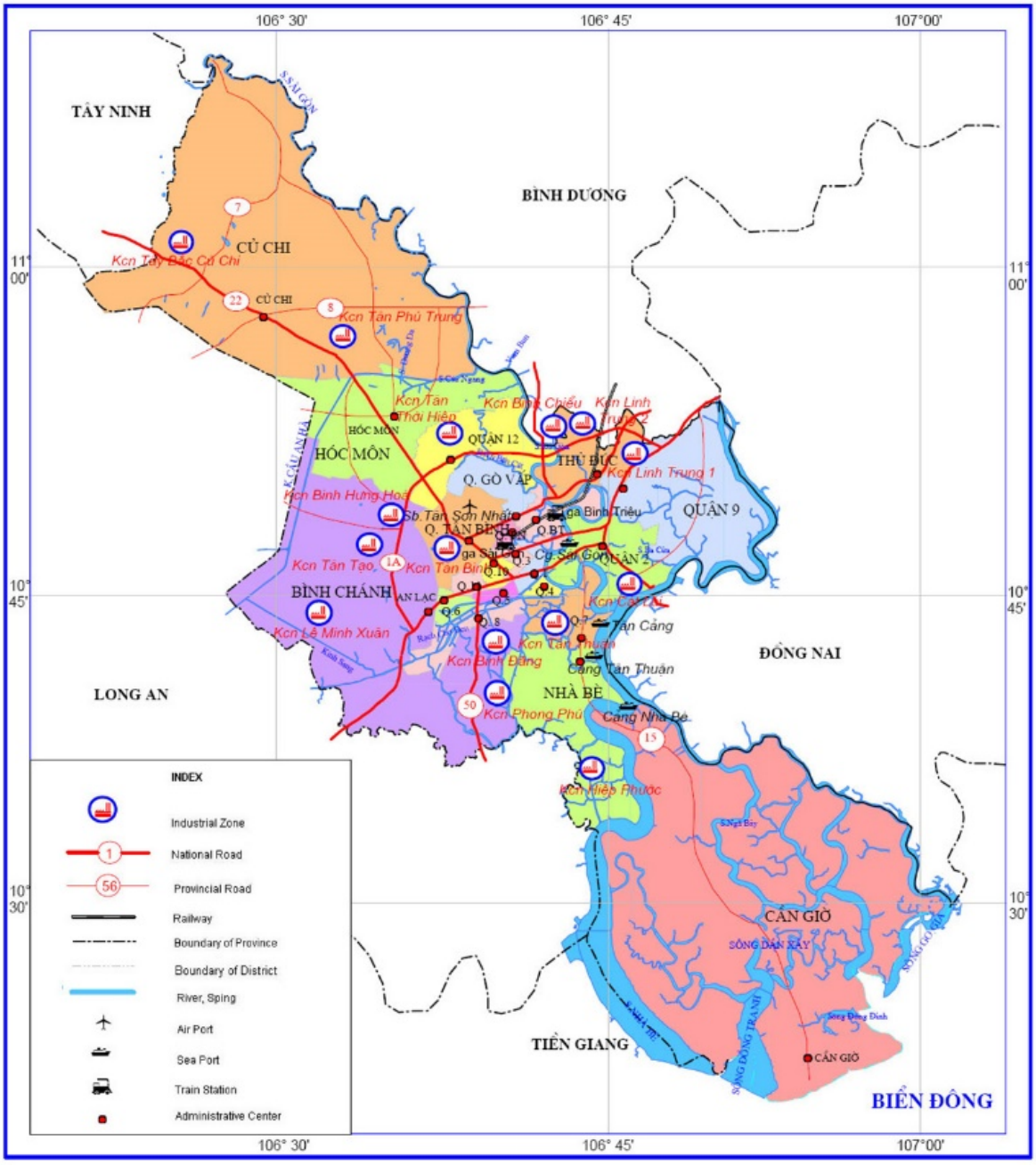

Fig. 1 HCM City map.

With an average flow of 20-500 m³/s and an annual supply of 15 billion m³ of water, the Dong Nai River becomes the main freshwater source of the city. The Saigon River originates from the Hon Quan area, flows through Thu Dau Mot to HCM City, with a length of 200 km and flows along 80 km long of the city. The Saigon River has an average flow of about 54 m³/s, with a width of 225 m to 370 m and a depth of 20 m. Thanks to the Rach Chiec canal system, the two rivers of Dong Nai and Saigon connect in the expanded inner city. Another river of HCM City is the Nha Be River, formed at the confluence of the two rivers of Dong Nai and Saigon, flows into the East Sea by two main ways, Soai Rap and Ganh Rai. In particular, Ganh Rai is the main waterway for the ships to the port of Saigon [1].

1.1.3 Meteorology-Climate

As in some other southern provinces, HCM City has two seasons: dry season and rain season. Rainy season starts from May to November (hot and humid climate, high temperature and heavy rain), while dry season is from December to April of next year (dry climate, high temperature and low rainfall). On average, HCM City has 160 to 270 hours of sunshine a month. The average temperature is 27 °C, the highest is up to 40 °C and the lowest is 13.8 °C. Every year, the city has 330 days with an average temperature of 25 to 28 °C. The average rainfall of the city reached 1,949 mm/year, of which the year 1908 reached the highest of 2,718 mm, the lowest was 1,392 mm in 1958. In one year, the city has an average of 159 rainy days, the most rainfall from May to November, accounting for about 90%, especially in June and September. In the city space, rainfall distributes unevenly, trends to increase along the southwest-northeast. Urban districts and districts in the north have higher rainfall than the rest [1].

HCM City is affected by the two main wind directions which are west-southwest and north-northeast monsoon. West-Southwest wind from the Indian Ocean has an average speed of 3.6 m/s in the rainy season. North-Northeast wind from the East Sea has an average speed of 2.4 m/s in the dry season. There is also a south-southeast trade wind from March to May, an average of 3.7 m/s. It can be said that HCM City is located in the region without storms. As rainfall, the air humidity in the city rises in the rainy season (80%), and low in the dry season (74.5%). Average air humidity reaches 79.5% per year [3].

1.2 Flooding Situation

In addition to the main rivers, HCM City also has a diverse network of canals: Lang The, Bau Nong, Can Tra, Ben Cat, An Ha, Tham Luong, Cau Bong, Nhieu Loc-Thi Nghe, Ben Nghe, Lo Gom, Ken Te, Tau Hu, Kenh Doi, etc.. Rivers and canals help HCM City to irrigate, but due to fluctuations in the tidal range of the East Sea, tidal floods have impacted badly on agricultural production and water drainage in the inner city.

Total length of the river system is 7,955 km. Total area of water surface is 16%. The lowland terrain is less than 2 m high and the water surface is 61% of the natural area. It also is located in the estuary with many large dams in the upstream. Therefore, the risk of flooding is high.

The average rainfall in HCM City is quite high, ranging from 1,800 mm to 2,700 mm in seven months from May to November, accounting for 90% of rainfall.

Due to the two main seasons of the rainy season and the dry season, the flow regimes in the two rivers of Saigon and Dong Nai rivers also form two corresponding flow regimes. At the same time, because of the impact of the East Sea, rivers and canals in the inner city of HCM City are strongly influenced by tides all the year.

By early 2017, HCM City has 171 flooded sites assigned by the district level; 40 submergence points assigned by Steering Center of Flooding Control Program, and 9 tidal flooded points.

In recent decades, tides have been more and more irregular due to many causes, including climate change. Climate change causes sea level rise and sea level rise creates high tide. The flooded points are very volatile. The rapid urbanization makes tides become violent, high and swirl [2].

2. Methodology

2.1 Criteria Selection

According to the IPCC Third Assessment Report: “Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity” [4].

Therefore, based on this definition of vulnerability, there are four criteria: Hazard, Exposure, Sensitivity and Adaptability. These criteria are described below [5-7].

(1) Hazard (H): shows the magnitude, flooding level and the hazards that floods can damage to the study area. This study uses 3 indicators (Table 1);

(2) Exposure (E): is known as direct threats, including characteristics and changing levels of extreme factors in the area. This study uses 6 indicators (Table 1);

(3) Sensitivity (S): is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. Climate-related stimuli encompass all the elements of climate change, including mean climate characteristics, climate variability, and the frequency and magnitude of extremes. The effect may be direct (e.g., a change in crop yield in response

Table 1 Criteria for assessing vulnerability level to flooding in HCM City.

No.	Criteria	Symbols	Sources
1	HAZARD (H)		
1.1	Flooding area (m^2)	H1	Flooding data
1.2	Flooding depth (m)	H2	Flooding data
1.3	Flooding time (min)	H3	Flooding data
2	EXPOSURE (E)		
2.1	Density	E.1	Statistical yearbook
2.2	Population (people)	E.2	Statistical yearbook
2.3	Current land use	E.3	Land use map
2.4	Number of manufactures/factories	E.4	Statistical yearbook
2.5	Length of flooded road	E.5	Resident questionnaire
2.6	Type of housing	E.6	Resident questionnaire
3	SENSITIVITY (S)		
3.1	Social sensitivity		
	Working-age population	S.xh.1	Statistical yearbook
	Female ratio	S.xh.2	Statistical yearbook
	The poor/total number of households	S.xh.3	Statistical yearbook
3.2	Economic sensitivity		
	Income per capita	S.kt.1	Statistical yearbook
	Livelihood	S.kt.2	Resident questionnaire
	Main income source	S.kt.3	Resident questionnaire
3.3	Environmental sensitivity		
	Rate of households registering for waste collection (%)	S.mt.1	Officer questionnaire
	Rate of households using clean water	S.mt.2	Officer questionnaire
	Current state of air pollution	S.mt.3	Resident questionnaire
	Domestic water quality	S.mt.4	Resident questionnaire
	Potential for disease outbreak	S.mt.5	Resident questionnaire
4	ADAPTABILITY (A)		
4.1	Government		
	Number of staff working in the field of natural disaster prevention	A.cq.1	Officer questionnaire
	Ward health activities	A.cq.2	Officer questionnaire
	Flood adaptation plan/program	A.cq.3	Officer questionnaire
	Effectiveness of the flood protection program/plan	A.cq.4	Officer questionnaire
	Quality of District Public Service activities in the ward	A.cq.5	Officer questionnaire
4.2	Resident		
	Flood resistance	A.cd.1	Resident questionnaire
	Access to news (radio, television, internet)	A.cd.2	Resident questionnaire
	Quality of flood articles	A.cd.3	Resident questionnaire
	Community support/community solidarity	A.cd.4	Resident questionnaire

to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise). This study uses 11 indicators (Table 1);

(4) Adaptability (A): is the ability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. This study uses 9 indicators (Table 1).

2.2 Steps

Establishing the flood vulnerability criteria includes the steps which are shown as Fig. 2.

2.3 Formulation for Flood Vulnerability

After setting up the factors of criteria fully, the values of each variable have been collected and edited enough.

The values of each variable will be normalized from 0 to 1 [8].

The vulnerability index due to flooding is considered a function of four criteria: hazard, exposure, sensitivity and adaptability [9-11]:

$$FVI = f(H, E, S, A) \quad (1)$$

There are many different formulations in last studies but the formulas were used in this study as Eq. (2):

$$FVI = H \times w_H + E \times w_E + S \times w_S + (1 - A) \times w_A$$

in which, w_H, w_E, w_S, w_A: weight of 4 criteria.

Values of 4 citeria: H, E, S, A are defined from its variables. The formula for calculating these criteria use a weighted plus formula (Eq. (3)):

$$X = \sum_{i=1}^{n} X_i . w_i \quad (3)$$

in which: X—criteria to be determined; X_i—value of the variable i; w_i—weight of the variable i and $\sum_{i=1}^{n} w_i = 1$.

The values of weight are calculated by the AHP (analytic hierarchy process) method [12].

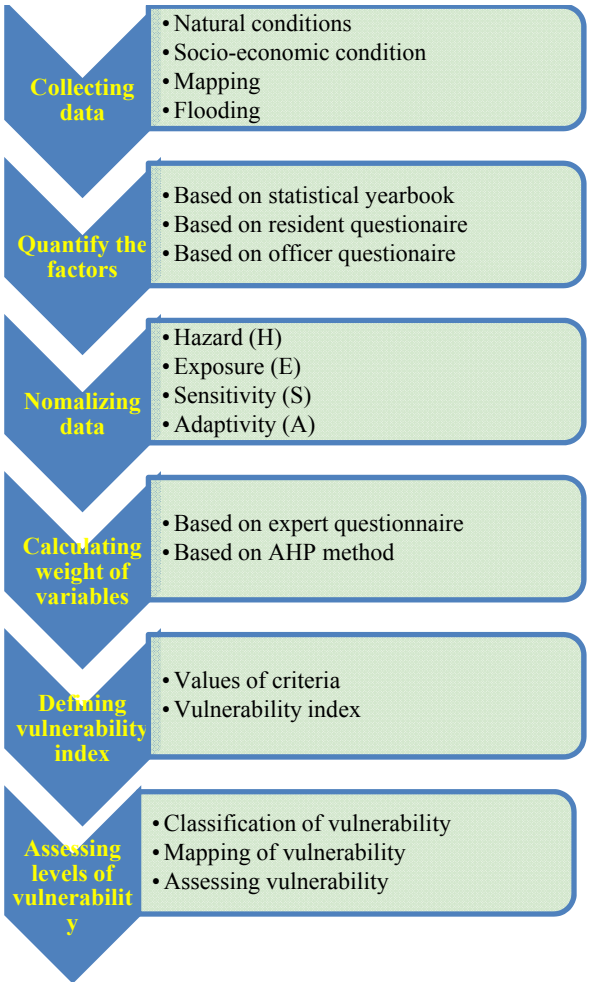

Fig. 2 Steps for assessing flood vulnerability in District 6, HCM City [3, 4].

3. Assessing Flood Vulnerability in District 6, HCM City

3.1. Introduction to District 6, HCM City

District 6 consists of 14 wards, located in the southwest of HCM City. District 6 is shaped like a triangle.

Main fields of District 6 are trade and service. It mainly trade exchange with the provinces in the Southwest region. In addition, most of them are laborers, especially many Chinese-Vietnamese people who are experienced in handicraft business and production. District 6 has a total natural area of 7.14 km^2, accounting for 0.34% of the natural area of the city. The current population of District 6 is 252,811

people, with an average population density of 35,408 people/km^2, of which 53% are women.

Flooded areas in District 6 are Bung Binh Cay-Tan Hoa Dong-Ba Hom (in Tan Hoa-Lo Gom basin). Especially, Cho Lon Bus Station is typical flooded area due to inadequate drainage and encroached canals. The canal sections are narrowed, so the water level of canals is high up in the rain. Moreover, when heavy rain coincides with high tides, the water level in the canal is higher than the height of the road surface causing severe flooding. In addition, since the Bau Cat which is upstream of the Tan Hoa-Lo Gom Canal has been urbanized; it has increased the flow and water level at the Ong Buong bridge, causing flooding in this area. It is worth mentioning that even if there is only rain in the upper of Tan Hoa canal (Tan Binh District), the area is also flooded by the inundation.

3.2 Database of Flood Vulnerability in District 6, HCM City

The data used for the vulnerability assessment for District 6 of HCMC include:

(1) Statistical yearbook for economic and social data of District 6 (District Statistical Office);

(2) Background maps and land use maps (Department of Natural Resources and Environment of HCM City);

(3) Flooding data (Flood Control Center, People's Committee of HCM City);

(4) Resident questionnaire;

(5) Ward/district officer questionnaire;

(6) Expert questionnaire.

Specific data sources of each variable and factor are shown in Table 1.

3.3 Results

(1) Hazard (H)

The results of flood hazard (H) for each ward are shown in Table 2:

(2) Exposure (E)

The results of flood exposure (E) for each ward are shown in Table 3:

(3) Sensitivity (S)

+ Social sensitivity (S_{so})

The results of social sensitivity (S_{so}) for each ward are shown in Table 4:

Table 2 Results of flood hazard (H).

Variable	w_i	P1	P2	P3	P4	P5	P6	P7
H1	0.10	0.60	0.60	0.00	0.00	0.00	0.78	0.00
H2	0.60	0.20	0.18	0.00	0.00	0.00	0.19	0.00
H3	0.30	0.25	0.19	0.00	0.00	0.00	0.22	0.00
H		0.26	0.22	0.00	0.00	0.00	0.26	0.00

Variable	w_i	P8	P9	P10	P11	P12	P13	P14
H1	0.10	0.00	0.00	0.69	0.00	0.00	0.51	0.55
H2	0.60	0.00	0.00	0.15	0.00	0.00	0.10	0.24
H3	0.30	0.00	0.00	0.08	0.00	0.00	0.17	0.36
H		0.00	0.00	0.18	0.00	0.00	0.16	0.31

w_i = weight; P1 = ward 1.

Table 3 Results of flood exposure (E).

Variable	w_i	P1	P2	P3	P4	P5	P6	P7
E.1	0.18	0.50	0.46	0.51	0.72	0.76	0.59	0.36
E.2	0.19	0.35	0.27	0.29	0.37	0.42	0.45	0.42
E.3	0.36	0.71	0.71	0.71	0.66	0.67	0.69	0.74
E.4	0.17	0.07	0.80	0.06	0.29	0.07	0.27	0.06
E.5	0.05	0.11	0.21	0.00	0.00	0.00	0.19	0.00
E.6	0.05	0.40	0.46	0.52	0.40	0.44	0.42	0.48
E		0.45	0.56	0.44	0.51	0.49	0.52	0.44

Variable	w_i	P8	P9	P10	P11	P12	P13	P14
E.1	0.18	0.70	0.55	0.17	0.33	0.45	0.36	0.62
E.2	0.19	0.70	0.36	0.65	0.75	0.80	0.75	0.65
E.3	0.36	0.66	0.69	0.70	0.70	0.69	0.72	0.67
E.4	0.17	0.08	0.10	0.25	0.23	0.30	0.40	0.10
E.5	0.05	0.70	0.55	0.17	0.33	0.45	0.36	0.62
E.6	0.05	0.70	0.36	0.65	0.75	0.80	0.75	0.65
E		0.54	0.46	0.49	0.52	0.55	0.59	0.53

w_i = weight; P1 = ward 1.

Table 4 Results of flood social sensitivity (S_{so}).

Variable	w_i	P1	P2	P3	P4	P5	P6	P7
S_{so} 1	0.59	0.38	0.30	0.29	0.39	0.47	0.42	0.38
S_{so} 2	0.29	0.53	0.54	0.52	0.52	0.51	0.53	0.52
S_{so} 3	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S_{so}		0.38	0.33	0.33	0.38	0.42	0.40	0.38

Variable	w_i	P8	P9	P10	P11	P12	P13	P14
S_{so} 1	0.59	0.76	0.38	0.64	0.74	0.80	0.72	0.69
S_{so} 2	0.29	0.53	0.52	0.52	0.53	0.52	0.52	0.53
S_{so} 3	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S_{so}		0.60	0.38	0.53	0.59	0.62	0.58	0.56

w_i = weight; P1 = ward 1.

+ Economical sensitivity (S_{ec})

The results of economical sensitivity (S_{ec}) for each ward are shown in Table 5.

The results of environmental sensitivity (S_{en}) for each ward are shown in Table 6.

The results of sensitivity (S) for each ward are shown in Table 7.

(4) Adaptability (A)

+ Government aspect (A_{Go}):

The results of Government aspect (A_{Go}) of Adaptability for each ward are shown in Table 8.

The results of resident aspect (A_{re}) of Adaptability for each ward are shown in Table 9.

The results of adaptability (A) for each ward are shown in Table 10.

(5) FVI (Flood Vulnerability Index)

From the results of H (Table 2), E (Table 3), S (Table 7) and A (Table 10), the formula (Eq. (3)) is used to calculate the vulnerability index due to flooding in District 6 of HCM City as shown in Table 11 and Fig. 3.

The results of the flood vulnerability index in District 6 of HCMC show that:

According to hazard criteria and results of data collected from the Flood Control Center in District 6, there are inundated wards of 1, 2, 6, 10, 13, 14 with lowest depth in ward 13 of 0.1 m and the remaining wards reach the threshold of 0.2 m. Ward 14 has a longest flooded time with 128 minutes and Ward 10 has the shortest flooded time with 30 minutes, The flooded time of remaining wards ranges from 60 minutes to 90 minutes. Flooded wards will be damaged more than others wards.

According to the values of the exposure in District 6, these wards, such as 2, 4, 6, 8, 11, 12, 13, 14 have a value of exposure over 0.5, in which, Ward 11, 13 and 14 are the most vulnerable areas because the number of business establishments as well as population is higher than that of other Wards. Particularly, Ward 14 has the largest population with 28,777 people and Ward 11 and Ward 13 with a population of nearly 27,000 people. Generally, wards with large populations, large factory facilities and frequently flooded roads have higher exposure levels.

Table 5 Results of flood economical sensitivity (S_{ec}).

Variable	w_i	P1	P2	P3	P4	P5	P6	P7
S_{ec} 1	0.59	1.00	0.89	0.83	0.86	0.87	0.79	0.83
S_{ec} 2	0.29	0.42	0.58	0.50	0.60	0.42	0.58	0.44
S_{ec} 3	0.11	0.34	0.36	0.38	0.36	0.38	0.44	0.36
Ss		*0.75*	*0.73*	*0.68*	*0.72*	*0.68*	*0.68*	*0.65*

Variable	w_i	P8	P9	P10	P11	P12	P13	P14
S_{ec} 1	0.59	0.83	0.85	0.86	0.88	0.91	0.82	0.75
S_{ec} 2	0.29	0.52	0.50	0.48	0.40	0.40	0.50	0.56
S_{ec} 3	0.11	0.34	0.38	0.36	0.32	0.34	0.40	0.38
S_{ec}		0.68	0.69	0.69	0.67	0.69	0.67	0.65

w_i = weight; P1 = ward 1.

+ Environmental sensitivity (S_{en}):

Table 6 Results of flood environmental sensitivity (S_{en}).

Variable	w_i	P1	P2	P3	P4	P5	P6	P7
S_{en} 1	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S_{en} 2	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S_{en} 3	0.23	0.42	0.42	0.46	0.48	0.42	0.42	0.50
S_{en} 4	0.22	0.22	0.22	0.22	0.20	0.20	0.22	0.20
S_{en} 5	0.33	0.22	0.22	0.22	0.20	0.20	0.22	0.20
S_{en}		0.22	0.22	0.23	0.22	0.21	0.22	0.23

Variable	w_i	P8	P9	P10	P11	P12	P13	P14
S_{en} 1	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S_{en} 2	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S_{en} 3	0.23	0.52	0.48	0.54	0.44	0.42	0.54	0.52
S_{en} 4	0.22	0.22	0.22	0.22	0.26	0.24	0.22	0.20
S_{en} 5	0.33	0.22	0.22	0.22	0.26	0.24	0.22	0.20
S_{en}		0.24	0.23	0.25	0.24	0.23	0.25	0.23

w_i = weight; P1 = ward 1.

+ Sensitivity (S):

Table 7 Results of flood sensitivity (S).

Variable	w_i	P1	P2	P3	P4	P5	P6	P7
S_{so}	0.62	0.38	0.33	0.33	0.38	0.42	0.40	0.38
S_{ec}	0.26	0.75	0.73	0.68	0.72	0.68	0.68	0.65
S_{en}	0.12	0.22	0.22	0.23	0.22	0.21	0.22	0.23
S		0.45	0.42	0.40	0.45	0.46	0.45	0.43

Variable	w_i	P8	P9	P10	P11	P12	P13	P14
S_{so}	0.62	0.38	0.53	0.59	0.62	0.58	0.56	0.60
S_{ec}	0.26	0.68	0.69	0.69	0.67	0.69	0.67	0.65
S_{en}	0.12	0.24	0.23	0.25	0.24	0.23	0.25	0.23
S		0.58	0.44	0.54	0.57	0.59	0.56	0.54

w_i = weight; P1 = ward 1.

Table 8 Results of flood adaptability—government aspect (A_{Go}).

Variable	w_i	P1	P2	P3	P4	P5	P6	P7
A_{Go} 1	0.18	0.40	0.40	0.40	0.40	0.40	0.40	0.40
A_{Go} 2	0.18	0.20	0.20	0.20	0.20	0.20	0.20	0.20
A_{Go} 3	0.31	0.40	0.40	0.20	0.20	0.20	0.40	0.20
A_{Go} 4	0.33	0.40	0.40	0.50	0.46	0.38	0.42	0.48
A_{Go} 5	0.06	0.20	0.20	0.20	0.20	0.20	0.20	0.20
A_{Go}		0.38	0.38	0.35	0.33	0.31	0.38	0.34

Variable	w_i	P8	P9	P10	P11	P12	P13	P14
A_{Go} 1	0.18	0.40	0.40	0.40	0.40	0.40	0.40	0.40
A_{Go} 2	0.18	0.20	0.20	0.20	0.20	0.20	0.20	0.20
A_{Go} 3	0.31	0.20	0.20	0.80	0.20	0.20	0.40	0.40
A_{Go} 4	0.33	0.52	0.50	0.50	0.44	0.42	0.44	0.52
A_{Go} 5	0.06	0.20	0.20	0.20	0.20	0.20	0.20	0.20
A_{Go}		0.35	0.35	0.53	0.33	0.32	0.39	0.42

w_i = weight; P1 = ward 1.

+ Resident aspect (A_{re}):

Table 9 Results of flood adaptability—resident aspect (A_{re}).

Variable	w_i	P1	P2	P3	P4	P5	P6	P7
A_{Re} 1	0.45	0.54	0.50	0.50	0.48	0.48	0.54	0.52
A_{Re} 2	0.28	0.72	0.70	0.74	0.78	0.76	0.74	0.78
A_{Re} 3	0.19	0.72	0.70	0.74	0.78	0.76	0.74	0.78
A_{Re} 4	0.08	0.60	0.60	0.60	0.60	0.60	0.60	0.60
A_{Re}		0.63	0.60	0.62	0.63	0.62	0.64	0.65

Variable	w_i	P8	P9	P10	P11	P12	P13	P14
A_{Re} 1	0.45	0.66	0.62	0.44	0.44	0.48	0.44	0.40
A_{Re} 2	0.28	0.78	0.74	0.76	0.74	0.76	0.74	0.70
A_{Re} 3	0.19	0.78	0.74	0.76	0.74	0.76	0.74	0.70
A_{Re} 4	0.08	0.60	0.60	0.60	0.60	0.60	0.60	0.60
A_{Re}		0.71	0.67	0.60	0.59	0.62	0.59	0.56

w_i = e = weight; P1 = ward 1.

+ Adaptability (A):

Table 10 Results of flood Adaptability (A).

Variable	w_i	P1	P2	P3	P4	P5	P6	P7
A_{Go}	0.50	0.38	0.38	0.35	0.33	0.31	0.38	0.34
A_{Re}	0.50	0.63	0.60	0.62	0.63	0.62	0.64	0.65
A		0.50	0.49	0.48	0.48	0.46	0.51	0.49

Variable	w_i	P8	P9	P10	P11	P12	P13	P14
A_{Go}	0.50	0.35	0.35	0.53	0.33	0.32	0.39	0.42
A_{Re}	0.50	0.71	0.67	0.60	0.59	0.62	0.59	0.56
A		0.53	0.51	0.57	0.46	0.47	0.49	0.49

w_i = weight; P1 = ward 1.

Table 11 Results of FVI (Flood Vulnerability Index).

Variable	w_i	P1	P2	P3	P4	P5	P6	P7
H	0.50	0.26	0.22	0.00	0.00	0.00	0.26	0.00
E	0.23	0.45	0.56	0.44	0.51	0.49	0.52	0.44
S	0.19	0.45	0.42	0.40	0.45	0.46	0.45	0.43
A	0.08	0.50	0.49	0.48	0.48	0.46	0.51	0.49
VFI		0.36	0.36	0.22	0.24	0.24	0.37	0.22

Variable	w_i	P8	P9	P10	P11	P12	P13	P14
H	0.50	0.00	0.00	0.18	0.00	0.00	0.16	0.31
E	0.23	0.54	0.46	0.49	0.52	0.55	0.59	0.53
S	0.19	0.58	0.44	0.54	0.57	0.59	0.56	0.54
A	0.08	0.53	0.51	0.57	0.46	0.47	0.49	0.49
VFI		0.28	0.23	0.35	0.26	0.28	0.36	0.42

w_i = weight; P1 = ward 1.

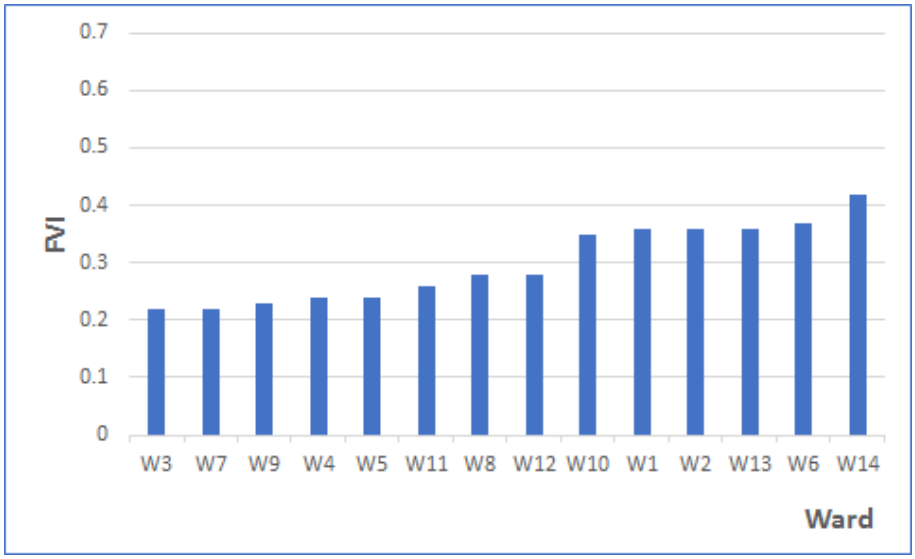

Fig. 3 Chart of FVI in District 6, HCM City.

Based on the values of the sensitivity in District 6, the wards which have the sensitivity greater than 0.5 are wards of 8, 10, 11, 12, 13 and 14. According to data collected from the statistical yearbook, the number of people in the working age of wards 11, 12, 13 and 14 is higher than that of other wards.

As for the adaptability, the higher adaptive capacity of wards is, the lower damage is. According to the calculated values, wards of 2, 3, 4, 5, 11, 12, 13 and 14 have low adaptability, so the damage will be higher than other wards.

The highest FVI (Flood Vulnerability Index) reached 0.452. The smallest value was 0.288 and the mean value was 0.390.

In general, in District 6, there were 4 wards with high vulnerability, including wards of 2, 6, 13 and 14 and the remaining wards had average vulnerability.

4. Conclusion

Based on the natural conditions, socio-economic characteristics and impact level of urban flooding in HCM City (Vietnam), the study identified a set of criteria for assessing vulnerability to urban flooding on socio-economic and environmental aspects.

The set of criteria includes the hazard (H), exposure (E), sensitivity (S) and adaptability (A). There are 29 variables belonging to 4 criteria. The variables and

criteria are basically suitable for urban flooding as HCMC.

Results for District 6 which is the typical flood level in HCMC show that there are 4 wards with high vulnerability, the vulnerability index is greater than 0.4, including wards of 2, 6, 13 and 14 and the remaining wards have average vulnerability.

Based on the assessment of the flood vulnerability, measures will be proposed for each indicator or criterion to minimize this risk. The proposed results will be presented in further studies.

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