Rehabilitation of abandoned public quarries in Greece - A methodological approach

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Abstract: Abandoned quarries, usually located near to urban districts is the heritage of extensive excavation activities of the past decades, since today's quarrying is based on a long term plan in Greece. Rehabilitation of such old abandoned quarries is a basic need for environmental and safety reasons.

The aim of the present study is to provide a methodological tool for use by the local administration authorities, at any level, to enable them to select the most appropriate solution for rehabilitation of abandoned quarries located in their territory, taking into account environmental, social and economic criteria based on their priorities and their economic and technical potential.

Representative study areas with extensive quarrying activities during the past 50 years are located in eastern Macedonia (Drama), western Macedonia (Kozani), Peloponnese (Patra), Epirus (Ioannina) and Attica (broad area of Athens).

A database including all quarry features and necessary factors influencing the rehabilitation of abandoned quarries in the above areas was made. In parallel, an integrated assessment study of the conventional and innovative methods for the rehabilitation of the abandoned quarry sites, the relevant environmental confinements and techno-economic preconditions is being performed.

The study resulted in the publication of a guide for use by the local authorities for the optimal use of quarry sites in suburban districts based on the methodology of multi-criteria analysis of abandoned quarries rehabilitation.

Résumé: Des carrières abandonnées, habituellement aux environs des villes, sont l'héritage d'une exploitation intense pendant les dernières décennies, tandis que l'exploitation actuelle en Grèce est basée à un plan de longue durée. La réhabilitation de quelques-unes de ces anciennes carrières abandonnées, c'est une nécessité pour de raisons de protection de l'environnement et de sécurité.

Objectif de cette étude est l'approvisionnement d'une méthodologie convenable, enfin que les autorités locales puissent choisir les meilleures solutions pour la réhabilitation des carrières abandonnées qui se trouvent dans leur territoire, avec critères de protection de l'environnement, sociales et économiques. Ces critères seront basés aux priorités et aux possibilités économiques et techniques des autorités locales.

Régions, avec intense activité à carrière pendant les dernières cinquante années, représentatives enfin d'exécuter de la recherche, il y en a en Macédoine Oriental (Drama) et Occidental (Kozani), au Péloponnèse (Patras), en Epire (Ioannina) et en Attique (à l'environ d'Athènes).

Une base de données, avec toutes les caractéristiques des carrières et les facteurs nécessaires qui influencent sur la réhabilitation d'anciennes carrières abandonnées dans les régions déjà mentionnées, sera créée. Parallèlement, une étude complète avec les méthodes conventionnelles et innovatives qui sont utilisées à la réhabilitation des carrières abandonnées, les restrictions relatives à l'environnement et les conditions technico-économiques, est préparée.

Les résultats de la recherche à la publication d'un guide à l'usage des autorités locaux, pour la meilleure utilisation des sites de carrière qui se trouvent aux environs de villes, basée à une méthodologie d'analyse de données multiples, concernantes la réhabilitation de carrières abandonnées.

Keywords: quarries, environmental impact, regional planning, remediation, protection

INTRODUCTION

In Greece, because of the abundance of decorative rocks and aggregates, intense quarrying activity was developed from antiquity to the present. The traces of this activity have been imprinted in the natural environment and have degraded its characteristics. The historical value of ancient quarries requires their maintenance but the environmental problems that were created by the operation of modern quarries need to be solved in the best possible way.

After World War II, the need of utilisation of enormous quantities of aggregate arose, due to the intense growth of large urban centres and infrastructure works. This need, along with the lack of environmental sensitization and the absence of a strict legal framework, led to the uncontrollable operation of many quarries, which, for reasons of economy with regard to transport, were opened very close to the cities. The continuous expansion of the city fabric in many cases 'encaged' the old quarries in the urban environment, where they were then abandoned and no measures were taken for their rehabilitation.

Thus, in many cities and towns, the abandoned quarries create numerous and complex problems. Apart from the visual impact, many of them constitute focal points of severe chemical pollution since they operate as uncontrolled waste dumps, while they also present increased safety hazards, given that the access in them is generally free.

The above mentioned problems as well as the lack of free spaces and the considerable increase of the land value, both in the region of Athens and the smaller urban centres, created the need of exploitation of these spaces for public use. In certain cases abandoned quarries have been transformed to communal facilities for sports, recreation and cultural events. As a general rule, the rehabilitation of quarry areas was carried out in a rather haphazard way, without being included in the general urban planning for the most optimal use of these spaces. The exploitation of old quarries is a multidisciplinary problem, since, beyond the obliteration of the problem and the assessment of needs to be covered in the neighbouring communities, consideration should be taken of environmental, legal, technical and economic factors.

The present work aims at the elaboration of a methodological tool for the Local Authorities, at any level, for the most adequate exploitation of abandoned quarrying places, using not only environmental criteria but also economic ones, based on the priorities and the possibilities (economic and technical) of each legal entity.

REGIONS OF STUDY –METHODOLOGY OF RESEARCH

In Greece, there is no systematic recording of the quarrying activity at central level. For the granting of operating concessions a number of public authorities are involved (Prefectures, Mining Inspectorate Agencies, Departments of Industry and Mineral Wealth of the Regional Administration), varying according to the ownership status of the land (public or private) and the commodity produced (marble, aggregates etc.)

The active quarrying activity is filed at the Prefectures, while the abandoned quarries, especially if they are more than a decade old, are often of 'unknown identity,' that is to say it is almost impossible to find concrete elements for the period of operation, the exploiter or their property arrangement.

According to the results of a study on the sector of marble, in 2000, about 300 - 350 quarries of marble were operating, located mainly in the regions of Attica, Drama, Kavala, Thassos, Argolida, Arkadia, Lakonia, Korinthia, Kozani, Veria, Imathia, Ioannina, Larissa and Volos. The number of aggregate quarries is much larger and more or less is dispersed all over Greece. A lot of quarries are found under a regime of provisional operation (extension of operation, service of projects of national importance). In total, the abandoned quarries outnumber the active ones, however, modern excavations occupy generally a much larger area, due to the use of powerful excavating machinery and modern production organization.

This pilot study is realised in selected representative regions of Greece having a history of quarrying activity. Specifically, the prefectures of Attica, Achaia, Ioannina, Drama and Kozani have been examined (Figure 1).

SURVEY OF ABANDONED QUARRIES - CREATION OF A DATA BASE

In the selected regions, with the collaboration of Prefectures and local Municipalities, a survey of abandoned public quarries was carried out, particularly of those found within a radius of 0-10 km around the large urban centres of the selected Prefectures, so that as many as possible alternative solutions could be examined. In the framework of this study a questionnaire was drawn up with elements such as the geographic site, the area, access and the orientation of each quarry, its morphology, as well as data on the ground, the climate, the fauna and flora of the region. Furthermore, topographic imprinting of quarries was also carried out and recording of geological, mineral, hydrogeological, hydrological, geotechnical and ground characteristics. Land use in the direct and wider environment of the quarry was also recorded, as well as the population (size, economic activity etc) and the lack (deficiency) of communal facilities. In quarries, where large quantities of waste have been dumped, laboratory control is implemented aiming to determine the degree of water or other pollution incurred. Those elements are recorded in a database and are processed by the use of Geographic Information Systems.

HELLENIC AND INTERNATIONAL EXPERIENCE

Hellenic and international experience on modern alternative rehabilitation and utilization methods of abandoned quarries, classified per category of use (plantation, recreation areas, exploitation of remaining products and by-products at the quarry site, etc) are taken into consideration in parallel with the survey. At the same time, the natural, environmental and economic-technical conditions of each application and the legal bounds are also examined

The abandoned quarries image at the above mentioned five pilot areas is as follows:

Prefecture of Attica

The ancient quarries of Penteliko marble were mainly located at the SW sides of Penteliko mountain in the valley of Cave. It is reported that there existed 25 quarries from where more than 400 000 m^3 of marble have been excavated. Most traces of the ancient works have been eliminated due to recent excavation and only one ancient quarry is maintained today relatively well, at the Cave valley at an altitude of about 700 m. Apart from the marble quarries, numerous aggregate quarries have been developed in the region of the capital and its suburbs. Old aggregate quarries, consisting of carbonate rocks, are dispersed all over the foothills of Hymettus, Penteli, Parnitha and Aigaleo mountains surrounding the city of Athens as well as at the internal hills (Lycavittos, Tourkovounia, Filopappou). In total, 87 abandoned quarries were recorded at the wider area of the Athens plateau. Many of them are located in adjacent sites of the same region. These quarries were abandoned for at least 30 years, since, after 1976, the operation of all quarries located in the plateau side and were visible from populated areas was prohibited.

The strong building activity developed in the Athens plateau during the last 50 years, the continuous expansions of the city plan, resulted in the lack of communal recreation and athletic facilities. This deficiency, combined with the aesthetic degradation and the safety problems arising in the vicinity of abandoned quarries, led the local authorities to the search for exploitation solutions. Thus, an important number of inert quarries has been restored and attributed to the citizens for use either as places of recreation, sports and culture, or, in other cases, the old relief has been restored and forested. (Figure 2). The inert quarries of Penteli constitute a specific case, due to their archaeological and aesthetic value. The distant quarries of Koropi, Keratea and Grammatiko, are waste disposal areas.

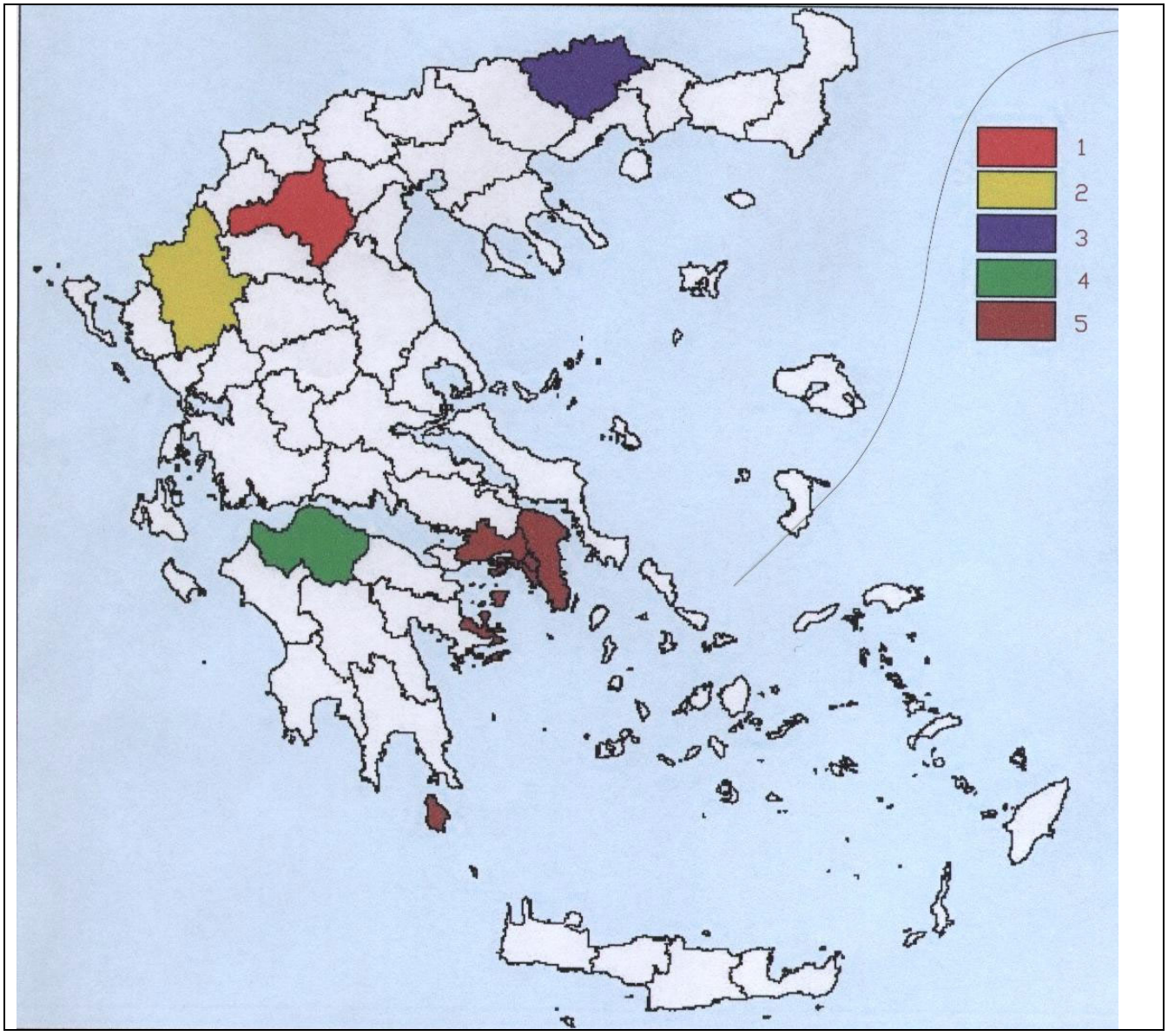

Figure 1. Pilot Project implementation areas 1) Kozani 2) Ioannina, 3) Drama, 4) Ahaia and 5) Attika

Certain quarries are in the stage of study by various public institutions aiming at their reformation, while those located in the periphery of the plateau become disposal centres for building material waste, aiming at the re-establishment of the natural relief and reforestation. The relative authorisation for deposition of materials was given by the authorities immediately after the earthquake of 1999 in Athens, which was followed by a lot of demolition of residences because of serious damages and, consequently, places for debris deposition were needed urgently.

Practically, therefore, most of the inert quarries of Athens are restored in some way, but this does not mean that the most rational solution was selected. In the frame of investigation of alternative solutions of rehabilitation, we point out the problems that arise from the particular applications.

The modern quarrying activity is developed today mainly in delimited quarrying zones, westwards of the Athens plateau, in the region of Xiroremma. A special category of quarries are those that continue their operation under the pretext of environmental restoration, or temporary extensions of permits, as the enormous quarry "Merenta" in the Municipality of Markopoulo, westwards of the airport El. Venizelos.

Prefecture of Achaia

Out of a total of 22 abandoned quarries that were registered in the prefecture of Achaia, 20 are aggregate quarries, one is a marble quarry and one a clay quarry. Their dimensions are widely ranging as well as the environmental problems that were created by their operation and their later use. Two of the bigger quarries of the prefecture that belong to the municipality of Messatida are found at a distance of about 5 km from the city of Patra, an intensely developing region. They are visible from Patra and the adjacent region and from the national road of Patra – Pyrgos.

Another big quarry of aggregate material is located in the site "Valvousi" a small distance from Kalavryta, on the road towards the ski centre of Helmos.

Two abandoned quarries that create intense visual disturbance, are located in the region of Araxos, where, in close vicinity, the most important quarries of aggregate materials of Achaia prefecture continue functioning; suspension of their operation has already been issued, since the neighbouring region has been declared protected (NATURA zone), but has not yet been in power. None of those quarries has been restored in any way, while five small quarries that were abandoned some 20-30 years ago, have been covered by natural vegetation and do not create particular aesthetic or other types of problem. Taking into account that these quarries are located away from populated regions, in forest areas that are also protected (NATURA zone), it can be considered that they have been reverted to the natural environment and are not the subject of further examination.

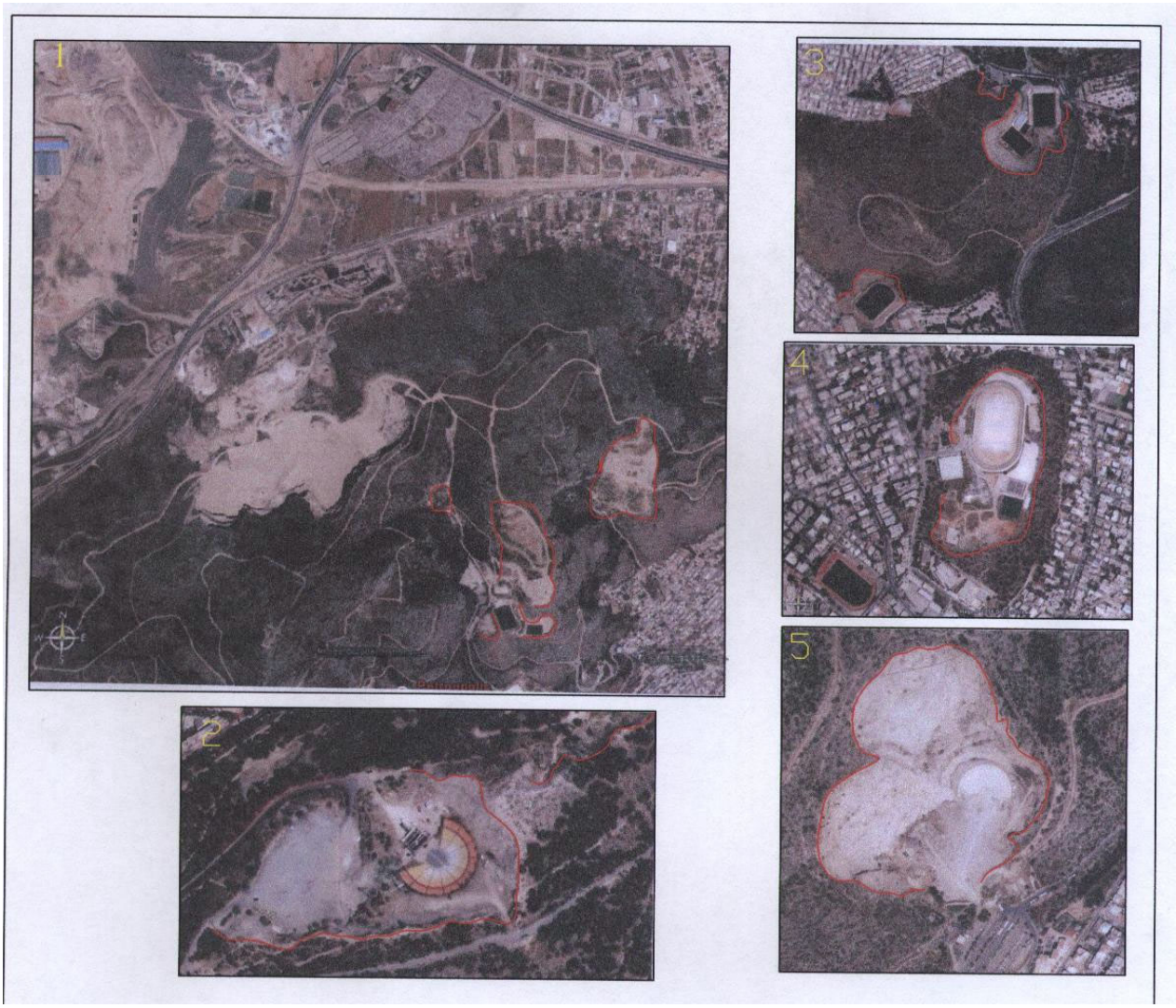

Figure 2. Examples of rehabilitated quarries within the city of Athens: 1. North Aigaleo Partly rehabilitated quarries sided to Athens city, 2) Lykabetous (Open theater), 2) Kaissariani (sport centre), 3) Holargos (sport centre), 5) Petroupoli (theatre).

Prefecture of Ioannina

In the prefecture of Ioannina intense quarrying activity has been developed both in the sector of decorative rocks (marbles of Ioannina) and aggregate materials. Numerous abandoned but also active quarries are located in many sites of the prefecture. In the present study the quarries found in an area about 10 km from the city of Ioannina are examined as a priority. Ioannina is one of the larger urban centres of Greece. In this zone, 34 quarries have been recorded, mainly of aggregate materials, which served the needs of development for Ioannina city and its road network. There are very few active quarries in the same region, under the regime of temporary operation.

Prefecture of Drama

For many decades, the quarrying activity in the prefecture of Drama constituted the main employment of a high percentage of the local population. Excavation of marble volumes was carried out by small family enterprises. More than 200 such quarries are located in the mountain “Falakro”, northward of Drama. The volume of excavations varies from a few cubic metres up to hundreds of cubic metres. Most of the small quarries of marble that were abandoned 30- 40 years ago, have been reverted harmoniously to the environment, after having been covered, totally or partially, by bushy vegetation, while the chromatic contrast of artificial slopes has been noticeably decreased. Apart from the quarries of marble, there are five big abandoned quarries of aggregate materials in the hill "Korylovo", that is located in the northern end of the city of Drama. These quarries because of their volume and their closeness to the city of Drama, create problems of optical pollution, dangers of pollutions due to uncontrollable deposition of wastes, but also of safety because of the free access of citizens. The rehabilitation of these specific quarries has to be immediately encountered by the local society and the institutions of the city.

Currently, the quarrying activity is continued by a few marble companies, at a distance over the 15 km from the city of Drama, while for the production of aggregate materials a quarrying zone has been delimited in the east of the prefecture. The operation of big enterprises for the treatment of local marble in the industrial area of Drama, has created a big environmental problem, because of the accumulation of thousands of tones of waste from the treatment. The possibility of industrial use of this material should be also investigated and, in case of negative results, the possibility should be examined of transport and deposition of the material in the abandoned quarries of Drama.

Prefecture of Kozani

The prefecture of Kozani constitutes one of the main quarrying and mining centres of Greece, with particularly increased environmental impacts. Quarries of white marble are functioning, located mainly in the region of Tranovaltos (25 km south of Kozani city). The excavation in this site began in 1954 at a public territory and in total 16 quarries functioned, seven of them have been abandoned, without any rehabilitation measures. The intense aesthetic alteration of the landscape is intensified by the accumulation of barren materials of excavation, the volume of which is multiple of the marble blocks production. There are also numerous quarries of aggregate materials, that occur individually or assembled in the carbonate rocks of the mountainous volumes of the prefecture, while some of them are encaged in the fabric of the city. It has to be noted that, in the prefecture of Kozani and specifically in the basin of Ptolemaida, the biggest lignite quarries of Greece are functioning mainly open pit excavation. The rehabilitation of these specific mines is the responsibility of the Public Power Corportion S.A. Also, in the region, the abandoned mine of asbestos of Zintanion is located, the open excavation of which remains still in the form that had at the shut-down of its operation, while partial restoration with tree planting has taken place along the extensive piles of the processing deposits. Finally, in the region of Vourino mountain, westwards of Kozani, are located many surface excavations of chromite, since in this region the bigger mines of chromite in Greece operated up to 1990. Additional environmental alteration resulted from the opening up of the main road axis of Egnatia, that crosses the prefecture of Kozani in E-W direction, about 3 km north of the capital of the prefecture. The axis in question is one of the bigger infrastructure projects at national but also international level and contributes considerably to the local economy. However, in its major part inside the prefecture, it crosses the mountainous rocky relief and created very high slopes, that often exceed those of the quarries.

In this frame that has been previously described, sporadic restoration of some abandoned quarries is not effective in altering noticeably the whole situation. With the methodology that is being elaborated, in close collaboration with the local authorities, we believe that it can be achieved a noteworthy improvement of the environment, especially in the vicinity of cities and towns. A systematic survey of the inert quarries around the city of Kozani is being carried out. Two of them, lying at the edge of the residential zone, have been rehabilitated by the Municipality of Kozani, the first as an open theatre and the second as a waste transhipment station and garage for municipal waste trucks.

ELABORATION AND APPLICATION OF SELECTION CRITERIA FOR QUARRY REHABILITATION

The application of old or most up to date, rehabilitation solutions for the above quarrying sites, is not possible to be carried out simultaneously for all the quarries for obvious reasons. It is therefore needed to establish criteria, according to which a priority list will be established for the selection of the most adequate quarry sites for rehabilitation.

The application of criteria with determined factors of gravity, can set the quarries of a district in order of precedence and consequently lead to the rational planning of feasible solutions of rehabilitation.

Such criteria for a priority list of inert quarry sites for restoration/ rehabilitation, at a prefecture level, could be the following:

1. The intensity of the pollution problem
    a. Water table pollution
    b. Health hazard
    c. Safety hazard
    d. Visual disturbance
2. The possibility of stockpile exploitation of products, byproducts or residues from the operating phase of the quarry
3. The adequacy of the quarry site for communal facilities
    a. Deficiencies of the neighbouring settlements in communal facilities (recreation places, sports or cultural, parking lots for trucks and large vehicles, waste transportation stations, cemeteries etc.)
    b. the specific characteristics of the quarry site (area/volume, distance, accessibility, visibility etc.)

Following this stage, for each selected quarry site, set in order of precedence, the feasibility and the efficiency of each alternative rehabilitation solution should be examined.

The characteristics that are examined, in general, for the selection of the most adequate solution are listed in Table 1, which, of course, are widely differentiated according to the uses of the site that are being examined.

Table 1. Criteria of quarry selection for rehabilitation

Quarry site characteristics	Dimensions Morphology Health and safety hazards
Distance from the civic centre	
Distance from the basic infrastructure networks	Rural Water supply Electricity
Visual disturbance	Visibility from main roads Visibility from residential areas
Other environmental impacts	
Land uses in the surroundings	Zone of residence Cultivation district Forest Special environmental protection
Regional development plan	

DEVELOPMENT OF A METHODOLOGY FOR THE SELECTION OF THE OPTIMAL SOLUTION

This stage of the study concludes in the methodology for the selection of the optimal solution or combination of solutions, based on the socioeconomic priorities and the potential of the district with the application of multi-criteria analysis. The basic criteria that are taken into account are summarized in Table 2.

Table 2. Selection criteria for the optimal rehabilitation solution

1.	Local/ peripheral needs
2.	Requirements of each solution in space and infrastructure
3.	Investment cost/economic limitations of the operator
4.	Technical requirements/ capabilities
5.	Environmental impacts
6.	Legal framework/ limitations
7.	Possibility of combination of different solutions
8.	Compatibility with the development plan of the district
9.	Operating cost/ Maintenance cost

CONCLUSIONS

The study, up to now, in the above mentioned five prefectures has concluded in the following:

1. A great number of abandoned quarries (aggregates, decorative rocks and industrial minerals) are located, more or less, all over the country. Some renters continue their suspended operation under the pretext of site restoration. Other quarries have been left in the restoration capabilities of the nature. Quite a few have been used as uncontrolled waste dumps, thus becoming a major focal point for severe environmental pollution.
    a) During the last 30 years it appears that there is a growing interest in the restoration of the abandoned quarries by the local authorities as well as the rational organisation of the quarrying activity. It became at last common belief that the operation of a quarry has severe impact on the natural environment and can damage the environmental equilibrium (natural relief, water resources, ground, flora and fauna). Now the legislation for the exploitation of quarries is taking into account the

protection of the natural environment and is becoming more and more strict all over Europe, with more environmental limitations for the quarrying activity. Today for the European administration authorities the environmental protection is of greater importance than the economic results from a quarry operation.

2. The gradual restoration/ exploitation of abandoned quarry sites with local intervention can contribute to the amelioration of the environmental quality in and around the cities and towns and can be included in the regional development planning.
3. The image of left quarry excavations reminds us of a recent past of irrational quarry exploitation. Very high and steep slopes, irregular levels are a very common image resulting in safety hazards (rock falls, mass movement). The adverse impact on the environment is obvious, while the problem is enlarged in the vicinity of large civic centres, in the boundaries of which many aggregate quarries are usually found.
4. Besides the excavation activity, a major aesthetic disturbance of the landscape is caused by the residues of the processing plants, especially the fine materials, as well as during the construction of the road network.
5. The proposed methodology for the selection of the adequate quarry sites and determination of the most suitable rehabilitation solution that this study is dealing with, could become a useful tool for the local administration at any level. The compiled database can go on being enriched with new elements, concluding from the materialization of the proposed solutions.
6. As far as the legal framework for quarry restoration is concerned, a multi-law framework exists and the involvement of too many public authorities, leading finally to a reduced control of the obligatory restoration of the quarry.
7. In parallel with the restoration of the abandoned quarries emphasis should be placed on active quarry activity as follows:
    a) Restructuring of the legislation and in accordance with the contemporary needs. Determination (setting) of a clear, distinct, simple and strict legal framework for the operation and restoration of quarries.
    b) Establishment of an integrated quarry administration scheme responsible for:
        - a) the delimitation of quarry zones based on the long term regional development planning
        - b) elaboration of an exploitation/restoration plan for each quarry zone
    c) Environmental impact study
        - Imposition of a general “environmental levy” as a percentage of the volume of production, which could be reserved and used exclusively for quarry restoration.
        - Employment of skilled personnel. The final responsibility for the restoration should be assigned to the regional administration, that must be staffed with the adequate scientific and technical personnel. They will also be responsible for the exploitation inspection and they will have an advisory role for small quarry enterprises.
        - Elaboration of contemporary exploitation/restoration studies in close cooperation with research institutions in Greece as well as within the E.U. investigation of the feasibility of underground quarrying, especially where it is impossible to delimit a quarry zone without environmental impact.
        - In any case, the final solution must be a compromise between the positive economic results of a quarry operation and the conservation of the ecological equilibrium

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