Evaluation of Environmental and Social Parameters of a Gold-Mining Project at the Prefeasibility Stage: A Case Study

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***Abstract*-The aim of the specific study is to present/evaluate the environmental and social parameters of a gold mining project in its pre-feasibility and permitting stages. The parameters are analysed and evaluated for a pioneered gold-mining project in North-Eastern Greece. Results benchmark the key environmental and social parameters for the next phase of a feasibility study. Although the economic and environmental challenges of the project can be mitigated with the existing framework, the triple bottom line of sustainable mineral resource development requires the amendment of the country's mining act. Such an amendment will take into account the needs of the people in the region to have an effective engagement in the exploitation of mineral resources in the region, based on a negotiated tri-partite mutual agreement of impacts and benefits to company, country and region. The analysis provided in this work is expected to be useful for decision makers, managers and environmentalists related to gold-mining.**

Keywords-Gold-mining; Environmental Performance; Social Assessment; Sustainable Mining; Permitting

I. INTRODUCTION

Mineral project evaluation has always been multifaceted and complex. Currently, most multinational mining corporations operate on a triple bottom line basis (i.e., economic, environmental, social). Nonetheless, it is the case that mining is in a stage of transition, particularly in the developed world, where new or existing projects have to meet strict environmental standards and often encounter social opposition. The environmental sensitivity in first world countries has also increased dramatically over the years. Although an environmental review process is most certainly already established and legislated in a country, it does not often reflect the particular environmental/social concerns of local communities. Improving environmental performance is critical to ensuring that the environment is protected, but that alone does not necessarily ensure the social health and welfare of any associated mining communities [1].

Today the industry is faced with new systemic problems: issued mine permits around the world are often being challenged by local groups; projects can become political and legal liabilities for central governments; and, they can damage the corporate image of the industry after causing turmoil in local communities. A lengthy judicial process often results in a loss of confidence in the overall permitting process and invalidates the assumptions included in initial bankable feasibility studies and the project risk assessment. Sustainable development issues, as these are seen by the region, are often at the centre of a dispute that can make an empowered local community or group in a first world country the strongest stakeholder in a new mineral resource development (either as advocates or opponents). If confrontation becomes the means of conflict resolution, the project can enter a prolonged phase of continuous legal disputes with ambiguous results. Unlike public utility projects with national importance, a mineral resource development can be an issue too controversial for a region to be handled exclusively by a central government. Furthermore, the decentralization of government power within first world countries brings too high a responsibility for a central government to commit to such a project without the concurrence of the people in a region.

These challenges have resulted in a significant realignment of the traditional factors that are used to evaluate the feasibility risk of a mining project. In many cases, the socioeconomic dimension of mineral resource development is not evaluated appropriately at the initial planning stages of a project when key decisions are made, and opportunities to establish a working relationship between the company and the local community can be pursued, that will mark the success or failure of the project. The traditional axis of national government versus capital, upon which the allocation of direct and ripple effects benefits from a mining project was traditionally based, has shifted primarily to a capital versus community axis[2,3,4,5], as shown in Fig. 1.

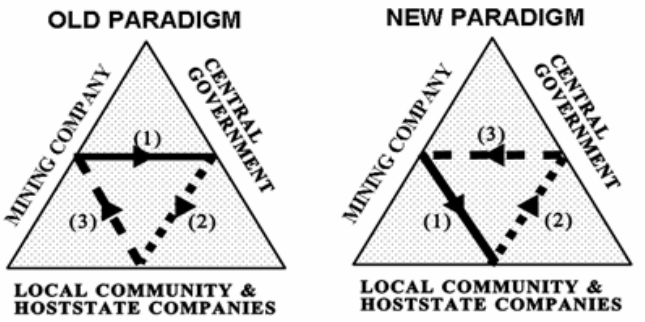

Fig.1 Old and new paradigms for mineral resource development based on tri-partite interaction principles[2]

Specifically the mining of gold has been well known for centuries and nowadays occurs almost everywhere in the world[6]. The history of gold-mining, in particular, is associated with both positive and negative social, political, economic and environmental effects [7]. The supporters of gold-mining sustain that the exploitation of natural resources (mineral, energy, hydrocarbons) strengthens the growth of gross domestic product of a county and the welfare of its citizens. A number of researchers, on the other hand, underpin that gold-mining does not offer any kind of net benefit [8]. During the last few years, gold-mining industries have been trying to operate under the "sustainability" framework, mainly through the adoption of the proposals of the Minerals, Mining and Sustainable Development report [9]. Sustainability notion, with its equally important pillars of environment, economy and society, has been designated as a definite challenge of the twenty-first century and is a fundamental goal of society's economic and social progress [10]. In order to achieve sustainability, new practices were adopted: a) for the protection of the environment, and b) the distribution of benefits to local community and next generations. As a result, a gold-mining operation permit can be obtained nowadays if certain environmental and social aspects are met and assured.

Therefore, mining industries have started to publish, together with their economic valuation report, their environmental sustainability report based on the Global Reporting Initiative [11]. However, the application of sustainable development principles, especially for gold-mining industry, remains problematic [12]. Specific attributes of gold-mining, such as the high ratio of waste per ton of produced gold, the usage of toxic-hazardous reagents and insufficient environmental measures may result in significant degradation of environmental media[12], with indicative environmental problems the deforestation, acid drainage, particulate matter emissions and soil and water pollution [13]. Furthermore, the social performance of a mining project is highly related with dynamic and subjective parameters such as benefit distribution, personal communication, political groups and others.

In large mining projects, the pre-feasibility study is often considered to be the key stage in the project design as it lays the foundation for the project work scope carried forward into the feasibility study. By the time a mining project has progressed to the pre-feasibility study stage, the scope of information collection expands into several parallel efforts including, amongst others, the environmental baseline data collection and determination of possible elements of concern with respect to environmental media and community consultation in order to identify any issues that may impact on the final project design and to gain public support throughout the permitting process.

In 2012 two spatially adjacent gold mining projects, located both in NE Greece and more specifically in the area of Thrace, were entered in their final permitting stage. More concretely, the Preliminary Environmental Impact Studies (PEIS) were approved for the Perama Hill and the Sappes Gold projects on February and July respectively following a 1.5 year evaluation period from the Ministry of Environment. The relevant Environmental Impact Studies were submitted for both projects in order for the final environmental terms to be granted.

Another, world-class gold project besides the two gold projects situated in Thrace, is the Olympias-Skouries Project, located in central Macedonia, Northern, Greece. The specific project has a lengthy 15-year history with ownership regime changes, strong local opposition and cancellation from the state court of the environmental terms granted by the Ministry of Environment through a Joint Ministerial Decision for the construction and operation of a gold mine at Olympias. The terms were cancelled on the grounds that "the weighting of the expected benefit from the project and the anticipated impacts is inadequate and violates the sustainable development principles". All the aforementioned projects were mainly examined from the technical point of view, whereas the opposition of a portion of the local community was attempted to be deviated through the direct contact with the central permitting authorities.

In the next sections, an evaluation of the environmental and social parameters of the Perama Hill gold mining is attempted. The reasons for the social opposition and a different approach to overcome the gridlock are discussed.

II. PROJECT DESCRIPTION

The Perama Hill Gold Project is directed by Thracian Gold Mines, a wholly-owned subsidiary of Eldorado Gold Corporation, a gold mining company based in Vancouver, British, Columbia [14]. The project, currently at the prefeasibility, fast tracking-permitting stage, covers an area of approximately 2,000 Ha in two mining titles and it is located in the region of Thrace in Northeastern, Greece, between the municipalities of Alexandroupoli (45,000 population) and Sappes, as shown in Fig. 2.The predominant character of the areas is rural and the total population of nearby villages is less than 300 inhabitants. The deposit is situation 5 km north of the Aegean Sea and is sparsely vegetated with small oak trees and Mediterranean thorn and scrub bushes. The topography is dominated by a hilly terrain of ridges and moderately steep-sided valleys, with a varying altitude of 25-300 m above sea level, used for occasional goat grazing, as shown in Fig. 3.

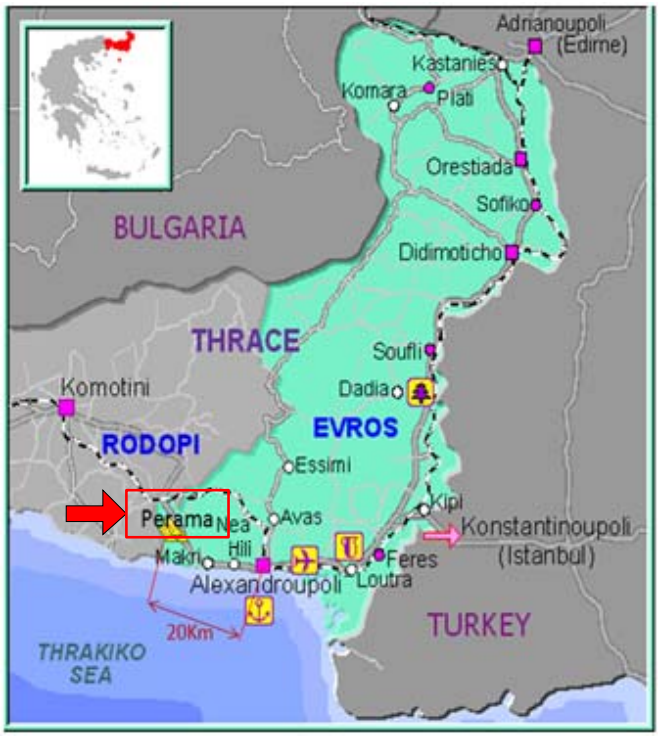

Fig. 2 Location of the Perama Hill Site at the Evros Prefecture of Greece

Fig. 3 Landscape of the Perama Hill area

The climate of the wider project area is characterized as Mediterranean with warm, dry summers and mild winters. The mean annual air temperature is approximately 15°C with the minimum monthly average to appear in January (5°C) and the maximum monthly average in July (26°C). The mean annual rainfall and evaporation is 557 mm and1,660 mm respectively.

The prevailing winds in the area come from the northeast and are of low to moderate intensity (2 to 4 Beaufort) while the percentage of calmness is quite high (~30%).

The fine grained gold-silver mineralization is within a deeply oxidized stratabound sedimentary sulphidation epithermal system, located at the eastern edge of the volcano sedimentary Maronia Graben as shown in Fig. 4, hosted mainly within felsic sandstone with overlying andesitic breccias with the rest of the mineralization associated with breccias and conglomerates.

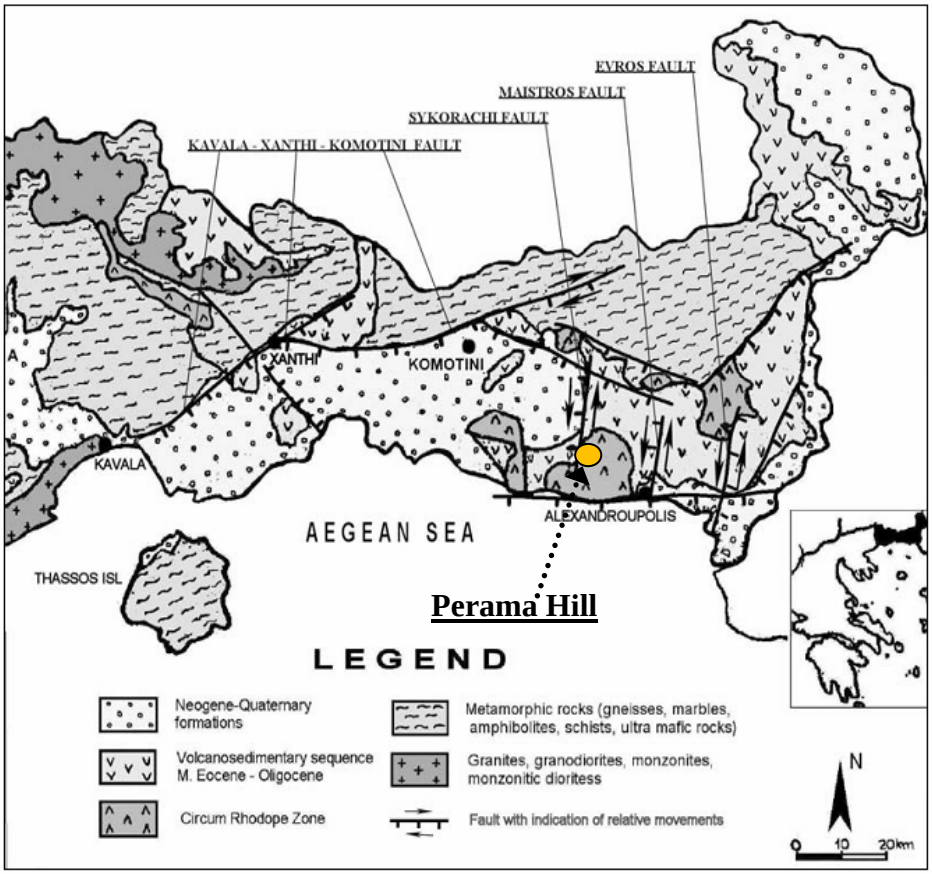

Fig. 4Geological map of the region [15]

The deposit extends 550 m in the north-south direction and up to 300 m in the east-west direction, with a thickness of 15-20 m at the sides and up to 130 m at the centre, as shown in Fig. 5.The orebody is amenable to open pit mining with slopes ranging from 37.5°-32° (east-wall) to 31°-35° (west wall).

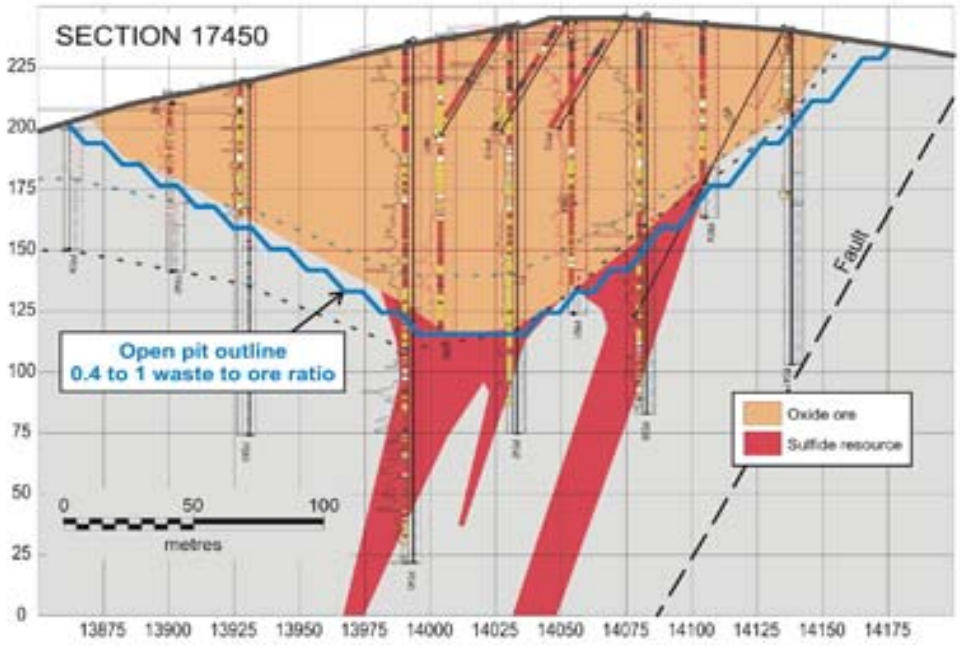

Fig. 5 Section of orebody indicating the planned open pit outline[16]

Approximately 60% of the open pit will be mined out by blasting, 30% by mechanical excavation and 10% by mechanical ripping at a daily rate of 3,400 tonnes for an 8-year period, as shown in Table I.

TABLE I MINERAL RESOURCE AND PROJECT DESCRIPTION

Project characteristic		Value
Mineable resources		9.378 MT @ 3.2 g/t Au, 3.75 g/t Ag
Gold resources		1.36 million ounces Au (0.966 million recoverable)
Metallurgical Recovery		Gold 90%, silver 60%
Average Production	Processing Rate	1.25 MT ore/yr (3,400 tonnes/day)
	Gold	120,000 ounces/yr
Stripping ratio (waste: ore)		0.29:1
Total excavated waste		2.742 MT
Total excavated material (ore & waste)		12.2 MT
Total affected surface area		130 hectares
Project life		1 year construction 8 years gold production 1-5 years rehabilitation and monitoring
Personnel need		182 persons

The standard hydrometallurgical process of the CIL (Carbon in Leach) circuit for non-refractory ore at a rate of 3,400 tonnes/day is followed by the detoxification of the remaining cyanide by the INCO SO_2/air process and the production of Doré metal for the recovery of gold and silver, through an elusion carbon electrowinning system. The steps of the customized process are indicated in Fig. 6.

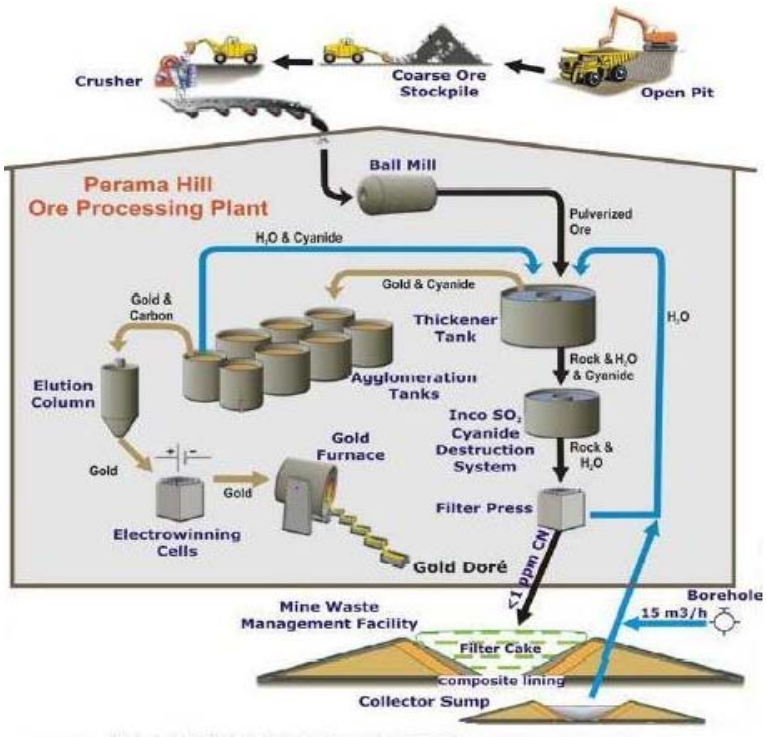

Fig. 6 Material flowchart for the processing of ore in Perama Hill [16]

The process includes:

- Stockpiling, crushing and milling of the ROM (Run of Mine) ore to produce classification with 80% of the particles passing 75μm product size;
- Thickening of the milled ore prior to introduction to the CIL leaching circuit with a total pretention of 20 hours.
- Production of gold Doré from the carbon-gold concentrate of the CIL process;
- Detoxification of the tailings produced from the CIL process from the remaining cyanide by the INCO SO_2/air process, with a target concentration of<1mg/LCN_{WAD}, and final disposal in a lined tailings storage facility.

III. ENVIRONMENTAL PARAMETERS

The evaluation of environmental parameters is essential in triple line evaluation of a mining process and its successful permitting. Based on the description of the project analyzed above, the Perama gold project can be characterized as of small to medium scale and the project lies on a region that is not included in a protection regime either under the European or the country's environmental legislation.

A qualitative assessment of the environmental impact of the major mining activities of the proposed Perama Hill project was carried out, based on the information presented in the Preliminary Environmental Impact Assessment Study (PEIAS)[17], submitted to the Ministry of Environment and the results are summarized in Table II

TABLE II MAJOR MINING ACTIVITIES AND ASSOCIATED IMPACTS TO ENVIRONMENTAL MEDIA

Miningactivity	**Environmental impact to**								
	Atmospheric environment		**Aquatic environment**		**Soil environment**		**Natural environment**		
	Particulate pollutants	Gaseous Pollutants	Surface waters	Ground waters	Soil characteristics	Topo-graphy	Flora/ Fauna	Eco-systems	Bio-diversity
Soil and vegetation removal	+		++	++	+++	+++	++	++	++
Diversion of surface waters			+++	+++	+	++	++	++	++
Disposal of soil (for later use at rehabilitation)			++	++	+++	+++	+	+	+
Disposal of waste rock (permanent)			++	+++	++	++	++	++	+
Disposal of waste rock (for later use)			+	+	+	+	+	+	
Construction of tailings management facilities	++	+	+	+	+	++	+	+	+
Ore and waste rock excavation and removal	++	+	++	++	++	++	+		
Disposal of tailings	++	+	+	++			+		
Transportation activity (ore, waste rock, tailings, etc.)	++	++					+	+	
Emissions from industrial processes (beneficiation, etc.)	+++	+++	++	++			++	+	+
Accidental releases (industrial and/or natural disaster, etc.)	++	+++	+++	+++	+++	+	+++	+++	++
Emissions due to natural causes (wind erosion, etc.)	+++	+	+		+		+	+	+

+ Minor impact ++ Medium impact +++ Serious impact

The issues monitored in mining projects are commonly related with raw material consumption, waste management, energy, water resources and biodiversity [11, 12]. Those issues are specified to parameters and concrete indicators that are calculated and reported into technical documentation [11]. Therefore, in order to compare the project to other gold mining projects globally, specific technical characteristics were calculated and compared with other operating gold mines worldwide[12]. The conclusions of the analysis are summarised as:

- The estimated energy consumption (43 GJ/kg Au or 0.116 GJ/t ore) is significantly lower in comparison with the average of the examined projects (143 GJ/kg Au and 0.311 GJ/t ore).
- The estimated water consumption (100 m3/kg Au or 0.26 m3/t ore) is significantly lower in comparison with the average of the examined projects (691 m3/kg Au and 1.42 m3/t ore).
- The ratio of waste rock to ore tonnage (WR/t ore = 0.29) was significantly lower in comparison with the examined gold projects. The specific indicator is quite important since it expresses one of the core objections of gold mining projects, related with the disproportionate waste/product mass balance.
- The estimated consumption demand of 190 kg CN/kg Au is within the range (80-456 kg CN/kg Au) of the examined projects and higher than the average (141 kg CN/kg Au) due to the distribution of gold particles in the orebody.

The Preliminary Environmental Impact Assessment Study[17]was approved (February 2012) and the final Environmental Impact Assessment (EIA), has been submitted to the permitting authorities. Currently the project is in the process of obtaining the final Environmental Permit License. The PEIAS presents satisfactory the potential impacts from the implementation of the

project at all the environmental media (atmospheric, aquatic, soil and natural environment). The environmental impacts are estimated to be of local scale and are analysed in a satisfactory level. More specifically:

- The project and the existing state of the environment are described adequately in the PEIAS.
- The basic potential sources for the degradation of the environment are listed.
- Measures for environmental protection according to Best Available Techniques (BAT) are proposed such as:

o The dewatering of tailings in order to improve the stability and leach ability characteristics of the disposed tailings to increase the storage capacity of the disposal facility and to minimize the project occupancy area;

o The sealing of the tailings management facility;

o The improved management of the acid mine drainage due to the separation of the produced waste rock in its production phase;

o The regime of zero discharge of liquid effluents (treated and untreated) to natural receivers;

o The diversion of upstream of the project surface waters;

o The application of an environmental monitoring program prior to construction, during operation and after the closure of the project;

o Application of a closure and rehabilitation program of the wider area of intervention.

It is expected however, that the following issues should be dealt more detailed in the following steps of the project:

- The potential changes on the characteristics of the hydrological basin downstream of the project (soil erosion, surface hydrology change, recharging of underground reservoir, structure and composition of riparian flora and fauna, etc.);
- The impacts on atmospheric environment during unfavourable conditions (i.e., extremely dry, wet or windy conditions, extreme precipitation, etc.);
- The application of a detailed environmental monitoring program during the development, operation and closure phases of the project;
- Presentation of the environmental impact of the project to the neighbouring community and incorporation of the community feedback to the project design and management.

IV. SOCIAL PARAMETERS

The feasibility of a mineral resources development is directly related to its acceptance by the community residing in the project area. The mining law in Greece gives the right to the affected regional municipalities to provide their opinion regarding a submitted Environmental Permit Application of a proposed capital-intensive investment in the region to the Ministry of Environment. This can impact the permitting process, but does not provide the ground for negotiating impact and benefits that are vital to a community or to encourage the establishment of direct communication links between the company and the affected communities. A description of the characteristics of the community and a preliminary evaluation of the potential benefits of the proposed project, were tabulated.

The community in the vicinity of the Perama Hill is comprised of three villages in the immediate area and the municipalities of Alexandroupoli and Sappes. The three villages are inhabited by Muslim population of less than 300 people in total, while the overall population of the municipalities, based on the census of years 1991, 2001 and 2011 is indicated in Table III.

TABLE III POPULATION OF THE MUNICIPALITIES IN THE AREA

Municipality	Population			Change (%) 1991-2011
	1991	2001	2011	
Sappes-Maronia	16.356	17.186	14.710*	-10.1
Alexandroupoli	41,860	52,720	72.750*	73.8
Total	58,216	69,906	87.460*	50.2

* Data for the restructured municipalities in Greece effective since 2010 [18].

The GDP of the area has been less than the average GDP of the country for the period 2000 to 2007, with increasing rates of discrepancy as seen in Fig. 7.

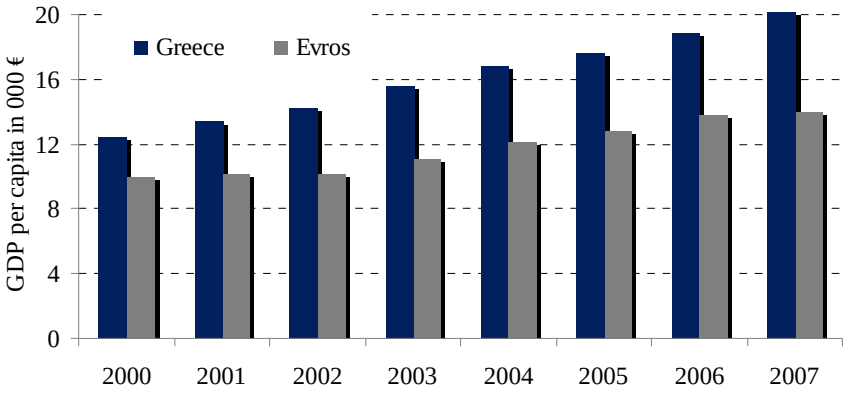

Fig. 7 Gross Domestic Product per capita for Greece and the prefecture of Evros for the years 2000 to 2007 (Current prices in 000€) [18]

The residents of the three villages are occupied by farming activities, while in contrast, the town of Alexandroupoli is the main commercial, transportation and administration centre of the area with a concentration of public sector employees. The social characteristics of the residents of the area are presented below.

- The residents have strong cultural, socially sensitive and religious characteristics.
- Lack of trust in the central government for regional decision making.
- The citizens prosper as a result of the location, the existing infrastructure and by being a regional centre and a transport hub.
- Lack of industrial development background in the region, with farming and services being the primary occupations.
- Concentration of public services as a major source of employment.
- The average literacy level of the residents of the farming areas is low, whereas the City of Alexandroupoli has one of the highest in the country and is a host city of university faculties.

The dominance of agriculture and public service employment in the area is indicative of the low industrial development. The only experience of mining activity in the area is the abandoned mine of Kirki, north of Alexandroupoli, with residual environmental rehabilitation problems.

It has been realized that the active engagement of a community to the development of a mineral resource impacts the permitting process and the determination of the impacts-benefits to the community. Socioeconomic parameters that can be affected by the mineral resource development can include benefits that are similar to other cases described [3,4,5,19]. The categories of potential benefits were customized for the particular case, based on appraisal of the population views during a 3-month stay in the area, discussions and observations that are presented in the qualitative parametric analysis of Table IV. Explanation for each category is provided at the bottom on the table.

TABLE IV PRELIMINARY EVALUATION ANALYSIS OF POTENTIAL BENEFITS TO THE COMMUNITY
(BASED ON REVIEW OF THE POPULATION IN THE AREA DURING A 3-MONTH VISITING PERIOD)

Evaluation analysis of potential benefits to the community	Significance Low→High
1. Permanent and temporary employment positions.	
2. Spin-off and ripple effect jobs for transportation, marketing, services, room and board.	
3. Allocation of compensation to the municipality.	
4. Allocation of part of the taxes to benefit the residents of the region.	
5. Exploration program for the enhancement of the mineral reserves.	
6. Contribution to regional development and infrastructure programs.	
7. Transfer of professional expertise.	
8. Rehabilitation of the environment in old ermining works in the area.	
9. Technology transfer.	
10. Collaboration with relevant sectors for natural resource development, industrial production and construction.	
11. Loan guarantees for business development in the region.	
12. Programs for quality of life enhancement, sustainable development and education.	
13. Work progress updates.	
14. Dispute resolution process during the work cycle.	

Data availability	Very high	High	Medium	Low	Very low
Ranking					

Explanations:

1: The number of permanent positions for the stated duration of the project of one decade reduces the financial benefits. The employment of people from the region, benefits both the company and the community. The capital investment will enhance the expertise of technical personnel.

2: The indirect work positions from spin-offs need a supporting infrastructure from the regional municipality. This, being the first mineral resource investment in the region, will provide entrepreneurial opportunities to businesses and further investments.

3, 4: The determination of the distribution of financial benefits (compensation, taxes, benefits) from the exploitation of the mineral resource to the municipality from the exploitation of the mineral resource, in addition to the creation of employment opportunities, requires the collaboration of the three parties: government, municipality and company. At present, the identification of such benefits is uncertain.

5: The company has an incentive to increase the mineral reserves, something that will bring additional benefits to the community by increasing the life span of the project.

6: The capital investment presents opportunities for participation to regional development programs, that will benefit the community, but, at present, the identification of such benefits is uncertain.

7,9,10: The training and the development of professional expertise are limited to the company employees. There are no data regarding the technology transfer through technological educational institutions in the region.

8: There is interest from all parties to enact the rehabilitation of the mining works area in Kirki, without a definite plan and an agreement in place.

11: The collaboration of the banks and the company can augment the exploitation of spin-off opportunities from businesses in the region.

12, 13, 14: These subjects require direct negotiation between the municipality and the company.

The social dimension of the sustainable development of a gold project in the vicinity of the Perama Hill site is discussed in [20]. The need to negotiate and implement reciprocal benefits to the community will be analysed in the next section.

V. DISCUSSION

The project of Perama Hill at the present stage is facing challenges related to:

- The permitting of the project by state authorities pertaining to the feasibility, operation and conformation to environmental regulations;
- The negative perception of people in the community for environmental degradation risks and revenue sharing;
- The political decision making in a country going through a financial austerity restructuring.

The challenges are discussed in an effort to set objectives that can improve the conditions for the project to move forward by addressing the core issues that affect the company, the central government and regional communities. The fact that there is no precedent of an approval of a gold mining project in the country requires pioneering in several aspects of a strategic plan forward to manage the socio-political risk of the project as well as the economic austerity restructuring process in the country.

The permitting process includes the provision for consultation with the impacted communities in an effort to determine mitigation strategies and incorporate the environmental concerns of the community for the proposed project. Notwithstanding the significance of this provision, it does not enable direct communication between the investing scheme and the community nor negotiations to reach an agreement that reflects the impacts and the benefits to the people of the region.

This identified deficiency restricts the residents of the region or other stakeholders from engagement in a constructive dialog to address their concerns and seek solutions through a legitimate process that is fostered by the mining code. Furthermore, there is no provision in the mining code to enable negotiations pertinent to the impacts and benefits of the project that can facilitate the direct communication between a company and the impacted community. The aforementioned process for the environmental review by the state authorities does not fulfil all relevant concerns of the residents for a mineral resource investment in their neighbourhood. This can lead to chronic confrontation and polarization within communities, as was found in the case of the Cassandra Mines in the nineties [21], where the proposed investment was delayed indefinitely despite obtaining the required environmental permits.

The exploitation of mineral resources around the world has often encountered social challenges despite the favourable assessments of central government offices.

Irrespective of holding or not a de-jure title or right, the neighbouring community is a de-facto stakeholder that holds the

moral right to be engaged in the process for amelioration of the impact and optimization of the benefits of the resource that was discovered in the vicinity of their residency. Regional governments are not empowered by state law to initiate and carry out a negotiating course of action, similar to impact-benefits agreements conducted elsewhere in the past fifteen years[2,5] to offer a catalyst to the amending of social challenges in mineral resource ventures.

The main issues associated with potential environmental impacts from gold mining are [9]:

- The high ratio of the volume of waste to the volume of final product, associated with increased amounts of energy and water especially for low grade gold deposits;
- The highly publicized accidents and infrastructure failures that have raised public concern over safety and environmental protection issues;
- The potential environmental impacts associated with the preferable technological choice of cyanide use for gold extraction.

The Perama gold project is a mining project of small to medium scale that lies in a region not included in a protection regime and with an estimated energy and water consumption significantly lower than the average of other gold projects. Moreover, the ratio of waste rock to ore tonnage is expected to be significantly lower compared to other gold projects, whereas the cyanide consumption is estimated to be within the range of other projects.

The conducted analysis through the examination of the project PEIS and the evaluation of local characteristics identified that the major potential environmental impacts, although of local scale, are related to:

- The risk management for catastrophic incidents such as failure of tailings dam, flooding of diversion work sand stockpile areas, uncontrolled acid mine drainage, etc;
- The improper management of waste product such as tailings (in sludge form or dewatered), waste rock, ore resulting in down-stream pollution in environmental medic (ground and surface waters, land, etc.);
- The application of cyanide in metallurgical process for the extraction of gold, mainly due to the psychological burden associated with its use and the subsequent opposition from the local population due to lack of experience from similar industrial activities;
- The potential changes on the characteristics of the hydrological basin downstream of the project (soil erosion, surface hydrology change, recharging of underground reservoir, structure and composition of riparian flora and fauna, etc.).

The analysis of environmental impacts throughout the mining cycle evolve in project design as indicated by [22] to optimize mitigation practices and offsets with input from the community review process. Such analysis can be conducted as part of advancements in feasibility, permitting and project design studies.

The lack of familiarity with gold mining in the country, feeds the uncertainty of a process that, although is practiced in other countries, is unfamiliar to most people of the region. This, coupled with the limited opportunity of the community to influence the decision making process, creates uncertainty for engagement in an unbiased process of impact control and benefits-sharing agreement of the proposed venture to the community. The community review that was conducted in 2004[23] indicated that much of the community is not in favour of the particular mineral resource investment. Despite the country being in financial austerity with high unemployment, the fundamental reasons for the negative opinions remain today, leading to a potential deadlock of the proposed investment. The authors foresee the following contributing steps that can facilitate the advancement of the social issues to move the project forward in the next stage of feasibility study:

- In collaboration with the mining industry of the country, lobby for the foster a modification of the existing mining act regulations to enhance and sensitise the role of the community in the determination and management of impacts and reciprocal benefits of a proposed investment that will provide a roadmap for exploring the establishment and endurance of a social license.
- Propose key aspects of the necessary changes in mining act, development policy and regional governance articles for social licensing based on practices in other countries that include revenue sharing in the form of royalty, taxation and beneficial monetary contribution to the region, in addition to employment opportunities.
- Support the structuring process for the new legislation by setting a paradigm for application.
- Based on the requirements of the new legislated process, initiate formal communication with the community for the potential establishment of a tri-partite impact-benefits agreement.

The people of the region can be constructively sensitised to environmental and regional issues that require facilitation of concerns through a negotiated process that will be part of a future amendment to the mining act. An attempt for resolution of conflicting issues can mobilize the pursuing of a social license for the proposed mineral resources exploitation. With the assumption that a social license is equally important to an environmental permit in the triple bottom line of a bankable feasibility study for mineral resource development, measures should be taken to institute procedures for community

engagement. Legislative changes in the country for the restructuring of the state economy, provide an opportunity for the pursuit of regional economic development initiatives. This can provide a process to obtain and sustain a social license through enhanced communication and harvesting of negotiation opportunities for the benefits of shareholders and stakeholders.

It is the opinion of the authors that the environmental impacts can be managed by the investing scheme and the risk mitigation solutions can be established. The relatively small life cycle of the proposed project can be counterbalanced by increasing the mineral resources or by venturing with mining enterprises in the region that pursue similar development, e.g. Sappes, through a government-sponsored incentive investment agreement.

VI. CONCLUSION

A gold mining project that is at the prefeasibility and permitting stages is encountering social resistance in a country which is in the process of socio-economic austerity restructuring. Although the economic and environmental challenges of the project can be countered within the existing framework, the triple bottom line of sustainable mineral resource development requires the amendment of the country's mining act to take into account the need of the people in the region to have an effective engagement in the exploitation of mineral resources in the region based on a negotiated tri-partite mutual benefit agreement of impacts and benefits to company, country and region.

The examination of the project environmental parameters through the evaluation of the Preliminary Environmental Impact Study and its local characteristics indicated the local character of the potential environmental impacts from the particular gold project. Those issues are related to proper risk management for catastrophic incidents, to the management of waste products, to the application of cyanide in the gold recovery process, and to the potential changes on the characteristics of the hydrological basin downstream of the project footprint area.

REFERENCES

[1] M. Veiga, M. Scoble and M.L. McAllister, "Mining with communities," Natural Resources Forum, UNEP, Elsevier, pp 191-200, 2001.

[2] V. Kazakidis, S. Moutsatsos, R.F.C. Haliburton and N. Vayenas, "Sustaining mining in a developed world: shifting the paradigm," paper presented at the International Conference on Sustainable Development Indicators in the Mineral Industry, SDIMI, Milos, Greece, p.6, 2003.

[3] S. Moutsatsos, V. Kazakidis and J. Fowler, Linking IBA's and project management – a case study, paper presented at the International conference on Sustainable Development Indicators in the Mineral Industries, SDIMI, Milos, Greece, p.7, 2007.

[4] ICME, Mining and indigenous people: case studies, International Council on Metals and Environment, Canada, p. 50, 1999.

[5] ICMM, Indigenous peoples mining, International Council of Mining and Metals, London, U.K., p. 120, 2010.

[6] (2005) W.C. Butterman and E.B. Amey, Mineral commodity profiles-gold, U.S. Geological Survey, Open file report 02-303, Reston, VA, U.S.A., p. 66, retrieved from pubs.usgs.gov/of/2002/of02-303/.

[7] A. Muezzinoglu, A review of environmental considerations on gold mining and production, Critical reviews in environmental science and technology, 33 (1) pp. 45-71, 2003.

[8] S.H. Ali, Gold mining and the problem rule: a challenge for producers and consumers in developing countries, Journal of Cleaner Production, 14 (3-4), pp. 455-462, 2006.

[9] MMSD, Mining, minerals and sustainable development, The report of the MMSD project, Earthscan Publications. Ltd., London and Sterling, VA, 2002.

[10] DIUS, World Class Skills – Implementing the leitch review of skills in England, Department of Innovation, Universities and Skills, London, U.K., 2007.

[11] GRI, Sustainability reporting guidelines, Global reporting initiative (GRI), Amsterdam, The Netherlands, p. 44, 2006.

[12] G.M. Mudd, Global trends in gold mining: Towards quantifying environmental and resources sustainability, Resources Policy, v.32, pp. 42-56, 2007.

[13] A. Kumah, Sustainability and gold mining in the development world, Journal of Cleaner Production, v.14, pp.315-323, 2006.

[14] G. Markopoulos, Sustainable development approach of the Perama Hill Gold Project, paper presented at the International conference on sustainable development indicators in the mineral industries, SDIMI, Milos, Greece, 2007.

[15] T. Rondoyanni, C. Georgiou, D. Galanakis and M. Kourouzidis, Evidence of active faulting in Thrace region (Northeastern Greece), Bulletin of the Geological Society of Greece, v. XXXVI, pp. 1671-1678, 2004.

[16] 2011, TGM, Thracean gold mining website, retrieved from http://www.tgm.gr/.

[17] TGM, Preliminary environmental impact assessment study of Perama Project, Thracean Gold Mining, Enveco, Echmes Ltd., Athens,Greece, 2009.

[18] 2011, EL.STAT. Hellenic Statistical Authority website. Retrieved from http://www.statistics.gr/portal/page/portal/ESYE.

[19] S. Schafrik and V. Kazakidis, Due diligence studies for the assessment of social risk, International Journal of Mining and Reclamation of Environment, v.25 (1), pp. 86-101, 2011.

[20] A. Shaw and D.C. Constantinides, Sustainable development practices in mining: The Sappes Project, paper presented at the International conference on sustainable development indicators in the mineral industries, SDIMI, Milos, Greece, pp. 165-170, May 2003.

[21] 2011, Anonymous, The struggle against gold mining in Greece, retrieved from http://www.mmpindia.org/greece.pdf.

[22] M. Nazari and D. Proebstel, Biodiversity offsets in mining, Mining.com, Environment and Communities, pp. 41-44, 2009.

[23] K. Kitsopoulos and E. Pavlidou, Exploitation of gold ore deposits – The press and local society, environmental protection and concern – the case of Thrace region [in Greece], Proceedings of the 10th International Congress, Bulletin of the Geological Society of Greece, Thessaloniki, Greece, pp. 350-359, 2004.

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